Uncovering the Purpose of the Map

How geospatial data visualizations can influence responsible actions of governmental policy- and decision-makers in deprived urban areas.

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This master's thesis is the final product and end of my double degree program with the master degrees in Philosophy of Science, Technology, and, Society and Communication Science, provided at the University of Twente in Enschede. At the time of writing this preface, I have been, unofficially, working on this research for a year. My interest in the topic of research already emerged during the previous summer break, when my “skills-line mentor” Michael Nagenborg asked me if I already had some ideas on my master thesis. Originally, I would not have started before February 2023, therefore, I was completely oblivious to the direction for my thesis. Here, Michael saw an opportunity and he introduced me to Project FRAME-PRO. He believed that I would be a suitable match due to the joint educational program I was following.

What followed was an introduction with the PhD candidate of the project: Isaac Oluoch. Together, we had many brainstorming sessions to see if and how I could be integrated into this project. Half a year ahead of time, we decided that I should be part of this project and revolve my master's thesis around gathering opinions on geospatial data visualizations through several workshops. Now, Michael was not only my skills-line mentor but also became my master thesis supervisor. For me, this was the perfect combination of both my master’s degrees since I could tackle a philosophically oriented problem with theories and approaches from Communication Science. Yet, this was only the first step of fabricating a joint master thesis, since, besides Michael, I also need supervision from Communication Science. Immediately, I thought of Joyce Karreman, who was one of my lecturers during my courses in Communication Science. Due to her affinity with technological communication and knowledge of UCD, I believed she would be a great fit to join this project. Luckily, she saw the potential in this project and agreed to come aboard.

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ABSTRACT

This study contributes valuable insights into the use of geospatial data and visualization techniques to influence responsible actions of governmental policy- and decision-makers in deprived urban areas. The study came forward from the PhD Project Frame-Pro that performed research on deprived urban area mapping, i.e., slum mapping, considering humanitarian aid. Specifically, the project has looked at a case study in Nairobi that concerned the visualization of waste management. The current study used a User Centred Design (UCD)-approach to gather insights into the topic of research, which concerns an iterative approach, early focus on users and tasks and empirical measurement. This research has employed a multi-faceted approach involving the performance of five focus group discussions, which is a common method for UCD-approaches. Four of the focus group discussions consisted of an academic audience of philosophy specialists, geospatial data specialists, visualization specialists, students, and other participants. One focus group discussion consisted of a more lay-men audience of people from Nairobi that contributed to the data gathering process of the waste management, i.e., the 'Community Mappers'. Findings of the focus group discussions highlight the significance of accurate definitions and non-generalized visualizations in mapping deprived areas, considering ethical concerns and cognitive load. The study emphasizes the importance of detailed base layers for usability and advocates for the careful selection of attributes and relationships to avoid information overload. The inclusion of pictures in visualizations positively stimulates engagement and awareness. Stakeholders recognized maps as tools for raising awareness, reframing issues, and prompting action, necessitating clear context, and framing. While the study's UCD-approach is pioneering, limitations suggest broader and more diverse participation for comprehensive perspectives, involving actual governmental decision-makers. Since this study investigated to what extent visualization designs can influence responsible actions, the term responsible mapping has been used. This indicates designing a map in a responsible manner to be able to prompt responsible actions. Generally, responsible mapping involves various actors and tailoring maps to its context, audience, and purpose. Additionally, the study proposes applying cognitive load theory to visualization design, taking information overload and mental representations into account. Moreover, it extends the notion of 'geospatial data visualization' from information-about-reality to information-for-reality, guiding human actions through well-designed visualizations. The recommendations for future research are to explore expert-driven visualization designs, conduct comparative studies with diverse participants, and engage the Community Mappers in longitudinal studies for real-world impact insights.

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1. INTRODUCTION

The use of maps is, and has been, central to European governmental policy- and decision-making processes since the 15th century (Latour, 1987). During that time, and especially during the colonial expansion, maps were seen as a source for European governments and municipalities to exert power over the areas and inhabitants that were being mapped. Important here is the geo-political situation, which is framed from a European lens (Mignolo, 2009). This idea of power means that while the inhabitants had ownership over the area they lived in, the European governments and municipalities took that ownership by colonizing the area. Generally, by using maps, governmental figures can make sense of specific areas, allowing them to make decisions (Harvey, 2020). In this manner, maps are graphical representations of political claims towards an organization of specific territories. Thus, maps can be seen as pivotal documents for governments to collect, analyze, and communicate information. According to French philosopher Bruno Latour, maps for governmental policy- and decision-making were created by writing down and drawing up information that was gathered by Europeans during exploration voyages with ships to yet unknown and distant lands in the 15th and 17th centuries (Latour, 1987). This was done by drawing the shape of the encountered area on a piece of paper and by collecting all information in notebooks. On those ships, various technical instruments were present, e.g., a compass, that helped the shipmen gather information. The purpose of drawing up those maps was to gather knowledge about those distant lands for governments to be able to dominate those areas, i.e., the power exertion. As cited by Latour, a few centuries later in the beginning of the 20th century, a French engineer called Conrad Schlumberger had the idea of inventing an electric current that could be sent through the soil to measure electrical resistance and, in turn, map the soil and what was beneath it (Latour, 1987). By using such probes, engineers did not need to travel to distant lands to gather information concerning that area[1]. Both historical examples have in common that they made it feasible to accumulate traces on maps and in this way contribute to existing knowledge. The more scientist-explorers bring back additional information, the bigger the accumulation and the easier to exert power and make prospects about the area. This is what Latour calls the center of calculation (Latour, 1987), which can be seen as the prerequisite for combining layers in the process of overlay mapping in geographical information systems.

From these examples, it becomes apparent that using these technical instruments to fabricate a map creates a purpose for the map. In this manner, the map shapes the perception one has toward the real world and influences the actions one could take from the map. Especially, with the shift from traditional paper maps to digital maps by using geospatial data in geographical information systems (GIS) as the most recent example, many implications arise for decision-making processes. This notion of geospatial data refers to geographical information about earth, specifically, it is *"information that describes objects, events, or other features with a location on or near the surface of the earth. Geospatial data typically combines location information and attribute information with temporal information"* (What Is Geospatial Data? | IBM, n.d.). The concept of GIS can be defined in many different manners, where the commonality is that GIS has a powerful toolkit able to capture, store, process, and analyze large amounts of geospatial data. In turn, this can be used to display representations from the real world (Burrough et al., 2015; Conroy, 2006)[2]. Improvements to GIS have made their emergence in the past years due to technological developments in the field (USCDornsife, 2021), hence it is an evolving and important technology to consider for society.

More traditional maps have proven to be useful for decision-making for decennia long, and due to the developments in the field of GIS and its use for real-time problem-solving, governments are highly interested in using it for decision-making processes (O'Looney, 2000). Moreover, since governmental institutions are responsible for the safety, welfare, and health of their citizens, GIS can be a helpful tool to consider fundamental issues and values and to weigh the potential harm their actions could entail for future generations (O'Looney, 2000). Thus, by using the outputs of GIS, i.e., geospatial data visualizations, GIS allows governments to be aware of the long-term effects of specific actions and to improve their efficiency and responsibility towards those actions. Several studies have been performed on this topic of geospatial data visualizations, ranging from studying basic visualization principles, the cognitive process behind using visualizations, and the way visualizations are able to display complex information in governmental decision-making processes (Dennis & Carte, 1998; Jankowski, 2009; Milutinović et al., 2019; Padilla et al., 2018).

For this thesis specifically, the use of GIS for deprived urban area mapping has been investigated. Deprived urban areas can be referred to as slums, informal settlements, and areas of inadequate housing, where it is implied that the standard of living is below the average standard of the general population (Herbert, 1975). These areas, mainly considered to be found in the so-called Global South, can be mapped using GIS to inform urban policymaking by representing the social, political, and environmental issues facing those living in deprived urban

[1] More details on the historical examples can be found in Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Harvard university press.

[2] A definition and elaborate clarification on both maps and GIS are provided in Appendix A.

areas (Oluoch, 2022). The term deprived urban area is used instead of slum or informal settlement to avoid the historically prejudiced view of the term 'slum', and to consider not just singular households, which is the way UN-Habitat classifies them, but looking at the economic, social, and environmental situatedness in which these areas are found. Over the past two decades, there has been an increased push to make use of geospatial data methods and technologies to identify and visualize these areas, which are often not very consistently represented in national census data or reference maps (Oluoch, 2022). However, maps are not only produced solely by the state and professionals in the field of cartography, also people on the ground level are working with GIS to capture geographical information about the area. This causes the role of the map to be shifted with a better balance of power since it is not solely a government tool of use (Oluoch et al., 2022). In turn, this causes governments to rethink the way they use maps for decision-making and how to incorporate inhabitants in the mapping process.

In the literature[3] on maps for governmental policy- and decision-making, it was found that governmental institutions in the public sector can benefit tremendously from using GIS to serve their obligation to weigh the potential harms specific actions could have to future generations (O'Looney, 2000). Specifically, the importance of using geospatial data visualizations of GIS for policy and decision-making is emphasized in the current literature. Geospatial data visualizations are outputs of geographical information, made to provide visual context to the locational data that is displayed (Hynek et al., 2021). However, no research has been performed on how the specific design of a geospatial data visualization contributes toward making decisions in deprived urban areas. This means that the effect of different design choices and map attributes on policy- and decision-making is unknown. Moreover, not much literature is focused on the role shifting of the map by incorporating more inhabitants into the process, which also creates a certain understanding of responsibility towards them.

In short, a gap was found regarding the effect of different geospatial data visualizations on governmental policy- and decision-making, researched from a user-centred design approach (see Chapter two). More specifically, it has been argued that a more user-driven approach would contribute to the deprived urban area mapping process. Also, participatory GIS has become a trend in governmental GIS use. Both indicate that the user must be considered more prominently and preferably at the start of research. One human-centred study has been performed that investigated different visualization techniques for movement mapping (Dodge & Noi, 2021), yet did not discuss how this could be implemented in governance and only focuses on movement mapping. Another paper argues, based on the results gathered, that more research should be performed on human experiences toward using visualization tools for knowledge gathering (MacEachren, 1995; MacEachren et al., 2005). Moreover, an exemplar study of a UCD-approach by Çöltekin et al. (2017) has already performed workshops, a common method for a UCD-approach, on the topic. These workshops served to gather knowledge on challenges found in applying geo-visualization by surveying the participants, yet they did not gather opinions on different visualization designs. Thus, if workshops are to be held to measure if different geospatial data visualizations can influence responsible actions of governmental policy- and decision-makers from a user-centred design perspective, the identified gap will be tackled.

Thus, the gap identified within literature, the increased use of GIS, the ongoing developments of new ways to visualize geospatial data, and the shift in the role of the map ask for more research to be performed on using geospatial data visualizations for deprived urban area mapping. More specifically, research is needed on how different designs of geospatial data visualizations contribute to the decision-making process of governmental policy- and decision-makers in deprived urban areas to have a better understanding of how GIS can play a more societal role. Especially of interest to this research is the way geospatial data visualizations can influence the responsible actions of governmental policy- and decision-makers. This comes forward from the connection with the PhD Project Frame Pro (University of Twente, n.d.). Within this project, it has been found that there is a growing awareness of the ethical challenges corresponding to the use of GIS, i.e., surveillance, access to data, and privacy (University of Twente, n.d.), yet a better understanding of the societal role of GIS and its impact on the responsibilities of various stakeholders is required. Therefore, this thesis' central research question will be *"To what extent do different geospatial data visualizations influence responsible actions of policymakers and their decision-making process in deprived urban areas?*

The first chapter of this thesis will provide a more thorough overview of the history, current state, and future of using maps in governance. Here, a clear outline will be given of the state-of-the-art research concerning the topic of geospatial data and maps for policy- and decision-making in deprived urban areas and visualization techniques. Furthermore, studies will be discussed that have looked more in-depth into the framework behind visualization techniques. All the information gathered in the literature review provides a framework for formulating the sub-questions, developing the workshops, and performing this research.

[3] An extensive literature review consisting of papers and books about maps can be found in Chapter two.

The sub-questions are:

1. What do various stakeholders currently know about using geospatial data for deprived urban area mapping?

2. How does the level of detail, a picture, or overlay mapping in a geospatial data visualization stimulate engagement with the topic?

3. What different opinions do various stakeholders have on how a map and geospatial data visualization can help to influence the responsibility of policymakers and their decision-making process in deprived urban areas?

In the third and fourth chapter of this thesis, the methodology of the research instruments will be explained. In this case, the UCD-approach will be elaborated on and the use of focus groups with a workshop style will be thoroughly explained. Four workshops in total were performed with a variety of stakeholders based in the Netherlands. Additionally, a fifth workshop has taken place with African affiliates that gathered the geospatial data that served as input for the previous four workshops. This is done to also have a bottom-up approach, instead of solely a top-down approach, and to provide feedback on what has been done with their data.

After the workshops have been performed, transcribed, and coded, the results will be discussed in chapter five. These will be analyzed to provide an answer to the research questions. This will be followed by a philosophical analysis in chapter six. Here, the purpose of the map will be central to the discussion. The opinions, values, and actions that came forward from the workshops will be looked at, categorized, and evaluated. This will serve as a base for understanding the process behind decision-making based on geospatial data visualizations. Additionally, the right to privacy will be elaborated on considering governmental GIS use. In chapter seven, the findings of the workshops will be interpreted and analyzed. Moreover, it will be discussed if the results found are in line with what was already known from the literature review. This will be followed by the limitations, and practical and theoretical implications of this study while discussing the recommendations for further research. Finally, a conclusion will be provided to answer the central research question of this thesis.

To provide an answer to the research questions, this thesis will use theories and methods from Communication Science to acquire insights into the opinions, actions, values, and perceptions of various stakeholders on the topic. This will be done by performing workshops in a focus group discussion style. Additionally, this thesis will be part of a PhD project called Project Frame Pro (University of Twente, n.d.). In this research project, the central research question is: "*To what extent do geospatial data technologies affect the responsibilities of various stakeholders to improve the lives of the urban poor?"*. This thesis builds upon this project, by further investigating the use of geospatial data technologies and researching the visualization outputs of such technologies and how those influence the responsible actions of governmental policy- and decision-makers in deprived urban areas. For the philosophical analysis of this thesis, theories from the field of Philosophy of Technology will be used, arguing that technologies are not neutral tools but shape how act upon the world around us (Feenberg, 2009; Rosenberger & Verbeek, 2015; Verbeek, 2015a). Based on this claim that technologies are not neutral, this will be further argued by using works from Latour, Verbeek, and Borgmann (Borgmann, 1999; Latour, 1994; Verbeek, 2015b). The argument this thesis makes is that geospatial data visualizations are indeed able to influence the responsibility of governmental policy- and decision-makers, yet the purpose of the map is influenced by different contexts of using the map. Within this argument, maps can be seen as a guide for human action and for this thesis specifically as a guide to prompt action to the governmental policy- and decision-makers in deprived urban areas. Additionally, the work from Curry (1997) will be used to shed light on the more ethical concern of privacy that can be associated with governmental GIS use. This thesis will contribute to overall scientific development and existing knowledge in the field since it bridges the gap found in current literature, complements what is already known about GIS and governmental policy- and decision-making in deprived urban areas, and contributes by researching it from a UCD-perspective and analyzing it from a philosophical perspective.

2. LITERATURE REVIEW

This chapter serves to create a basic understanding of the state-of-the-art of the current literature on the topic of using maps of GIS for governmental policy- and decision-making, specifically in deprived urban areas. In Section 2.1, the history, current state, and future of governmental map use will be discussed, followed by the literature on maps for policy- and decision-making in deprived urban areas in Section 2.2., and an elaboration on the background for the sub-questions in Section 2.3.

2.1. HISTORY, CURRENT STATE, AND FUTURE OF GOVERNMENTAL MAP AND GIS USE

Cartography's paradox reveals that, even while those creating maps may intend to be depict 'truthful' and 'accurate', these maps cannot fully represent reality and inevitably contain slight misrepresentations and distortions (Monmonier, 1991). These inaccuracies are integral to the design process, where mapmakers must decide which geographical features to include and how to visualize them. These 'lies' in mapmaking occur through projection, symbolization, standardization, classification, aggregation, and zonation. However, more significant distortions with substantial consequences occur for (geo-) political purposes, such as resource maps, campaign advertisements, and propaganda. A striking example is gerrymandering, the manipulation of voting district boundaries for political advantage (Tapp, 2019). Gerrymandering emerged in the 1800s and is a powerful political technique to tell lies via maps and distribute political power and is notably used in the United States. This boundary manipulation has severe consequences in terms of representation for people living in those areas (Manson, 2017). This specifically has a major impact during election time. In terms of geopolitics, lies are told concerning the representation of specific territories, emphasizing territorial disputes between different countries. An example here can be found in the regions of Kashmir and Jammu, located along the border of China, Pakistan, and India in South Asia, which are displayed differently on different maps based on their territorial claims (Manson, 2017).

These examples illustrate that political map distortions have historical roots, as maps have been used to assert state power by manipulating boundaries (Biggs, 1999). From the 1700s onwards, early European modern states were concerned with the representation of space that was occupied by the state (Biggs, 1999; Farish, 2009; Oluoch et al., 2022). Many difficulties and ambiguities were present concerning the control of the states' space, especially toward the states' lack of knowledge of their territories (Scott, 1998). Thus, to gain a broader understanding, state-controlled territory had to be made comprehensible in a universal language, which resulted in the emergence of cartography, the visualization of cities and the demarcation of boundaries. In turn, this resulted in more industrialization and centralization of states due to the state's purpose to systematically survey space (Oluoch et al., 2022). The design of these maps inherently involved lying, as states could alter them to suit their preferences and, in this way, cartography became a tool to exert the states' power over space. Especially, to improve the body of the states' legibility and to distinguish the state's knowledge and power in contrast to their controlled non-European colonies (Edney, 2019). However, these local and indigenous communities of the 'discovered' lands have not lived by any state lines, since they have always lived there. Therefore, they remain invisible by the formal nation-states and naming conventions from the European colonial historical lens (Mignolo, 2009).

In the mid-90s, Geographic Information Systems (GIS) emerged as a valuable tool for problem-solving in the public sector. However, effective implementation in local governments and decision-making processes posed challenges. One of the first studies that addressed potential challenges, argued that despite GIS's potential difficulty arises in measuring the actual benefits of using GIS for local government decision-making processes. (Ventura, 1995). Ventura poses a new way of thinking where GIS should be used to make local governments more efficient, effective, and accessible and not be seen as the end-goal. Others have emphasized the need to evaluate GIS's role within the broader social context before the public sector benefits from its implementation (Pickles, 1995). Due to rapid emergence of GIS, various frameworks emerged to optimize GIS use, transforming how governments handled spatial data (Mennecke and Crossland, 1996) and approximately 80,000 local government agencies adopted GIS (Masser, 1998).

Moreover, GIS, according to Haque (2001), empowers examination of political, social, and economic circumstances also posing challenges to decision-making. Importantly, he argues that He proposes that GIS should not become a discipline that is dominated solely by facts, but by understanding the environment in which it is used. This indicates that not only data should be acquired but knowledge should be gathered from the data. An

example here is the implementation of Electronic Governance (e-governance), which applies information technology to government services (Palvia and Sharma, 2007). Despite, the implementation of e-governance, Lewis and Ogra see more potential in governmental GIS use by linking it to Good Urban Governance (2010). They argued that GIS should be focused on municipal governance and specifically on service delivery, resource mobilization, and planning. Others have also explored the impact of e-governance on GIS (Rathee and Rishi, 2011), highlighting the potential of GIS visualizations for governmental issues such as resource allocation, distribution, and site determination. As well as improving community empowerment.

Rathee and Rishi hint at participatory GIS, i.e., pGIS, at the end of their paper but do not go into detail about the concept (2011). A paper that does explain this idea of pGIS in detail is by McCall and Dunn and they have defined pGIS as *"a form of participatory spatial planning which makes use of maps and other geo-information output, especially using GIS, thus incorporating the tools within the context of use. Participatory mapping and Participatory GIS are used as a single approach to represent the participatory local-level (community) use of spatial representations with sketch maps, topographic maps, remote sensing images, aerial photographs, GIS products, or other geo-referenced material."* (McCall and Dunn, 2012, p. 83). This indicates that pGIS involves non-cartographers in mapping processes and makes cartography accessible to the public. They have investigated the potential of using pGIS for spatial planning by discussing the five principles of good governance, which are accountability, equity, competence, respect, and legitimacy (McCall and Dunn, 2012). They found that pGIS tools create more interaction with and inside communities, identifying them as geo-information users. In this manner, there is more engagement which will help in gathering local spatial knowledge and thus in achieving the goals of governmental policy- and decision-making. However, they do note that social dynamics are a major challenge in the benefits of pGIS.

Research also addresses the future of cartography when deploying full GIS utilization. Kim (2015) explores cartography's modalities for making maps more critical in political contexts, focusing on the field of critical cartography. Instead of looking at GIS as a participatory matter, the author proposes an authored map, yet states that more research needs to be performed. Basaraner (2016) performed more research on this topic and developed a framework for effective map use. He advocates adhering to cartographic design principles to improve spatial cognition and resource management, resulting in governments being able to monitor and manage the world and its corresponding resources as effectively as possible. Moreover, Griffin et al. (2017) outline four research agendas focusing on use and user issues, big data and geovisual analytics, persistent cartography challenges, and map design across various contexts. For example, recent research examines geoprivacy concerns in sharing large data sets, using geomasking as a tool (Wang et al., 2022).

2.2. MAPS FOR POLICY- AND DECISION-MAKING IN DEPRIVED URBAN AREAS

This thesis aims to assess if different visualization designs can prompt responsible actions of governmental policy- and decision-makers in deprived urban areas and eventually improve the quality of life for lower-class people. This aligns with the PhD 'Project FRAME-PRO' which it contributes to (University of Twente, n.d.). Thus, it is explored how GIS can effectively be used in deprived urban areas, especially since most research is on Western countries and much less on non-Western countries (Crampton, 2010; Oluoch, 2022).

As seen during the COVID-19 pandemic, the societal vulnerabilities of global cities have increased. As a response to decreasing the spread of the virus, GIS has been used to gain a better understanding of the temporal and spatial dynamics of the spread (Oluoch, 2022). The reason behind using GIS, especially visualized in apps, dashboards, and digital maps, is that it offers *"important insights into spatial dimensions and the relations of vulnerability and resilience"* as well as *"enhances risk communication and support decision-making in all phases of disaster management"* (Heesen et al., 2014, p. 74). Geospatial information is useful in gathering location-based data on both macro and micro scales and can represent temporal and spatial dynamics as well as contribute to decision-making processes (Oluoch, 2022). The COVID-19 pandemic is a prime example of how GIS can be used for governmental policy- and decision-making in deprived urban areas, here mainly focused on decision-making for risk management by visualizing spatial information (Oluoch, 2022). However, it must be taken into consideration that maps are not objectively displaying facts, postulating reality as it is, but are encapsulated in relations of power (Crampton, 2010; Oluoch, 2022; Wood et al., 2010). In this way, *"mapping is involved in what we choose to represent, how we choose to represent objects such as people and things, and what decisions are made with those representations"* (Crampton, 2010, p. 41). It is also important to consider *"who is doing the representing and mapping"* (Oluoch, 2022, p.43). This indicates that specific morals, knowledge, and codes are

embedded in the decision-making process and research shows that these codes are dominated by Western standards (Crampton, 2010; Heesen et al., 2015), excluding deprived countries (Pickles, 2004).

Through the development of collaborative tools, mapping applications, and the geospatial web over the past 20 years, the creation of maps has shifted from the sole domain of government and professional cartographers to the involvement of other parties, i.e., inhabitants (Oluoch et al., 2022). However, the intelligibility and power relations in which digital maps are ingrained still demand attention (Crampton, 2010). Particularly because the mapmakers may assume universal intelligibility, *"subtleties of visual representation such as projection, generalization, and color schemes"* (Heesen et al., 2015, p.245) that may appear clear to one audience may lead to misinterpretation by other audiences. Hence, even though the people involved in making maps may have changed, the epistemic and ontological decisions made in digitized maps frequently remain hidden (Heesen et al., 2014; Oluoch, 2022). Furthermore, it is often the case that data on a map is standardized which reduces the complexity present in social processes (Heesen et al., 2014). Specific variables are left out that could indicate certain vulnerable demographic standards, which could lead to difficulties in understanding the social processes at play and the effectiveness of decision-making in deprived urban areas. This could negatively impact the people being mapped and influence the accuracy of the map (Oluoch, 2022).

Oftentimes, the regions that are difficult to visualize accurately on a map are deprived urban areas and an issue arises in politically and spatially representing such deprived areas. Since a map is not neutral and objective but is embedded with power relations, many states fail to include these areas and consequently, the people living in those areas are not seen as members of the city or country they are habituated (Brito et al., 2020; Oluoch, 2022). Especially, considering the COVID-19 example mentioned earlier, these regions find difficulties in meeting the WHO guidelines for preventing the spread of the virus due to their living conditions (Corburn et al., 2020; Iwuoha and Aniche, 2020). What becomes apparent is that these regions are not considered in the governmental policy- and decision-making process (Oluoch, 2022). Thus, it is of utmost importance to use GIS more accurately for visualizing the data coming from these deprived areas. Currently, these areas are mapped via four approaches, which are aggregated approaches, field-based mapping approaches, human imagery classification approaches, and semi-automatic imagery classification approaches (Kuffer et al., 2020).

However, the existing geographic knowledge about deprived urban areas is deficient (Kuffer et al., 2016), complicating the mapping process. They argue that more research should compare established deprived urban area characteristics and geographical image interpretation (Kuffer et al., 2016), with imagery increasingly collected via unmanned aerial vehicles (Sliuzas et al., 2017). Here, citywide surveys and enumerations of deprived urban areas can aid strategic decision-making and public policy processes (Masser, 1986; Sliuzas et al., 2017). Deprived urban area mapping should integrate into regular urban mapping initiatives addressing risks and environmental conditions (Sliuzas, 2004). Moreover, these areas must be understood in their broader context due to intricate social, physical, and environmental relationships (Abbott, 2001). Citywide deprived urban area maps could incorporate for example information on site conditions or building density in addition to showing the deprived urban area's position and breadth. As status and change data can be used as input for policy development, decision-making, and monitoring activities, it is preferable that all data be multi-temporal (Sliuzas, 2004). Multi-temporal means that images are created based on multiple sensors. Recently developed very high-resolution imagery are necessary component for site-specific mapping processes (Sliuzas, 2004), meaning to analyze the physical situation and facilitating communication between deprived urban area inhabitants and experts. Through comprehensive socioeconomic, environmental, and physical enumerations, that may be updated as needed throughout the project cycle, very high-resolution images enable the construction of a reliable baseline (Davidson and Payne, 2000).

According to Sliuzas et al., it is worthwhile to investigate hybrid approaches when mapping deprived urban areas because they provide the best of both worlds (Sliuzas et al., 2017). On the one hand, they provide the ability to incorporate local knowledge, e.g., to identify and delineate deprived urban areas through crowdsourcing. This can, on the other hand, be combined with the ability to systematically produce key indicators, e.g., layout pattern and density. In this way, hybrid approaches combine visual interpretations with a large set of automatically generated indicators that typically perform well. Hence, these might be useful to track changes in regions that are already recognized to be deprived urban areas. Such information could shed light on how deprived urban areas evolve, perhaps revealing problem areas that urgently need renovation or other measures. However, it must be taken into consideration that both the adoption and trust of the deprived urban area inhabitants as well as the power and expertise to detect deprived urban areas with unmanned aerial vehicles do not completely coincide. Thus, it has been argued that a socio-technical approach towards deprived urban area mapping must be required, due to the sensitivity of the mapping process (Haarsma and Georgiadou, 2017; Sliuzas et al., 2017).

This sensitivity can be decreased by applying a more user-driven approach compared to a solely data-driven approach (Owusu et al., 2021). This paper has shown that by applying a user-driven approach that incorporates user requirements and local knowledge, geospatial data relevant to policy- and decision-making can be provided. According to their findings, end-user requirements, local context knowledge and geo-ethics all contribute to a more accurate conceptualization and contextualization of deprived urban areas (Owusu et al., 2021). They have provided a framework for user-driven deprived urban area mapping, which aggregates deprived urban areas into the proper unit to reduce the inclusion of excessive details and ensure the exchange of ethical data. This indicates that by contextualizing and conceptualizing deprived urban areas with the user in the back of the mind, the area can be classified accurately. In this way, the final output includes enough details to become useful, yet still protects the rights of the inhabitants being mapped. Hence, choices can be made toward the inclusion or exclusion of specific attributes based on the user of the visualization. Moreover, by deliberating beforehand about possible ethical concerns, i.e., infringing the privacy of the inhabitants, that may arise from visualizing the deprived urban area, geo-ethical concerns can be diminished.

Furthermore, many studies have argued that advances can be made in deprived urban area mapping by incorporating machine-learning algorithms, deep learning models and artificial intelligence (Davidson and Payne, 2000; Kellenberger et al., 2021; Kuffer et al., 2016; Owusu et al., 2021; Sliuzas et al., 2017; Sliuzas, 2004). Also, it has been stated that using OpenStreetMap provides benefits to the mapping process (Beaud, 2020). Yet, the problem of access of information occurs, due to the data scarcity in deprived urban areas. Hence, the accuracy level of the data and corresponding geospatial data visualization decreases.

2.3. SUB-QUESTIONS

Besides gathering knowledge on the current knowledge of various stakeholders on the topic of this research, i.e., sub-question one, it becomes apparent that three design topics should be investigated during this research. These are: (1) the inclusion or exclusion of details, specifically looking at how privacy plays a role in the visualization of geospatial data; (2) the use of images or text, emphasizing the different ways of processing in the human mind; and (3) the use of overlay mapping in the field of GIS, highlighting how this technique is perceived. These design topics connect with sub-question two. For design topic one it is expected that the level of detail influences the readability and usability of a map, which affects how much engagement is stimulated. For design topic two, the expectation is that images stimulate more engagement compared to textual attributes. For design topic three, overlay mapping is expected as a necessary component for a visualization being able to stimulate engagement. Moreover, since this thesis tries to understand if and how geospatial data visualizations could influence the responsible actions of governmental policy- and decision-makers in deprived urban areas, the topic of responsibility will also be discussed. This relates to sub-question three.

Focusing on privacy in the field of geo-ethics, this mostly concerns questions of accountability, fairness, and transparency regarding how the inhabitants are mapped, represented, and acted upon (Haarsma and Georgiadou, 2017). Hence, the deprived urban area 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 thought processes on geo-ethical issued could result in jeopardizing the deprived urban areas, e.g., causes of stigmatization and the risk of eviction (Gevaert et al., 2018). Therefore, it is important to perform more research on the issue of privacy considering geo-ethics and especially in deprived urban areas. Privacy can be investigated by looking at what Tim Ingold has discussed in his work on the perception of the environment. He states that 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). This paradox shows that to present an image that is truthful and useful an accurate geospatial data visualization contains white lies (Monmonier, 1991). Moreover, Monmonier emphasizes that inherently to the visualization of a map are the biases of its creator. In this way, a map tells only one way of a story and could 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 visualization.

Another reason why details are left out of the geospatial data visualization concerns the issue of privacy. Especially when using GIS, a balance must be found between the protection of the personal privacy of those being mapped and the access to that data (Crampton, 2001). An example can be found in two case studies where unmanned aerial vehicles (UAVs) were used to gather geographical data for purposes of urban upgrading in deprived areas in East Africa (Oluoch et al., 2022). In those case studies, different perceptions of privacy were found in the local context, especially since it concerns mapping sensitive geographical data, i.e., data of "slums"

[4]. The issue here is that the goal of gathering this data is to be able to accurately display and visualize the deprived urban areas to improve the lives of the members of the communities. Yet, when adding too many details of the location and specific geographics of the area, you may violate the privacy of the inhabitants. 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 normally are a snapshot of reality, yet Ingold argues that a map should be more focused on capturing the dynamics of life. If nowadays details are left out of the map for specific reasons, while potentially being relevant to the usefulness of the map, a question arises of how many details should be included in the visualization.

From dual-coding theory, it is proposed 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 compared to 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 evoking reactions from the human mind. (Krcmar and Haberkorn, 2020). In the light of geospatial data visualizations and governmental policy- and decision-making, mental representations are highly beneficial to the process. To understand the geospatial data visualizations' meaning and act upon it, mental representations must be constructed in the mind of the decision-maker. Additionally, by looking at visual communication research, it has been stated that images have a certain number of advantages compared to text (Dewan, 2015). These are 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 differently processed compared to images when looking at the geospatial data visualizations of GIS data.

It is common practice in GIS to use map layers for organizing 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 in GIS. 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.). 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 among 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 thus also highly relevant for the visualization process of GIS data for governmental policy- and decision-making. Therefore, it is beneficial to gather information on how overlay mapping is perceived by stakeholders.

As mentioned earlier, the role of the map has shifted since more local ground-level people are contributing to the deprived urban area mapping process. Advances in digital mapping have made it possible for researchers, non-governmental organizations, and geographic information producers to contribute to enhancing the legibility of deprived urban areas. It represents a different kind of cartographic gaze than one that is *"predicated on mastery of the earth, nature, and subjects"* as Pickles puts it (2004, p. 83). In this way, geoinformation is crucial to making these cities more legible since the use of these technologies is predicated on mastery of spatial data (Oluoch et al., 2022, p. 7). This comes forward from the bigger availability of tools to produce maps, which can be used by a greater variety of actors to make their own spatial claims (Oluoch et al., 2022). Despite the inclusion of more different actors in the mapping process, the government is still a key player in this process. This is because the claims made by the local mappers are oftentimes completely against the territorial claims made by the state or are only provided sanction by the states' approval (Oluoch et al., 2022). Here, it becomes apparent that a certain level of power emerges to the one who has control over the geospatial data and then the question emerges – *"what responsibility do those who control the spatial data have over those who are represented in the data?"* (Oluoch et al., 2022, p. 7). This thesis will use this question to gather insights from different actors on how responsibility is connected to the use of geospatial visualization and especially, how map users can be prompted to more responsible actions. Both an academic audience as well as the ground-level inhabitants will be asked about their opinion on responsibility in the mapping process, due to those advances in digital mapping.

[4] In this thesis, the term deprived area is used instead of slum due to its sensitivity to the community. This choice has been made since this is the term used in the case studies that are discussed. The communities that participated in these case studies agreed upon this term.

3. METHODOLOGY OF STUDY 1

In this chapter, the method applied for the first part of this research will be discussed. The methodology for this research is based on a user-centered design approach (Gould and Lewis, 1985), which is focused on three principles: early focus on users and tasks; empirical measurement, and iterative design. This will be done by gathering the opinions of various stakeholders early on during focus group sessions, going back to the design by reevaluating specific choices, and making changes accordingly. Firstly, the research design will be elaborated on in Section 3.1. as well as the required materials in Section 3.2. This will be followed by an explanation of the procedure in Section 3.3., the participants used in Section 3.4, and how the data has been processed and analyzed in Section 3.5.

3.1. RESEARCH DESIGN

For this exploratory research, focus groups have been performed to gather information and opinions towards visualizations of geographic information for governmental policy- and decision-making for deprived urban areas. This came forward from the PhD Project FRAME-PRO and the Nairobi waste management study (Georganos et al., 2021). This concerned a study performed by Monika Kuffer and her fellow researchers at ITC on how to map waste concentrations in deprived urban areas in Nairobi. The goal was to convince local authority to act and clean up the waste. The problem they encountered was that authorities often rely on outdated data and rough estimates due to the difficulty in accessing the location of the areas and the rapidly changing environment of the cities. Therefore, the researchers have worked together with local communities to increase the accuracy of the data, i.e., the Community Mappers. The data gathered by the Community Mappers served as input for the study of Monika Kuffer and her fellow researchers as ITC as well as for the visualizations of geographic information used in this study. These visualizations of geographic information were made by Isaac Oluoch, the PhD candidate of Project FRAME-PRO, who created those designs with the program ArcGIS. For both studies, the focus was on multiple regions in Nairobi to have a broad overview of the general population and because 60 per cent of inhabitants of Nairobi are living in deprived urban areas.

To gather information for this thesis, participant background knowledge of deprived urban area mapping was discussed, different visualization designs of deprived urban areas were explored, the notion of responsibility was addressed, and a case study was performed to tie everything together. The choice has been made to perform focus groups since more data could be gathered in the same period, compared to interviews (Morgan et al., 1998). Also, the insights that come from the discussion in the focus group provide a more in-depth understanding. In total, four focus groups have been held 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 people within the UT with an affinity to geo-information technology and/or decision-making processes and/or visualization techniques. During the sessions, four topics were discussed which were based on the found gap in the literature and on the work and necessities of the PhD candidate Isaac Oluoch. These topics were: knowledge about using geospatial data for deprived urban mapping; Nairobi waste management mapping and visualization techniques; responsible mapping, and case study for responsible mapping.

The idea behind the first topic was to gather insights on the ground knowledge of the participants on 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 geographic visualizations of the Nairobi waste management study individually and rank them afterward. This served to gather opinions on the visualization designs. The third topic served as a bridge from topic two to topic three, by connecting the notion of responsibility with the use of specific design attributes. Finally, the fourth topic ties everything together by applying all information gathered during the group discussions on a different case than the Nairobi waste management study.

3.2. MATERIALS

To have fruitful focus group sessions the following materials were necessary. Firstly, a big conference room with a whiteboard was needed for presenting the presentation and gathering all the participants. This was arranged by using the Situation Room of BMS in Raveleijn at the UT. Secondly, all participants needed to have a tablet to explore the different visualizations made by the PhD candidate involved in this project. Thirdly, basic items were necessary such as papers and pens if the participant felt the urge to write down notes for themselves. Also, a piece of paper where the participants needed to fill in their demographic factors and the ranking needed to be present.

Fourthly, it was beneficial for the goal of topic one to have post-its present during the workshops, so the participant could write down elements that first came to their mind. Fifthly, coffee and tea needed to be available during the entire session so the participants would feel comfortable and taken care of. Lastly, a recording device was necessary to generate an audio file that could be later used for the transcribing phase.

3.3. PROCEDURE

3.3.1. Introduction to Visualization Design

It is necessary to understand the basic environment of cartographic visualization to avoid unnecessary mistakes in the visualization designs of this research. The way visualization tools in cartography have been, are, or could be used to visualize geospatial data is researched thoroughly. One of the first books to address how maps can be used for visualization is by MacEachren, claiming that due to the then-current geo-visualization technologies, ways have emerged to facilitate information transfer into linked research communities with highly interactive tools built on strong semantic foundations (1995). A paper from Slocum et al. builds upon this claim and argues that to develop effective methods for geo-visualization theory-driven cognitive research and evaluation of methods via usability engineering principles must be used (Slocum et al., 2001, p.2). The former indicates studies on the understanding of the human creation of mental representations of the geographic environment. The latter indicates that software must be iteratively analyzed by its ease of use as well as its responsivity to user tasks, whereas in cartography the terms user studies and user testing are used (Slocum et al., 2001). Examples of such visualization methods are proposed by Skupin and Fabrikant, for geographic as well as non-geographic information (Skupin and Fabrikant, 2003).

Moreover, different appliances of visualization tools and methods for geographic information are discussed by MacEachren et al., focusing on the visualization of information uncertainty in cartography (MacEachren et al., 2005). They specifically elaborate on challenges in visualizing information uncertainty in decision-making processes. Others have investigated the effect of animated geo-visualizations compared to static geo-visualizations (Harrower et al., 2008). They propose that to use animated maps effectively, their representational tasks and how different designs of animated maps can impact communication and learning abilities must be understood more in-depth. Additionally, in the broader context, they claim that human cognitive processes in knowledge extraction of highly interactive geo visualizations must be better understood to increase efficiency in decision-making processes regarding societal needs.

Also, empirical research has been performed on design principles, i.e., visual variables of color value, color hue, orientation, and size, of 2D geospatial data visualizations (Garlandini and Fabrikant, 2009). They found that the most efficient and accurate visual variable is size, and the least is orientation. More recent research by Lata et al. has investigated tools like real-time visualization for effective decision-making and found that by implementing such tools, in this case, a Web-GIS-based dashboard, quicker interpretation can be enabled for policy- and decision-making (Lata et al., 2022). Other recent research has investigated why maps can be meaningfully used (Mocnik, 2022). They have researched the complexity of map creation by identifying factors for readability, misunderstandings, and non-interpretability. By taking these factors into consideration, it becomes possible to behave more reflectively and actively in the mapping process.

3.3.2. Protocol Summary

To perform these focus group sessions, a protocol was formulated (see appendix B). In this protocol, the complete structure and topics of the focus group sessions are elaborated on in detail. These topics can be summarized as follows. The first topic concerned the introduction of the moderator and assistant, the participants, the project, and an outline of the presentation. Also, relevant key definitions were elaborated on to get all participants on the same level of knowledge. This was followed by the first topic of discussion, which concerned knowledge on using geo-data for deprived urban area mapping. Within this first topic, the participants were asked to write down their first ideas about this topic on post-its. This was performed to break the ice and get familiar with the general subject of the focus group session. Afterward a discussion was held on the results of the post-it exercise. Together the introduction and the first topic had a duration of 30 minutes, hence, after the post-it discussion a break of ten minutes was provided.

When all participants came back from the break, an introduction was held for the second topic. This concerned the Nairobi waste management study and visualization techniques. Here, the participants received a more in-depth explanation of the case study of the PhD project and on the visualizations made by Isaac Oluoch, the PhD candidate of this project. These visualizations were designed via ArcGIS, where the GIS data from the Nairobi waste management study was used as input. They also received instructions to navigate the visualization designs on the tablets provided. When all instructions were clear for the participants, they received 20 minutes to explore the seven visualization designs Isaac Oluoch has made and write down their opinions towards the designs.

They were also asked to rank all seven visualization designs from one to seven based on three variables, which were the usability, readability, and accuracy of displaying a problem at stake. In this case, the problem of waste in Nairobi. After the participants had finalized the ranking exercise and written down their opinions towards the designs, an elaborate discussion was held on the specific visualization and design attributes that were valued positively and negatively.

This was followed by topic three, which was a precursor and somewhat of a bridge from topic two to topic four. This topic concerned the idea of responsible mapping and what this term entails. The third topic served to head into the topic of the case study. Here the maps from Isaac Oluoch, which were explored in the previous topic, were used as an example to introduce the topic of responsibility when mapping deprived urban areas. Here, the participants were asked 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 deprived urban area mapping. To give the participants time to think about this notion of responsibility and reflect on the visualization designs, a break of ten minutes was provided. During the break, printouts of all the visualization designs and the exercise of the final topic were laid on the table for the participants to look at.

After the break, the final topic of the focus group session was introduced which was a case study exercise. For this final exercise, the participants were asked to read a specific case about the flooding problem in Jakarta and how a visualization should be designed to prompt action toward the issue. They were asked to use the discussion on the visualization designs as input for this exercise. In this way, they were asked to discuss with one another which attributes of which design would work best for this issue. The choice was made to do a case study exercise to see if the participants had similar opinions about the visualization designs in a different setting of deprived urban area mapping compared to the waste issue in Nairobi. When the discussion of the case exercise came to an end, the focus group session was concluded, and all participants were thanked for their effort and time.

3.4. PARTICIPANTS

The focus groups were performed in English since the communication between the researchers and supervisors has been in English and due to the broad variety of nationalities of the participants. The sample size was 22 participants with two focus groups of five participants and two focus groups of six participants. The reason why this number is different between the groups is due to last-minute participant cancellations due to sickness and a no-show. The participants were gathered 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 was part of the University of Twente and had an affinity with geospatial data, visualization techniques, and/or policy- and decision-making. During the focus group sessions, several demographic factors were gathered. These were age, profession, and 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. These are geospatial data specialists (10 participants), visualization 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 in incorrectly, so those rankings could not be used. Thus, the sample for the ranking consisted of 20 participants instead of 22.

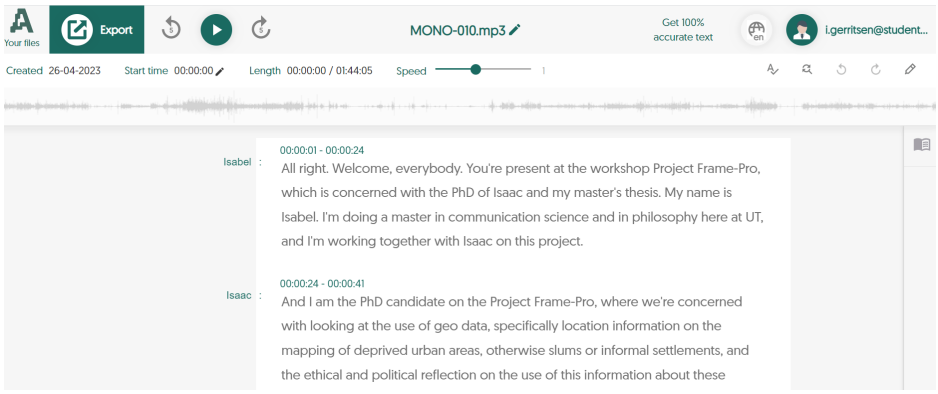
3.5. DATA PROCESSING AND ANALYSIS

To process the data, the program AmberScript has been used to transcribe the audio files of all focus groups. At first, the AI transcription tool was used and secondly, all the audio files were relistened to and altered only when it was necessary for the readability of the sentence. AmberScript transcribed the audio file sometimes a bit too literal, e.g., having sentences that did not make any sense due to the addition of a lot of words like "um", "let's say", "yeah". Thus, the decision was made to leave such words out when there was no additional value of them being present in the transcript, i.e., applying intelligent transcription. Especially, when it made the sentence difficult to read and comprehend. If such words had a clear purpose, they were not deleted from the transcript and verbatim transcribing was applied. For example, when the participant had trouble formulating the sentence or grasping the subject that was talked about, the words were left in the transcript. In this way, you can clearly see when topics are understood or rather difficult for participants to contribute to. After the transcripts were finalized, the names of the participants were changed to "Participant (number)", to ensure that their data is anonymized.

Consequently, the round of introduction that was performed at the beginning of each workshop was deleted from the transcript, since the participant could be traced back via this information. This was because they introduced themselves with their name, occupation, and faculty within the University of Twente. Both names of the researchers of this project, Isabel and Isaac, were not anonymized in the document. There is no need for the researchers to be anonymized since it is known that both are working on this project, and they provide no information that validates them in any sense in the transcripts.

Figure 1

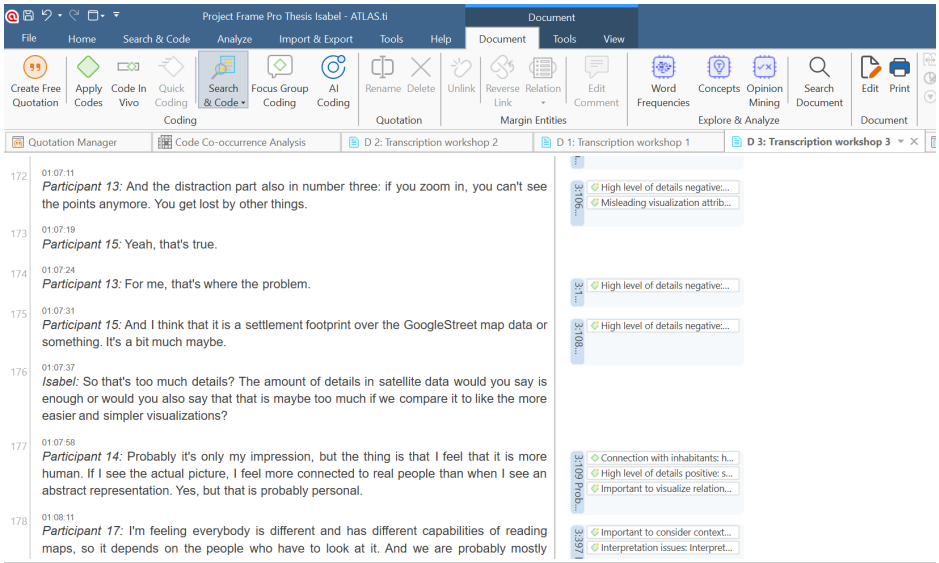
Example of transcribing process in AmberScript



When the transcripts were made final, the program ATLAS.ti was used for the coding process. For each transcript, open coding was performed. This indicates that each document was thoroughly gone through, and individual codes were assigned to specific passages and sentences of the transcript, specifically focused on the answers provided by the participants and not on the information presented by the moderator and moderator assistant. When performing this for transcript one, 201 unique codes were created through open coding. For transcript two this was 188 codes, for transcript three this was 218 codes and for transcript four this concerned 150 codes. After this first round of open coding, the AI coding function of ATLAS.ti was used to compare the already formulated codes with the codes from the algorithm, which concerned 1041 AI codes in total. To gather insight into which codes may be relevant, the most often assigned codes were identified. This was done for all the transcripts. However, in the end, it was found that the AI codes were not specific enough and did not contribute to the results of the coding. Thus, the decision was made to delete the AI codes from the codebook.

Figure 2

Example of coding process in ATLAS.ti



The second step that has been performed was axial coding, where codes have been compared with one another and merged if necessary. Open coding and axial coding were performed simultaneously to identify patterns in the data. This has been done by going over transcripts one and two again after transcripts three and four were coded, since now more familiar with coding. Afterward, quotations were looked at and altered when necessary. The structure of the coding was threefold having a code group, a code, and specific code segments. In total 11 code groups and 51 codes were generated for the final codebook, which can be found in Appendix B. Related codes were put together in categories related to the research questions of this study, which can be found in Table 1.

To measure the reliability of the assigned codes, a reliability analysis using Cohen's Kappa has been performed as well as a percentual calculation. The outcome of the reliability analysis gave a Cohen's Kappa of 0.740 (see Appendix C) with a 95% confidence interval of 0.66 and 0.82. This can be interpreted as a substantial agreement (Landis and Koch, 1977). Additionally, the analysis shows that 27 out of 113 codes are rated differently, resulting in a percentual calculation of the reliability of 76.12%.

The third step in the coding process was selective coding, to find out if links can be found between the categories. This has been done by filtering in ATLAS.ti and performing a co-occurrence analysis to see which codes are often mentioned together during the focus groups. The choice was made initially to perform this analysis on the most often grounded codes, i.e., 20 times mentioned or higher, to find bigger patterns in the data (see Table 1.). However, within this analysis, the code "Clarification" was left out since this code was not concerned with the content of the focus group but with the flow of the workshop. Also, co-occurrence analyses have been performed per category, to see any smaller patterns in the data.

Besides the transcripts of the workshops, the participants were asked to fill in a ranking for the visualizations during the workshop. They were asked to rank the visualizations from one to seven, where seven is the highest score. This data was processed by creating a crosstabulation in Excel. Moreover, a crosstabulation was made with the rankings and one of the gathered demographic factors, i.e., profession. This was done to see if there were additional differences between the participant categories.

Table 1
Categories for the code group

	Category	Code groups	Research question
Category one	Knowledge on using geospatial data for deprived urban area mapping	Deprived urban area Deprived urban area mapping Deprived urban area mapping issues Geospatial data	What do various stakeholders currently know about using geospatial data for deprived urban area mapping?
Category two	Visualization techniques and attributes	Visualization issues Visualization remarks Visualization strengths	How does the level of detail in a geospatial data visualization stimulate engagement with the topic? How does adding a picture in a geospatial data visualization stimulate engagement with the topic? How does overlay mapping in a geospatial data visualization stimulate engagement with the topic?
Category three	Responsible mapping	Purpose of the map Responsibility	What different opinions do various stakeholders have on how a map can help to influence the responsibility of policymakers and their decision-making process in deprived urban areas?

Table 2
Most often grounded codes

Code	Grounded	Code Groups
Clarification	46	Flow of the workshop
Important to consider context with mapping	42	Responsibility
Inclusion of specific relationships	40	Visualization remarks
Misleading visualization attributes	40	Visualization issues
Problem awareness	36	Purpose of the map
Important to use overlay mapping	34	Visualization remarks
Important to visualize relationships	34	Visualization remarks
Responsibility in map actors	32	Responsibility
Ethical concerns	31	Deprived urban area mapping issues
Symbology use positive	28	Visualization strengths
Deprivation in deprived urban areas	27	Deprived urban area
High level of details positive	26	Visualization strengths
Symbology use negative	23	Visualization issues
Consequences of mapping	22	Deprived urban area mapping
Design remarks	22	Visualization remarks
Interpretation issues	22	Visualization issues
Symbology use remarks	21	Visualization remarks
Deprived urban area characteristics	20	Deprived urban area
High level of details negative	20	Visualization issues

4. METHODOLOGY OF STUDY 2

In this chapter, the method applied for the second part of this research will be discussed. The methodology for this research is also based on a user-centered design approach (Gould and Lewis, 1985), which is focused on three principles: early focus on users and tasks; empirical measurement, and iterative design. This will be done by gathering the opinions of the Community Mappers who gathered the data that served as input for the visualization designs, providing the results of the earlier performed focus group sessions, going back to the design by reevaluating specific choices, and making changes accordingly. Firstly, the research design will be elaborated on in Section 4.1. as well as the required materials in Section 4.2. This will be followed by an explanation of the procedure in Section 4.3., the participants used in Section 4.4, and how the data has been processed and analyzed in Section 4.5.

4.1. RESEARCH DESIGN

Besides performing four focus groups, as explained earlier, a workshop has been executed with the Community Mappers group, i.e., the African affiliates that gathered the geospatial data that served as input for the visualization designs. The purpose of this workshop was to provide the Community Mappers with the results of the four focus groups to show what we did with their data. Additionally, this workshop also served to gather their feedback on some of the visualization designs. In this way, both a top-down as well as a bottom-up perspective is gathered on the visualization designs. This workshop had a duration of one and a half hours and was performed online. Concerning the target group, ten people from the Community Mappers group were asked to participate. Preferably, people who have gathered the data for this project. The set-up of the workshop consisted of four topics: (1) Introduction; (2) Methodology explanation; (3) Feedback exercise, and (4) Results of the focus groups. According to one of the supervisors of the project, Monika Kuffer, an elaborate introduction was necessary to make the participants feel at ease and get familiar with the researchers. After this introduction, the methodology of the focus group was thoroughly explained to show exactly what was done with their data. Continuing, a feedback exercise will be executed. This exercise will be done via Google Jamboard, which is an online sticky note application but can also be used offline. This decision was made due to the possible unstable internet connection. With this exercise, the participants are asked to add green or red sticky notes to four visualization designs. The green sticky notes concern positive aspects of the visualization design, and the red sticky notes the negative aspects. In this way, a large amount of feedback can be gathered in a short time frame. Finally, the results that came forward from the focus group sessions will be discussed and the participants get the opportunity to ask questions.

4.2. MATERIALS

Since the feedback workshop with the Community Mappers takes place online, different materials were necessary. For the researcher's side, a meeting room at the ITC building, a laptop, and a microphone were needed. For the participants' side, a smartphone per participant was needed. The presentation was shown by sharing the screen during the videocall and on the smartphone, the feedback exercise was performed. Here, the Google Jamboard website must be able to be used. The workshop was recorded via the video call application and stored on the laptop of the researcher. Most importantly, the outputs of the feedback exercise were saved and will be discussed in the results Section.

4.3. PROCEDURE

To perform this workshop, a protocol was formulated (see Appendix C). In this protocol, the complete structure and topics of the workshop are elaborated on in detail. These topics can be summarized as follows. The workshop session began with an extensive introduction that familiarized 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. This approach was guided by the cultural significance of mutual understanding, particularly in African settings. Subsequently, participants' agreement was sought regarding the recording of the workshop and the utilization of its outcomes. An overview of the workshop's agenda was provided, encompassing discussions on data usage, workshop findings, and an exercise on gathering opinions regarding visualizations through Google Jamboard. Notably, there was a strong emphasis on appreciating participants' perspectives beyond the academic realm. After the introduction, the first topic was centered on clarifying the usage of data. The specific

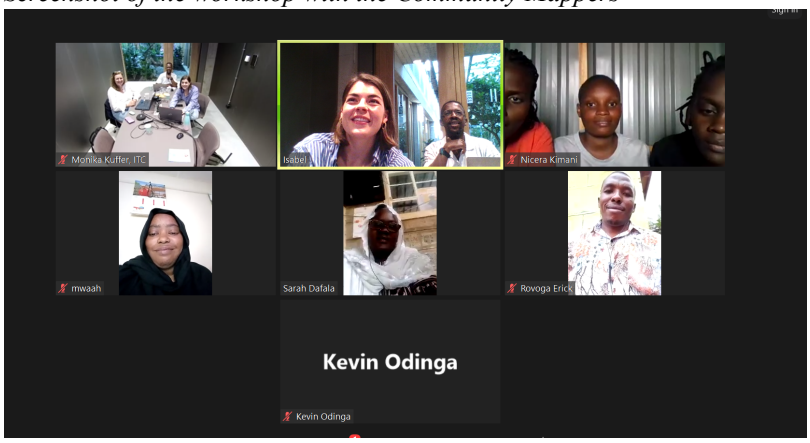
role of the Excel data file in generating seven geospatial visualizations was thoroughly explained. These visualizations varied in their degree of detail, which influenced both their background application and design attributes. Subsequently, these visualizations were subjected to testing in specialized workshops, which involved experts in geospatial data, visualization techniques, and philosophy. The primary objective of these workshops was to identify effective visualizations capable of raising awareness about waste issues among decision-makers in deprived urban areas and guiding the creation of maps that prompt responsible actions. This was followed by a feedback session, facilitated through Google Jamboard. Participants accessed diverse visualizations via mobile links and provided constructive feedback using digital sticky notes, noting both positive and negative aspects. This exercise, encompassing both OpenStreetMap and satellite-based visualizations, aimed to capture individual preferences. Subsequent open discussions were encouraged, contributing visual content for the results Section. At last, the researchers delved into the results of the research, i.e., the findings from the focus group discussions were presented, encompassing the rankings and qualitative outcomes. The workshop reached its conclusion with participants contributing advice, suggestions, or insights for the project. Gratitude was extended for their active participation, investment of time, and valuable input. Furthermore, acknowledgment was given to Nicera, the organizer, for their pivotal role in orchestrating and coordinating the meeting.

4.4. PARTICIPANTS

The participants of the fifth workshop consisted of ten members of the Community Mappers who took part in the data-gathering process of the geospatial data in the Nairobi waste management study. As explained in Section 3.1 this concerned a study by Monika Kuffer and associates on how to map waste concentrations in deprived urban areas in Nairobi. The goal was to convince local authority to act and clean up the waste. For this fifth workshop, a small number of affiliates from the Community Members participated. Some of the participants were part of the mapping process in Majengo, others in Kibera or Mathare. No other demographic factors were gathered from the participants. Due to the ongoing strikes in Nairobi, all participants participated online via their own phones.

Figure 4

Screenshot of the workshop with the Community Mappers[5]



4.5. DATA PROCESSING AND ANALYSIS

The decision has been made to handle the data that came from the Community Mappers workshop differently compared to the other four workshops because all relevant information on their opinions was already present on the Google Jamboard images. However, a transcript was made to be certain that everything that was discussed during the session was present on the Google Jamboard images, which was the case. Moreover, the connection was oftentimes a bit unstable, which made it somewhat difficult to comprehend what had been said. Therefore, these images serve as the main result of the workshop with the Community Mappers (see Appendix D).

[5] All participants agree with showing their faces in this screenshot for the purpose of this research.

5. RESULTS

This fifth chapter presents the findings and results of this research[6] and is divided into five Sections that correspond with the earlier mentioned categories, the topics from the focus group, and the Community Mappers workshop. As was seen from Table 1, the categories relate to the sub-questions of this research, and these will be answered in the upcoming Chapter. In every Section discussed in this chapter, all qualitative data from the four focus groups and the Google Jamboard outputs are used as the main input for the findings. The first three Sections are structured similarly and will all discuss the most often grounded codes, and the co-occurrences present in the category. Most often grounded codes are the codes that are assigned most often, and co-occurrences are combinations of codes that are assigned oftentimes together. Additionally, the results that came forward from the post-its exercise will be discussed in the first Section and the results that came forward from the ranking exercise will be discussed in the second Section. These results can all be found in an overview at the beginning of each Section and will be elaborated on throughout the text. Also, the results between all codes were analyzed, which was meant to find out if there are additional relationships between the categories. These results are integrated into the first three Sections. Quotations from the focus groups will be used to illustrate the findings. Fourth, the results of the feedback exercise on Google Jamboard will be discussed to find out the opinions of the Community Mappers that gathered the data. Finally, a short summarizing conclusion will be provided that will serve as input for the philosophical analysis and discussion of this research.

5.1. KNOWLEDGE ON USING GEOSPATIAL DATA FOR DEPRIVED URBAN AREA MAPPING

During the focus groups, the first topic that was discussed concerned the participants' prior knowledge of the use of geospatial data, specifically for deprived urban area mapping. This served to find out their level of expertise and to get all participants familiar with the concepts of the focus group. This was gathered by doing a post-it exercise and discussing the answers afterward (see Appendix E for an overview of all post-its). Generally, it was found that the base knowledge of the participants varied somewhat per focus group session. All participants knew about using geospatial data for different purposes and after explaining the key concepts and discussing the encountered experiences of the more "expert"[7] participants, all participants had the knowledge that was necessary for the rest of the focus group session. It did become apparent that the level of expertise differed per participant and per focus group, however, this helped to spike interesting discussions. Further on during the focus group sessions, a high level of expertise on the topic did not always help with the visualizations since the participants knew more than was expected and sometimes made discussions more difficult than necessary. Unfortunately, due to some time constraints, the post-its were not elaborately discussed in the first focus group session. Thus, no quotations related to the post-its are available for that session. Yet, this was discussed during all other focus group sessions.

The code groups that were assigned in the first category are "Deprived urban area", "Deprived urban area issues", "Deprived urban area mapping", and "Geospatial data". The codes that are present in these code groups can be found in Appendix B where the total codebook is displayed. To find out which topics the participants talked about the most, it has been looked at how many times specific codes were assigned to pieces of text. The most often grounded codes, i.e., codes that were assigned 20 times or more, as well as their co-occurrences, i.e., co-occurrences of four or higher, and related post-its can be found in Table 3.

[6] The actual data used for these results can be found in a separate document where the transcripts have been drawn up.

[7] The word "experts" relate to the focus group participants that had more experience with using geospatial data specifically for deprived urban area mapping. They shared their experiences in the beginning of the focus group, which helped other less "expert" participants understand the topics better.

"To what extent does the data capture the lived reality on the ground? So, you know, like the different degrees of deprivation, but also by whom will the data be used and for what purpose will it be used? For example, will it be used to evict communities?" (Workshop 2)

Table 3
Overview most often grounded codes of category two, co-occurrences, and related post-its

Name	Description	Example quotation	Co-occurrence	Related post-it
Deprivation in deprived urban areas	This code is used when the piece of text is concerned with specific aspects of deprivation that can be found in deprived urban areas.	"How do we actually define what deprivation is?" (workshop 2)	With the codes "Deprived urban area characteristics" and "Goal of deprived urban area mapping"	Level of deprivation
Deprived urban area characteristics	This code relates more to the general attributes of deprived urban areas.	"The first thing that came to mind is poor people, poverty and municipality maybe wants to do something. I don't know. Poor sanitation, poor schooling options." (workshop 3)	With the code "Deprivation in deprived urban areas"	Availability of facilities and attributes
Consequences of mapping	This code relates to all fragments in the transcriptions that are concerned with the consequences of everything that is related to making a map and using geospatial data.	"So, when I think about this responsible mapping it means that the ownness of the map maker is to think about things like possible and likely consequences of publishing such a map". (workshop 4)	With the code "Ethical concerns"	Purpose and user of the map Spatial information
Ethical concerns	This code is used when ethical issues related to deprived urban area mapping are mentioned.	"So, I also thought about the question of consent. Do people know that they are being mapped? Do they agree that it should be happening?" (workshop 2)	With the code "Consequences of mapping"	Privacy Accuracy

What became apparent from looking at the post-its, most often grounded codes, and co-occurrence analyses of category one is that the participants were mostly concerned with what a deprived urban area is, how the mapping process takes place, what results from mapping deprived urban areas and how mapmakers should be ethically concerned with making the map. Thus, they first discussed what deprivation entails and what that does to the mapping process before going into the consequences of mapping.

Firstly, the level of deprivation was often mentioned at the beginning of the focus group session, especially when deciding what is entailed by the notion of a deprived urban area. In some focus group sessions, this aspect also reoccurred throughout the entire session. According to the participants, the degree of deprivation differs quite a lot when looking at deprived urban areas, which makes it difficult to accurately visualize the area. The participants emphasized thinking about this idea of deprivation since they found that it is rather difficult to call something deprived and indicate what it means to be deprived. Therefore, the participants indicated that deprivation needs to be defined clearly when performing spatial analysis. Mainly, the participants discussed aspects that make an area be seen as deprived but that it is oftentimes the case that a map of such a deprived area

is more generalized. Moreover, they discussed that there is a diversity in the degree of deprivation in such areas and that a generalized map is not able to capture reality accurately.

This can also be found when the participants discussed general characteristics of a deprived urban area, that relate to how something can be indicated as being deprived. One could say that these characteristics may also contribute to framing the area as deprived. In this way, the term deprivation is identified as a characteristic of a deprived urban area when looking at it from a top-down perspective. However, if you would ask the inhabitants about the characteristics of the deprived urban area they live in, they would not necessarily experience it as deprived. Importantly, what must be taken into consideration is that there is quite a negative connotation to the word deprivation. Furthermore, the participants discussed more general aspects that relate to the location, facilities, problems, people, and activities that are present in deprived urban areas. Poverty and the fact that a deprived urban area is a home for its inhabitants were mostly mentioned by the participants as important characteristics. Other examples here are the presence of crime, drugs, low-level income, and social housing. Additionally, they related the characteristics to the level of deprivation, and it was found that a deprived urban area often struggles with a lack of available facilities. This can for instance make issues such as the waste problem more difficult to solve. In conclusion, it can be found that the goal of making a "good" map is to understand the diversity and degree of deprivation in an area. This means that the mapmaker should understand the spatial variation present and not simply generalize the map, as mentioned before.

Additionally, they emphasized that geospatial data is a necessary component to get insight into that spatial variation and spatial patterns. Especially, when using geospatial data for deprived urban area mapping, it is important to understand the spatial and temporal dynamics of the area to adequately visualize them. In this way, mapping can move away from the dichotomy of classifying something only as deprived or not deprived, i.e., generalizing the map. And minimize possible negative consequences that can result from the map. Especially, since most comments that were made about the consequences of mapping were mostly on the negative side. The participants focused on the afterlife of the data and the effect of the data when looking at it from a governmental perspective. They connected this with notions of accessibility, both for governments as well as inhabitants, and with actions governments could take when mapping is performed. Positive examples of the latter are sending a garbage truck to pick up the garbage or giving out money to inhabitants in need, while negative examples are evicting people or other people making nefarious use of the data when the government puts it out there. The important note here is that before a map is made, the mapmaker should think through all possible consequences of the map to do it responsibly. They illustrated this for example by emphasizing that the how, why, and who are important to know before making a map of a deprived urban area to minimize possible negative consequences. This reoccurring aspect of purpose and user of the map was also mentioned more throughout all entire sessions.

If the mapmaker does not take the purpose and user of the map into consideration beforehand, several ethical concerns were mentioned that could result from the mapping process. They discussed concepts such as privacy, biased maps, a person's code of ethics, accuracy, communication, consent, and the awareness of being mapped. Moreover, they discussed how mapmakers should be concerned about the consequences of mapping from an ethical perspective and connected the notion of accessibility and how the data is used as the main consequences of the mapping process. Most importantly, during the focus group sessions, it became apparent that ethics is inherently connected with the mapping process. For example, when making a map and in the effect of the map. Specifically, the notion of privacy and accuracy was important to the participants. Firstly, the participants were slightly undecided on the notion of accuracy when talking about geospatial data and deprived urban area mapping. On the one hand, they found that accuracy is a relevant topic for deprived urban area mapping, while on the other hand, it could also be a possible concern when visualizing the data. In this way, they questioned how accurate maps need to be to serve their purpose and how geospatial data could capture what is happening in the deprived urban area. Secondly, they related privacy often with the previous aspect of accuracy, with the notion of accessibility, and with the purpose of the map. Specifically, how all three have an impact on the privacy of the people being mapped. They indicated for instance that who has access to the map and what is displayed on the map relates to how the map will be used, both negatively and positively. For the negative impacts, infringing on the inhabitants' privacy was one of the main concerns according to the participants. Overall, they stated that ethics is a major aspect of all stages of the mapping process, i.e., beforehand, during, and afterward.

5.2. VISUALIZATION TECHNIQUES AND ATTRIBUTES

After the ground knowledge on the topic was assessed during the workshop, the participants were asked to interact with seven visualization designs. As mentioned earlier, the goal here was to find out which attributes of the maps were most readable, usable, and accurate in identifying that there is a problem at stake. The purpose of the maps was to create problem awareness to governmental policy- and decision-makers to act on the waste issue. Overall, it was found that the opinions of the participants on all the visualizations differed a lot. Thus, no overall conclusion can be made on which visualization works best. Yet, the attributes on the map were thoroughly assessed. In the second category the code groups "Visualization issues", "Visualization remarks", and "Visualization strengths" can be found. The codes that are present in these code groups can be found in Appendix B where the total codebook is displayed. As explained in Section 5.1, the most often grounded codes will be examined to find out which topics the participants talked about the most. An overview can be found in Table 4.

"I think you can use maps to tell these different stories. They reframe the problem in different ways, right? Based on the attributes that you're choosing to represent and the relationships that you're choosing to represent." (Workshop 1)

Table 4
Overview most often grounded codes of category two and their co-occurrences

Name	Description	Example quotation	Co-occurrence
High level of details negative	This code relates to all pieces of text where one of the participants showed a negative opinion towards a high level of details found in the visualizations.	"I think the maps with satellite data, the last three I think, I found them the least usable and readable, because there's information overload, especially like all the tiny details are there. And in terms of, let's say the location and the road names, maybe it's useful, but still, I found it a bit too much of information." (workshop 2)	No co-occurrence with any of the codes
Interpretation issues	This code was assigned when difficulties in the interpretation of the visualization or map design are mentioned.	"And what do they mean differs maybe for me and for you and how do the designers of the maps actually design it in thinking what and how the information is conveyed to the user?" (workshop 2)	With the code "Misleading visualization attributes"
Misleading visualization attributes	This code is assigned when attributes or specifics of the geospatial data visualizations mislead the user in any way.	"But when you look very carefully at it, then you are completely misled because some very strong colors seem to be just a little bit of trash when you are zooming in. So, it gives a false sense of accuracy. Uh, the idea is nice, but it does not account for the size of the problem. If you investigate the details." (workshop 1)	With the codes "Heatmap negative" and "Interpretation issues"
Symbology use negative	This code relates to all pieces of text that concern the use of specific symbols on the map in a negative way.	"I agree that map three with the crosses, the red crosses, that is confusing because I don't know what they are. They're not part of it. It's part of the base layer. But they're not part of the other dots. But they are red as well. When I first looked at it, I was wondering what they these were." (workshop 4)	With the code "Symbology use positive"

Important to use overlay mapping	This code is used when one of the participants mentioned anything related to the importance of using overlay mapping or the specifics of the layers of overlay mapping.	"I'm thinking if you have a have a tablet, you can just have different layers. You can toggle on and off." (workshop 3)	With the codes "Inclusion of specific relationships" and "Societal concerns"[8]
Important to visualize relationships	This code was given to all pieces of text that were related to the importance to visualize specific relationships on the map, besides only visualizing the data.	"I think I would prefer visualization three more than anything else that came into my best category because it gives the relationship like he mentioned, like there's churches, there's places wherever the trash is accumulating." (workshop 3)	With the codes "Inclusion of specific relationships", "High level of details positive" and "Design remarks"
Inclusion of specific relationships	This code relates to all specific relationships mentioned by the participants that would be beneficial to add to the visualization.	"I think something that I was missing, and I don't know if you have this data, but I was sort of wondering if there are sites of sort of waste disposal services that could be mapped here so that it's not just showing that there's the waste, but that it's showing that there's the waste because there's a lack of services." (workshop 1)	With the codes "Important to visualize relationships", "Important to use overlay mapping", and "Problem awareness"[9].
High level of details positive	This code relates to all pieces of text where one of the participants showed a positive opinion towards a high level of details found in the visualizations.	"And then the one, the fourth I think, was nice because it had a lot of additional data on it. It has a very information rich background." (workshop 3)	With the code "Important to visualize relationships"
Symbology use positive	This code relates to all pieces of text that concern the use of specific symbols on the map in a positive way.	"One for the same reason that 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 that dot on the map and you're like, okay sure trash is bad. But then you click on it and it really hits you with reality." (workshop 4)	With the code "Symbology use negative"
Symbology use remarks	This code is assigned when advice was given by the participant about adding specific symbology to the map.	"For example, you could bin the whole place with hexagons or squares, and you could color the hexagons for how bad the trash is in each hexagon." (workshop 4)	No co-occurrence with any of the codes

Concerning the results of category two, overlay mapping is necessary for mapping deprived urban areas since there are a lot of different relationships, factors, and attributes to be included in the map. Additionally, it was found that the participants valued the addition of a picture to the map since this really connects with what is happening on the ground. Also, it was found that adding too many details on the map led to an information overload, therefore, only necessary details for the purpose of the map should be present on the map, or different maps for different purposes should be made. However, when trying to fit everything in one map, again you will get that aspect of information overload. By using overlay mapping and being able to choose different layers in different

[8] It must be taken into consideration that the code "Societal concerns" is not part of the second category but is part of the first category.
[9] It must be taken into consideration that the code "Problem awareness" is not part of the second category but is part of the third category.

contexts, the result will be the most effective. The results highlight a division between showing problem awareness on the map and providing detailed information on the map.

During the focus group sessions, it became apparent that there is more than visualizing only the data about waste. The participants considered the broader picture of performing deprived urban area mapping and highlighted that the effect of the map on society is highly important. In this manner, they emphasized that overlay mapping is an easy tool to use and did not see concerns with how to create a map. Yet, in order to think about responsible actions toward the issue, the participants argued that we need to look further than the mapping problem. Moreover, they mentioned that it is helpful for practical reasons to know where the waste is located, but it is more helpful for governmental policy- and decision-makers to know why waste is located at certain places to solve the cause of the waste. In this way, there is more to the picture than mapping and especially this human connection with waste needs to be considered, according to the participants. The participants recommended adding more relationships to the map. By adding more relationships to the map, a higher level of detail can be found, and this correlation was valued positively by the participants, hence the usefulness of the map increases. The participants also found that more detailed relationships show more of the possible causes of waste accumulation and highlight the human connection to solve the problem. This is important for the end goal, which is to solve the waste issue, as briefly mentioned earlier. Additionally, it was found that several participants were positive toward a detailed base layer. Especially, since this gives some direction for the actions that need to be taken to solve the waste issue. This was both for the OpenStreetMap base layer as well as the satellite imagery. For the former, this concerned the additional value of landmarks, while for the latter, it was found that it makes the area more touchable. Overall, the participants had many remarks about all sorts of relationships or map layers that needed to be added to the visualization. The number one relationship to be included here is between waste and lack of services and highlights the importance of creating problem awareness among governmental policy- and decision-makers. Another relationship that was mentioned often was the inclusion of different forms of livelihood assets of the inhabitants, which also creates more problem awareness by showing the bigger picture of the problem. Furthermore, it was mentioned that connected structures and social dynamics must be included on the map to improve its purpose of problem awareness. Other examples of relationships to be included were economic scales, consequences of flooding, and other neighborhoods without waste problems.

However, it was found that mapmakers should make decisions on which relationships need to be presented on the map based on the audience and user of the map. According to the participants, the attributes, relationships, layers, and other design choices of the map should be assessed thoroughly before putting them on the map. In this way, the map will not be overloaded with information and can be tailored for its purpose and user. By doing this, the map can be made in a responsible manner. It became apparent that the most appropriate way of doing this was to accurately use overlay mapping. The participants discussed the process of layering thoroughly and how this can be useful for policy- and decision-making. Especially, since they stated that they were interested in the sort of overlaps that could be found in overlay maps. Specifically, the participants mentioned that switching between layers and having details on and of demand is most effective and that in this way the use of a specific layer depends on the type of decisions that need to be made. Overall, they felt that there is not one map that is able to cover everything in a deprived urban area, thus, overlay mapping is necessary. They made this claim more tangible by giving several examples of necessary overlay maps, which are economic scales, health consequences, flood levels, vulnerability maps, groundwater extractions point, or land subsidence. Overlay mapping is necessary when mapping deprived urban areas, due to the possible occurrence of negative consequences. Therefore, specific layers are necessary based on the context and purpose of the map.

Another reason why a map should be tailored to its user and purpose is due to the interpretation issues that can arise between different users of the map due to the different backgrounds of the user and the variety in the context of use. Specifically, the participants emphasized that interpretation issues often emerge with laypeople of mapping practices, which is often the case with governmental policy- and decision-makers. This can influence the usability and readability of the map and can decrease the actual effect of the map. Additionally, it can be found that due to the zooming issues of the maps, the participants had difficulty identifying where the actual problem is, which could in turn affect municipal policy- and decision-making. It can be found that it is more difficult to interpret a map when a visualization misleads in any way[10]. Consequently, this influences which decisions can and will be made based on the map. Specifically, the participants indicated that this occurs the most with using

[10] Different types of distortion and misleading attributes of the map were discussed during the focus groups. An example quotation is provided in Table 4 and another example is provided in Table D9 in Appendix D. Many other forms of distortion and misleading visualization attributes can be found in the transcripts of the focus groups, which are not part of this thesis document but in a separate document.

the zoom function since then the pattern of the map changes. This led to the participants being confused about how much waste was present at the indicated locations on the map, which resulted in them losing perspective of the actual size and accuracy of individual data points. Another concern that can be found is related to the heatmap design of visualization six. Here, the participants found that the visualization also misleads. Specifically, they indicated that this way of visualizing creates the idea that the entire area is "on fire" and generalizes the waste issue more than necessary. Additionally, the participants also connected the zooming issues with misleading with the heatmap design, since the heatmap design was not accurately visible anymore when zoomed in.

For the design of the map, there was no overall issue with a specific symbol on the maps, but the participants had several comments about using too many symbols on the map. The participants were mostly concerned that including too much detail on the map lead to an information overload and a decrease in the functionality of the map. This was on the one hand for the maps where satellite data was used and on the other hand for the maps that included the OpenStreetMap background with a lot of additional attributes on the map. Another example here is that different symbols on the map are too similar in color or size so that confuses the user of the map. In this manner, again an information overload is created which does not contribute to the purpose of the map of showing problem awareness. Moreover, the participants had some issues with the legend, since it was not coherent with what was visualized on the map. More positively, the participants found the inclusion of the picture in visualization one the most beneficial symbol that was used. This was due to the picture creating a connection with what is happening on the ground, which results in a higher level of showing that there is a problem at stake. Moreover, in all focus groups, the participants stated that a picture helps to tell stories with the map and is one of the key components to prompt governments to act. Moreover, it became apparent that participants like and dislike aspects of the same symbol. In this case, it was found that the use of pictures is important but needs to be made visible immediately for problem awareness. Currently, the pictures appear when the user clicks on an individual data point and scrolls to the bottom. To be an additional value, the picture must be more prevalent so that it connects with what is happening on the ground immediately.

Besides the qualitative data of the coding, results can be found for the ranking exercise performed during the focus groups. When looking at the average score per visualization, visualization one, four, and six have a slightly lower average score compared to the other visualization scores. However, the differences are minimal. This indicates that no conclusion can be made on which visualization works best for creating problem awareness to governmental policy- and decision-makers to act for the waste study. When connecting the ranking with the qualitative data from the focus groups, visualization one, four, and six are most thoroughly discussed during the sessions. Moreover, by looking at the results, it became prevalent that there are many different users and interpretations of the map, which correlate with the different opinions found in the ranking results.

5.3. RESPONSIBLE MAPPING

The final topic that was discussed during the focus group sessions concerned how maps can be made in a responsible manner to create problem awareness among policy- and decision-makers. This was done by an open discussion and a case study exercise. For the third category, the most often grounded codes, the results of the co-occurrence analyses, and the results of the ranking exercises are used as input. In the third category the code groups "Purpose of the map" and "Responsibility" can be found. The codes that are present in these code groups can be found in Appendix B where the total codebook is displayed. As explained in Section 5.1, the most often grounded codes will be looked at to find out which topics the participants talked about the most. An overview can be found in Table 5.

"I want to have a clear understanding of who the map maker is and who the audience is and what characteristics, biases, kinds of information, authority, relevance, etcetera each of these parties has to the map." (Workshop 4)

Table 5
Overview most often grounded codes of category three and their co-occurrences

Name	Description	Example quotation	Co-occurrence
Problem awareness	This code is assigned when the participants discuss how to make policy- and decision-makers aware of the problem with the visualization and how the visualization shows that there is a problem.	"The goal is to show this to policymakers and you want them to see there is a problem and they want them to act." (workshop 3)	With the codes "Important to consider context with mapping", "Responsibility in map actors" and "Inclusion of specific relationships"[11].
Important to consider context with mapping	This code is assigned when the participant explained that the context is important to take into consideration when talking about mapping and responsibility.	"So I agree, before you can make a map, you need to know better the context and also the possibilities of using which types of maps." (workshop 4)	With the codes "Responsibility in map actors" and "Problem awareness"
Responsibility in map actors	This code is used when the participants discussed how specific actors in the mapping process have a responsibility.	"Yeah. It's in different ways. You have 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. If it's intended for people to actually plan routes, it should also accommodate their needs. So, you have to be responsible not only for the subject topic you are mapping but also for the professional audience that is using it." (workshop 1)	With the codes "Problem awareness" and "Important to consider context with mapping"

The goal of this final segment of the workshop was to find out how to perform responsible mapping Most importantly, it was found that to create responsible maps, the context and purpose of the map need to be considered. This indicates that different actors in the mapping process have responsibilities and they emphasized the need to show the problem at stake and the potential for maps to reframe issues and prompt action. This is in line with what also became apparent in Sections 5.1 and 5.2.

Considering the waste issue, it was found that there is a relationship between raising awareness and making a map, especially, how this can be done in a responsible manner. Participants mentioned the notion of problem awareness when talking about the purpose of the map. Especially, by seeing the map as the humanitarian response to raising awareness. In this way, they discussed which maps were able to show exactly what the issue is and how big the issue is. Moreover, it was found that maps can be used to reframe the problem and thus contribute to prompting governmental policy- and decision-makers to act. Overall, maps are a powerful tool to create awareness for the waste issue. The way a map is made, presented, and communicated affects who is responsible for acting. In this manner, it is not only about creating maps in a responsible way but also about making governmental policy- and decision-makers responsible for the waste issue. The participants oftentimes discussed how a map can create problem awareness and to strengthen their claim they backed this up with an example of a relationship that should be highlighted on the map. By doing this, they connected necessary components of the map to achieving governmental policy- and decision-makers to act.

Additionally, the participants emphasized that responsibility, besides being an important aspect of the mapping process, applies to different map actors. Different actors that were mentioned by the participants were the user, the designer, the data collector, and the validator of the truth of the data. This can, for example, be found in the way a designer maps but also in how data collectors are trained in capturing the data. Most importantly, the participants agreed that the role of the user of the map has the most influence on which responsible actions come forward from the map.

[11] It must be taken into consideration that the code "Inclusion of specific relationships" is not part of the third category, but part of the second category.

However, a map can never be made in a responsible manner when the mapmaker does not consider the context of a map, according to the participants. This notion of context indicates that the audience, the user, the environment, and the purpose must be clear. When looking at the results of the focus groups, this is the core of what has been found. The participants found specifically that map users play a significant role in responsible mapping, as mentioned earlier, but that this cannot be detached from the context a map is made in. Especially, this notion of context applies to the way different users interpret a map and consequently take actions from the map. To take responsible actions based on the map, the map must be tailored to the context of the user of the map. This indicates that users can have a different understanding of the map, and thus, specific geospatial data visualizations must be chosen based on who is going to use the map. In this way, the problem can be framed in different ways and for different purposes. Specifically, for raising awareness for the waste issue, it needs to be made clear who the user of the map is, and how this user wants to make use of the map, and then a decision can be made to show which map to them. Also, the participants discussed that the broader responsible and political context maps are made in are important when raising awareness for the waste issue. This shows that mapmakers need to consider this broader context if they want to perform responsible mapping.

5.4. RESULTS COMMUNITY MAPPERS WORKSHOP

During the workshop with the Community Mappers, four visualization designs were evaluated (see Appendix F). Overall, it became apparent that the results were in line with what was already found during the earlier four workshops. Yet, one major difference was that the Community Mappers preferred a visualization design, which was not the case with the earlier four workshops. The Community Mappers emphasized a preference toward visualization three. The main reason for this preference was that it contained a lot of additional information on the map, which would benefit the user according to them. Especially, if they were the ones working with the map, they explained that it was highly useful. If the map would be used for a more academic audience, they preferred visualization five.

The first visualization that was shown during the workshop was visualization two, which had a minimal design from the waste piles in Kariobangi (see Appendix B for an elaboration on all designs). First, the participants were positive toward the professional outlook of the visualization and emphasized that this is an innovative way to communicate about waste and environment management. They elaborated that they had never been able to create such a visualization from the waste data they gathered. Thus, they were enthusiastic in general about seeing the visualizations that were created. Moreover, they were positive toward the clarity of the visualization and specifically how the design shows the distribution of waste. This indicates that they could clearly see where the waste is located and how much trash is present at that location. By clearly showing the distribution of waste, they found that the visualization can clearly show the magnitude of the problem. This shows that visualization two succeeds in its goal of showing that there is a problem at stake and creating problem awareness. Related to these opinions is the fact that the participants found that the legend contributes to the clarity of the visualization. Specifically, they liked that the legend clearly shows the amount of waste one must deal with. However, the participants missed the specific volume of the waste included in the visualization. This shows that more information is necessary for the participants for the map to have its full potential. Other negative comments that were made during the workshop relate to the level of detail to be included in the design. In general, they found visualization two less detailed to be useful. While they were positive about the clarity of the design, they would recommend adding several landmarks to the base layer of the visualization. According to them, this would lead to a better understanding of the location of the trash and how the waste could accumulate around specific landmarks. On the one hand, this is helpful for the user who needs to pick up the waste who is not entirely familiar with the area. Here, the landmarks can contribute to the wayfinding of the user. On the other hand, landmarks can be beneficial to identify how waste accumulates around certain areas. In this way, the environment, and the causes of the spreading of the waste can be visualized better. Thus, landmarks could not only serve as a tool on the practical level for waste management but also to solve the actual problem of waste accumulation. Additionally, a comment was made by one of the participants about the choice of language. Since the visualization is in English, it was asked if it could be translated to Swahili, to avoid interpretation issues of the user.

For the second visualization, i.e., visualization three about the Kibera region with an OpenStreetMap base layer, many positive opinions were given. As mentioned before, they missed the lack of additional information and especially the inclusion of landmarks in the base layer. Since the landmarks are prominently present in this visualization, they immediately were enthusiastic about the design. These landmarks add a higher level of detail to the map, which was important to the participants, e.g., they could see how many schools are

impacted by the waste accumulation. Thus, they stated that this map would be easier to use compared to the earlier shown visualization and they found it easier for a layman to interpret. Especially, since this level of detail makes it easier to connect to the location and magnitude of the waste piles. Moreover, they were positive toward the proximity of waste and how the visualization shows how close the waste is to each other and to certain landmarks. Also, they stated that this visualization shows the concentration of waste in different parts of the deprived urban area, which will allow future waste studies to know which areas to put their focus on. Like visualization two, they found this visualization clear in showing the waste distribution around the area. This was mainly due to the use of colored dots in different sizes, which is the case in both visualizations. Additionally, they found the sizing of the waste piles very useful for decision-making on the community intervention level. For example, when the size of the waste pile is one to two sacks, communities could organize themselves with waste management. For larger sizes, different solutions are necessary, and this is where the governmental policy- and decision-makers come into the picture. Yet also some negative opinions were given toward the use of these colored dots. First, they would recommend considering using colors that are not this close to one another for the designation of the waste piles. They argued that the red and the orange map appear similar, especially for users with inadequate eyesight. More specifically, it was stated that the maps should be made suitable for color-blind users since color blindness occurs often in their community. Moreover, they recommend using different shapes compared to only circles changing in size to be able to easier comprehend the magnitude of the waste. Especially, since they found the overlapping trash piles somewhat confusing. Here, it was explained that the visualizations work best in an interactive manner, where the dots do not overlap that much. In this way, the user can zoom in and can see the waste piles more accurately. Other negative opinions that came forward were concerned with more relational factors of the map. For example, they recommended including economic factors and neighborhood data such as income on the map. Additionally, they also discussed that it could be beneficial to indicate areas where it is more dangerous. They explained that oftentimes waste accumulates at places where so-called gangs come together. These gangs are often connected with criminality and therefore an indication of danger would be necessary for waste management. Despite including all these additional factors, the participants still emphasized being careful to indicate the areas with waste and discussed the number of layers to be necessary to not overload the visualization design. They related this with the claim that the design of a map strongly depends on the purpose, user, and audience of the map and that this also affects the design of the visualization.

Concerning the third visualization that was evaluated during the workshop, i.e., visualization five about the Mathare Waste Piles using VHR imagery, the Community Mappers were positive but not for their own use. They found the visualization to be useful for data storage, but not for outside communication. They argued that this is an adequate presentation to present to other intellectuals at a higher level and not to the community. In this way, the visualization works better at a more academic level compared to a more practical level, where the Community Mappers are part of. Moreover, they were positive toward the design of the visualization since it looks professional and has a high aesthetic level. This contributes to the validity and trustworthiness of the map. For the VHR imagery that was used, they stated that it accurately shows the accessibility of the area. Also, they found that the use of VHR imagery is beneficial for visualizing the topography of the area. Thus, they valued these satellite images but did not find them very useful for their own purpose of the map. Yet, they stated that the VHR imagery does not capture all locations of the waste, e.g., under trees. This decreases the accuracy of the visualization. Concerning other negative opinions, most importantly, they thought the visualization was difficult to interpret for laymen. One of the interpretation issues that was mentioned by the participants was the difficulty of understanding the big dots about where the waste is located exactly. Here they asked if the dot means that the entire area is covered with waste. During the workshop, it was explained that the bigger dot changes to several smaller dots when zooming in, i.e., when using the visualization in a more interactive environment. However, they still evaluated the design of the dots in a negative manner. First, the numbers in the dots were difficult to comprehend, specifically for the community for practical use. They did emphasize that it shows that there is a big problem, but this way of visualization is not very useful to them. Second, they were negative toward the use of only one color for the waste pile dots, since this did not contribute to showing the actual magnitude, location, and specifics of the waste pile. Third, they mentioned that there are no waste piles dots over the entire area, e.g., around the highway, which could lead to wrong interpretations that there is no waste present around the highway at all. The interpretation issue makes it difficult to be used for intervention and waste management planning and this creates further difficulties for the actual use for information communication. Therefore, the participants recommend that more explanation is necessary and more additional information and context must be added to the map before it could be useful. An example they gave was to add the legend and provide other useful information to prevent interpretation issues to arise.

The final visualization that was shown during the workshop, i.e., visualization 6 of the Kibera waste piles using a VHR Imagery Heatmap. Like visualization five, the participants emphasized that this type of design using VHR Imagery best suits a more academic audience, and they commented that all the additional information was tailored vocabulary-wise to that audience. Specifically, they stated that this map could be adequate at a policy level due to its distinct features. They also found that the satellite can show the infrastructure of the area and with the addition of the heatmap structure, it clearly shows where the deprived urban area is located. However, the participants had similar difficulties with this design compared to visualization five. They did not find it useful for the ground level and saw no benefit in presenting this to communities. Moreover, they believed that this way of visualizing does not show the magnitude of the waste issue. Additionally, they also encountered interpretation issues and now more specifically toward that heatmap design. They argued that numbers would work better since that is easier to interpret by all types of users. Also, they mentioned that this map is not suitable for color-blind users, like visualization three.

5.5. OVERALL CONCLUDING SUMMARY

The four focus group discussions revealed key findings regarding the use of geospatial data for mapping deprived urban areas. The findings were categorized into three Sections. For category one, the participants showed a strong concern for understanding deprivation and its impact on mapping. They emphasized the need for clear definitions, avoiding generalizations, 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 deprived urban areas. Moreover, the participants valued the inclusion of pictures in the map to connect with what is happening on the ground, yet they cautioned against information overload. In this way, decisions should be made on which relationship and attribute to include in the map of the deprived urban area. Hence, tailoring the map to the context and purpose, considering interpretation issues, and assessing design choices were emphasized. 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, context and the purpose of the map were identified as key factors to prompt responsible behavior from the map. This emphasizes 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 responsible and political context was deemed important to have 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 workshop with the Community Mappers, similar results to previous workshops were revealed. The evaluation focused on four visualization designs, and the Community Mappers expressed a clear preference for visualization three. They found it useful, especially for their work, due to the additional information included on the map. Visualization three was praised for its detail, showing waste proximity and concentration in different areas. Some participants recommended using more distinguishable colors and shapes for waste piles to accommodate various users. However, for an academic audience, visualization five was favored. Visualization five was considered valuable for data storage but less effective for community communication due to its complex design. Improvements for clarity were suggested. Visualization 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. Visualization six was seen as more suitable for academic and policy audiences than practical use. Participants encountered interpretation issues and proposed using numbers instead of colors for easier comprehension. Overall, the Community Mappers' feedback underscored the importance of tailoring visualizations to their target audience and incorporating relevant information for practical use and effective communication.

6. PHILOSOPHICAL ANALYSIS

In the following chapter, the results of this thesis are used for a philosophical analysis. This has been done by looking at the purpose of the map, which will be elaborated on in Section 6.1 and the notion of privacy in Section 6.2. A concluding section on why studying maps is relevant from a philosophical perspective will be provided in Section 6.3

6.1. THE PURPOSE OF THE MAP

6.1.1. Introduction

The participants emphasized the importance of tailoring the design choices, attributes, and relationships present in the visualization to be based on the purpose, user, and context of the map. Additionally, the participants mentioned privacy and accuracy as the main ethical concerns that could result from the mapping process. Therefore, this philosophical analysis will focus on these insights and concerns. Based on these results, this Section first uses theories from philosophy of technology to discuss three philosophical purposes of the map: the map as a script, the map as a mediator, and the map as a guide of human action. This philosophical analysis challenges how we think about maps, which is solely as displaying facts, yet more on how maps can contribute to decision-making processes and corresponding actions, specifically in deprived urban areas.

The results of the workshops invite an analysis that builds on a non-instrumentalist understanding of technology, indicating that technology is more than just a tool that can be used. An example here is the field of post-phenomenology. This approach has a strong relation to the phenomenological stream in philosophy, which focuses on concreteness, phenomena, and human experiences (Smith, 2018). Moreover, phenomenology strives to overcome the dichotomy between subject and object, where humans and the world cannot be conceived independently from one another. One always has a relation to the other (Smith, 2018). Post-phenomenology is inspired by this focus on experiences and relationality but differs from phenomenology by emphasizing the empirical analysis of existing or emerging technologies (Rosenberger & Verbeek, 2015; Verbeek, n.d.-b). One of the early philosophers in this field is Don Ihde, who uses the theories from the field of phenomenology to describe the relationships between technological artifacts and human beings. His approach focuses more on actual technologies and emphasizes the use of technological artifacts in people's everyday lives (Ihde, 1990). Other philosophers that contributed to this field are Peter-Paul Verbeek and Robert Rosenberger, who extended the work of Ihde by applying his ideas to a broad variety of topics, e.g., metaphysics (Rosenberger & Verbeek, 2015). Most importantly, technology is not merely seen as a tool within this standpoint, but it has been argued that technologies are not neutral objects but shape the perception and action of the user upon the world (Rosenberger & Verbeek, 2015; Verbeek, 2015b, 2015a). According to Rosenberger and Verbeek, technologies have a mediating nature and call this "technological mediation.", where technologies play a more prominent role in the life and environment of human beings. Specifically, technologies help to shape the relationship between humans and the world (Rosenberger & Verbeek, 2015).

While looking at the literature on this topic, works from Bruno Latour, Peter-Paul Verbeek, and Albert Borgmann, philosophers that are part of the field of philosophy of technology and contributors to the non-instrumentalist interpretation of technology, were used for the analysis. Moreover, works from Don Ihde and Michael Nagenborg also serve as input for this philosophical analysis. The first philosopher in this analysis is Bruno Latour, a French philosopher performing research in the field of science and technology studies, or the stream of philosophy of science. He is most famous for his Actor-Network theory, where the role between material objects, the user, and their environment is discussed (Latour, 2007). In this way, he withdraws from the division between subject and object, i.e., between the user and the material being used, by arguing that none of the elements is valued more important compared to the other (Stanford University, 2022), which is also argued by Barad with the term "intra-action"(Barad, 2007). Here, the term indicates that the ability to act comes forward from the relationship between individual and material. The second philosopher is Peter-Paul Verbeek, a Dutch philosopher focusing on the relationship between humans, technology, and the world (Verbeek, n.d.-a). He performs research in the field of Philosophy of Technology and has worked together with American philosopher Don Ihde to formulate a post-phenomenological approach (Ihde, 1995; Verbeek, 2001). Verbeek is most famous for his theory of technological mediation (Verbeek, 2015b), which will be used in this philosophical analysis. The third philosopher that comes forward in this philosophical analysis is Albert Borgmann, a German-born American philosopher also specialized in the field of Philosophy of Technology. His most seminal work concerns Technology and the Character of Contemporary Life, which entirely changed the discussion in the field of

Philosophy of Technology (Borgmann, 1984). Borgmann is one of the few philosophers that discussed the emergence and corresponding implications of maps and GIS early on, thus important for this philosophical analysis. Another German philosopher in the field of Philosophy of Technology, Michael Nagenborg, works on the interplay between technologies, cities, and human self-understanding. He has discussed the work of Borgmann (2023) which considers his work on maps and GIS more in-depth and therefore serves as additional input for this analysis.

The following Sections will show the philosophical analysis based upon the findings of this research. More specifically, the notion of a script mentioned by Latour is discussed in Section 6.1.2, the mediation theory developed by Verbeek will be discussed in Section 6.1.3., and the concept of technological information by Borgmann will be discussed in Section 6.1.4.

6.1.2. Maps as scripts

Latour discusses the idea of technical mediation (1994), where he argues that an object can contribute to a certain goal by being used by a person. The object is not neutral but also not fully responsible and intentional since it still needs a human being to operate its function. If this process of mediation occurs during a subject/object interaction, this involves a *translation* of the *program of action* of both. Translation in this sense means the reciprocal change of two entities or as Latour calls it *"a link that did not exist before and that to some degree modifies two elements or agents."* (Latour, 1994, p. 32) This program of action indicates both the intentionality of the human being as well as the functionality of the object, without invoking a divergence between both entities. Applying this to the results of this thesis, both the user as well as the map change in this process of mediation. The division between the map and its users becomes non-existent, both entities are intertwined, and are equally important in achieving specific goals in governmental policy- and decision-making.

A central concept in this mediation analysis of Latour is the notion of a "script", which is the user's desired program of action impressed into the object (Latour, 1992). In this way, according to Latour, objects or technologies are seen as "inscription devices" that contain a script from their designer. The general idea behind Latour's script is that there is a message, a prescription, which is built into the technology. This script serves to encourage its users to specific actions and behaviors, while the designer has an inscribed user with prescribed behavior and properties in the back of their mind when designing a technology. However, this does not automatically indicate that the user will behave precisely as the designer intended. In this manner, the user also needs to subscribe to the designer's inscriptions, i.e., "description" (Latour, 1992).

Following Latour, it can be argued that mapping and map-making can also be seen as a process of translating a program of action, an object that has a built-in prescription from its designer. In this way, scripts can be found in the designing process of the visualization designs and in the actual use of the visualizations. For this research, the question emerged if a script can be created to highlight that there is a problem at stake to governmental policy- and decision-makers to increase their responsibility towards the issue. Most importantly, it was looked at if the user can change their actions and behavior based on the design of the visualization. Here, it can be argued that different visualization techniques come with different scripts. Based on the focus group discussions, the participants heavily emphasized the clarification of context and the purpose of the map, which indicates that the script of the visualization design must be clear to its user. Additionally, the participants argued that maps can be used to tell stories and reframe issues, and this is exactly what the notion of a script entails. Moreover, they argued that maps could be a powerful tool for increasing responsibility to let governmental policy- and decision-makers act, which shows how users can be encouraged into specific behavior. However, the difficulty in the concept of a script, is that the user not automatically changes their actions and behaviors based on the intentions of the designer. This highlights the fact that users must subscribe to the designer's inscriptions before the map becomes the functional object the designer had intended. Thus, the idea of description also must be taken into consideration for the use of the geospatial data visualizations of this research since it could be the case that the visualizations are interpreted and used differently than intended. According to the participants, it is oftentimes inevitable to avoid interpretation issues, i.e., description, when using geospatial data visualizations, especially, with different types of users in different contexts.

Taking the interpretation issues mentioned by the participants one step further, scripts or affordances constitute the possibility of performing specific actions based on the properties of the object as well as the capabilities of its user (Gibson, 1977). In this way, technology can be seen as socio-material (Leonardi, 2013; Orlikowski, 2007, 2010; Orlikowski & Scott, 2008). Affordances are not a property of the technological object but indicate a relationship between the object and the subject that distinguishes how the object could be used. If a designer intends the user to have specific actions when using the technology, the properties of the object must be completely clear for the object to become functional, and the user must have enough capabilities to understand

the intention of the designer. If the built-in prescription is not clear to the one who uses the object, or the user has not had enough knowledge to comprehend the object, interpretation issues and alternate uses of the object can occur, i.e., description. This means that on the one hand, the script of the object must be designed appropriately to its intended goal and its intended user, and on the other hand, designers must understand that different users can interpret their object in different ways. Additionally, according to Leonardi, *"objects or phenomena do not have agency; people attribute agency to them when they use equipment, machines, formulae and other various apparatuses in an attempt to explain the machinations of the universe through the imposition of causality."* (Leonardi, 2013). This shows that a user's agency is imprinted on the technology by the way it is used, and it hints toward the idea that different users have different forms of agency. Those different forms of agency can result in different uses of technology. Moreover, others have researched that technologies have a high usability level when users can leverage their earlier experience (Norman, 2004; Polson & Lewis, 1990). Yet, more importantly, different types of users will inevitably leverage different forms of experiences to use that same technology (Blackler et al., 2003). In this way, it becomes clear that people who have prerequisite knowledge and culture about the technological object are more likely to encounter and understand the technology's script. In other words, context and background knowledge matter and shape the script and transform the process of technical mediation.

Applying this to the case of this thesis, the importance of context and the background knowledge of the user of the map can be found in the results. When the designer does not take this into account accurately, interpretation issues are easily around the corner. This became prevalent during the focus group workshops, where the participants mentioned that the user must always be thought of before making the visualization. Also, during the Community Mappers workshop, it was discussed that several map attributes are more difficult to interpret for laymen. Even when the script of the map is to prompt action in governmental policy- and decision-makers, it still must be taken into consideration that description and corresponding alternate behavior could occur. Thus, this is why context is so important in the process of map-making and designing map visualizations.

6.1.3. Maps as technological mediators

While it became apparent in Section 6.1.2. that technologies have a built-in prescription; it must be recognized that technologies can be used for many different purposes. This is where the idea of *multistability* comes into the picture. This notion refers to the idea that technology can be used for many different sorts of purposes, but not for all existing purposes (Ihde, 1995). More specifically, this indicates that technology can be used differently in different contexts yet is not able to cover all infinite purposes. Technologies have no essence, they are only what they are in their use (Verbeek, 2001). Relating this to what has been said about scripts, multistability allows various interpretations of a script by the way technology is used. This highlights the importance of context and the background knowledge of different users and shows that maps can be used for different purposes while this was not intended by the designer.

While both Ihde and Verbeek agree with Latour to abolish the division between subject and object and value both entities as equally important, this notion of multistability shows however that technology becomes something by being used. In this way, it can be argued, following statements of Verbeek, that both the subject and object are equally important but that the role technology plays could be different. Moreover, while Latour does talk about technical mediation, he makes his argument of the script mostly based on semiotics. This means that he looked at technology as conveying a message by displaying signs. However, Latour does take the role of technologies somewhat into account in his and Emilie Hemant's book 'Paris ville invisible' (Latour & Hermant, 2006) since the book's design, the perspective of the text and the pictures resemble the message they want to convey. In short, the text is structured like a long hallway that leads to every location in Paris that we claim to be able to "grasp" and allow us to view completely. Yet, we constantly become aware that the city is still invisible. We only understand a small portion of it; thus, the work must always be redone. This line of thought is not further elaborated on by Latour but emphasizes the role technology itself plays in the process of mediation. Specifically, the hermeneutic dimension of technology that is found in mediation theory, i.e., how technologies can actively contribute to shaping the user's interpretations of the world, is not considered by Latour (Verbeek, 2015b). Therefore, this theory takes the argument by Latour a step further and can be used to analyze the results of this thesis.

According to Verbeek, *"humans and technologies should not be seen as two "poles" between which there is an interaction; rather, they are the result of this interaction."* (Verbeek, 2015a, p. 1) This statement is completely in line with what was earlier mentioned by Latour when he argued that a reciprocal change occurs when humans and technologies interact, where both are seen as two equally valued entities. In this way, he argues that humans and technology mutually shape each other, but advances the argument that this relationship is part of a larger relation; between humans and the world they live in. He states that the basic idea behind mediation theory

is that it "*can inform practices of design, because it enables designers to analyze, anticipate, and experiment with the relations between humans and products, and the impacts of technologies on human experiences and behavior, and on social practices."* (Verbeek, n.d.-a). Two important aspects can be found in Verbeek's definition of mediation theory. First, it shows, like Latour, that technologies can change the actions of the user towards the world. Differently with mediation theory, the emphasis lies on how technology mediates how reality comes into being instead of how technology is used by the user. This is done based on the main claim that both human beings and the world they act upon can be shaped by interacting with technology. Second, the definition shows that technologies can change the perception of the user towards the world. This second aspect shows the underlying stimulus for the action, i.e., the response, and the interpretation of a user about the world.

The main argument from mediation theory, that technologies can shape the actions and perceptions of human beings towards the world, was applied during the focus group discussions. The goal of this research was to find out how governmental policy- and decision-makers could be prompted to act by using a map visualization of the waste issue. It became apparent that the actions of the user can only be shaped when the design is tailored specifically to the user. As mentioned earlier, this means that mappers should consider different outputs of the overlay design in different contexts before it is effective in prompting action to governmental policy- and decision-makers on the waste issue. Additionally, when using the map in the context of the Community Mappers, specific attributes are necessary to prompt action by the user. This means that maps were not useful if they did not contain all relevant information, e.g., landmarks. Concerning the shaping of perception, the findings show that the users' beliefs toward the deprived urban area can be shaped through visualization. Especially, in terms of who feels responsible towards the area but also in defining segments of the area as deprived and connecting the waste with the inhabitants. Thus, what can be seen is that a map can be a mediating technology but that there are many conditions that must be met before it has an effective purpose.

Besides analyzing the visualization design as a mediating technology, its presentation can be analyzed. During the focus groups, the visualizations were shown by letting the participants engage with the visualization designs by interacting with them on a tablet. In this manner, the technological mediation of the interactive visualization designs was considered to measure to what extent different geospatial data visualizations of geospatial data can influence the responsibility of governmental policy- and decision-makers. Both positive and negative results came forward from this notion of interactivity. One important finding during the focus group discussions was that the participants found being able to toggle between different layers of the overlay highly important. In this way, the interactivity of the technology is valued positively. It must be taken into consideration that humans naturally appreciate experiencing a certain level of control. This comes forward from making choices to achieve a desired outcome and feel the perception of control (Leotti et al., 2010). *"You have brains in your head, you have feet in your shoes, you can steer yourself in any direction you choose."* (Seuss, 1990, p. 2). In this way, people can exert power over their own environment by making choices. This could explain why the participants felt positive about them being able to make decisions for themselves with the interactivity of the tablet, compared to a static image which they have no control over. However, another finding concerned the zooming issues that were stated by the participants. Contrarily, this shows how the interactivity of the technology was evaluated negatively. Here, the participants did have the choice, but the complexity of the visualization diminished their perceived level of control since it mislead them to a certain extent.

Most importantly, it can thus be concluded that also the technology that presents the design has an influence on how effective the message of the technology comes across to its user. Considering this research, this means that the purpose of the map of highlighting a problem at stake and prompting governmental policy- and decision-makers to act depends both on the semiotics of the visualization, the user of the map, as well as how the visualization can be used with a specific technology.

6.1.4. Maps as a guide for human action

Until now, we have seen that the visualization designs of the waste issue in Nairobi and their presentation entail a desired program that could influence the actions and perceptions of the user toward reality. In other words, following the line of thought of the earlier mentioned philosophers, the designs can influence the responsibility of governmental policy- and decision-makers towards this issue. However, while mediation theory helps to explain and shape the relationships between users and their world by looking at the mediating power of technologies in the interaction with human beings, the theory does not shed light specifically on *how* human beings can use technologies for a specific purpose. This means that it is now obvious that technologies entail a story, that using technologies shapes both the user and its environment, and that different forms of use are possible. Yet, it is not discussed how technology can entail instructions for use specifically and how technology is able to be that technological mediator in practice. Moreover, maps and GIS are no topics that are discussed in mediation theory

research, and this is where the philosopher Albert Borgmann comes in. His work on information is especially relevant for this analysis since he elaborates on how technology specifically maps can be a guide for human action (Borgmann, 1999). When Borgmann wrote this piece, digital maps were only just emerging which explains his pressing concerns. But nowadays, digital maps are oftentimes taken for granted since people are used to them being there for a long time. The emphasis of Borgmann on GIS acknowledges that digital maps should not be taken for granted, yet this is something that both Latour and Verbeek tend to overlook. Thus, the choice has been made to use the work of Borgmann as a final piece of this philosophical analysis on the purpose of the map, since it sheds light on the practical use of technologies and is also specifically applied to the use of GIS.

In this work, he states that information can transform reality and mentions three types of information: information-about-reality, information-for-reality, and information-as-reality, where the latter is seen by Borgmann as most important (Borgmann, 1999). Yet, to understand the latter type, the former two serve as background knowledge. The first type of information can be defined as natural information. This type of information consists of natural signs that can tell its users something about the world they live in. Take as an example, reports about findings or records of music. Secondly, information-for-reality concerns cultural information. Here, Borgmann indicates conventional signs that help the user to perform the purpose of the natural information, e.g., a recipe for cooking a meal or sheet music to play music. Importantly, he argues that reality can be transformed by information-about-reality (Borgmann, 1999, p. 84) . In this way, natural information tells something about reality, while cultural information shapes natural information and in turn shapes reality. The final type of information concerns information that comes from technological devices, which is seen as information-as-reality. This indicates that the information is not telling something about a thing, nor is it explaining how to use the thing, but the information contained by the technological device is seen as reality. An example can be a CD because when a user is listening to a CD, they are listening to music and in this manner replaces reality. In other words, technological information does not signify a thing but composes its own reality.

If we see what Borgmann discussed about the theme of this thesis, i.e., visualization designs of geospatial data, he states the following: *"When it comes to information about reality, geographical information systems are the paradigm of technological information."* (Borgmann, 1999, p. 171). This shows something rather contradictory. On the one hand, it argues GIS as being information-about-reality, while on the other hand as technological information. This indicates that GIS can be seen similarly to a map that displays geographical information about the world, but also as a technological device that transforms the data into its own reality. More generally, Borgmann is interested in researching the consequences of GIS since he claims that maps are such technological instruments; *"maps are the instruments that render reality not just perspicuous but surveyable from end to end."* (Borgmann, 1999, p. 168). This shows that maps are not only able to show a clear overview of the world but also that the world becomes measurable. By looking at the emergence of GIS the more technological information aspect can be researched and thus, this spikes interest for Borgmann. When looking at the case of this thesis, it became prevalent that signs and signifiers are important to understand and comprehend the map. This can mainly be seen from the arguments made about landmarks and how those details help to increase the usability of the map. Yet, according to Borgmann, *"An object is not a sign or a thing simply; it depends on the context whether it is one or the other."* (Borgmann, 1999). Here, the visualization design becomes a specific signifier depending on the context. This indicates that different contexts cause different information to become prevalent from the visualization design and when looking at the results of the focus group discussions, this is in line with what was found. Importantly, it was argued that governmental policy- and decision-makers can only achieve to act responsibly toward the issue when taking the context into account, yet this context is often different.

However, what has been underexposed by Borgmann is the idea that maps are not only information-about-reality and technological information but as philosopher Michael Nagenborg argues, maps are also information-for-reality (Nagenborg, 2023). Borgmann considers, for example, architectural blueprints as information-for-reality due to their ability to display existing and future designs of buildings (Borgmann, 1999). One could say the same about the use of maps in urban planning. Since Borgmann argues that maps are information-about-reality, this implies that maps can contain false information if the attributes on the map do not correspond with ground reality. Yet, indeed what if a map combines both actual and potential landscapes? (Nagenborg, 2023). According to Nagenborg, maps must be seen as information-for-reality since *"Such maps contain information to be realized in a somewhat similar way that architectural drawings need to be realized through the act of building"* (Nagenborg, 2023, p. 8). This does not indicate that a map is a full instructional blueprint, but it is in fact a guide for human actions. Specifically, the ability to represent both actual and potential data, digital maps blur the boundaries between their function of information-about-reality and information-for-reality. Take the example of Latour mentioned in the introduction of this thesis, where maps were used to discover

new land and have power over those areas. Here, maps were used to showcase what was found during the voyages but also to connect further human actions of power to it.

This idea that maps can prompt action to its user sounds familiar and was the topic of interest during this research. When looking at what has been earlier on said, it was found that maps can indeed be used to prompt action and encourage the user to engage with the waste issue in Nairobi. Thus, it can be argued that maps are indeed both information-about-reality since it represents the waste issue in the visualization, and information-for-reality since it guides the actions of governmental policy- and decision-makers to do something about this issue. More specifically, this thesis has investigated how maps are able to influence the responsibility of those stakeholders, where it was seen that the map must be tailored to the context, purpose, and user of the map to be useful. This idea of governmental responsibility is strongly connected with the human actions that could come forward from the use of visualizations, which in turn connects with maps being information-for-reality. If the user decides to act in a responsible manner towards the issue, the map is an effective guide to responsible actions. In the case of the waste issue, the map contributes to the process of the designer making responsible decisions towards the people being mapped as well as the actions that would be taken when the map is used by various stakeholders.

6.2. MAPS AND PRIVACY

While the earlier Section discussed how maps can positively contribute to prompt action for the waste issue, it was found during this research that deprived urban area mapping could also cause privacy and accuracy issues to arise. One of the few philosophers who discussed how the developments in GIS could infringe on or even change the concept of privacy is American philosopher Michael Curry. He has devoted a lot of time over the past ten years to contemplating the nature and implications of the advancement of geographic information technologies, such as remote surveillance systems, global positioning systems, and computer-assisted cartography in addition to geographic information systems. The topics of space, place, and representation as well as more general social and cultural themes like privacy, property, and identity have all been strongly related to this research (UCLA, n.d.).

For this segment of this philosophical analysis his work ‘Digital People, Digital Places: Rethinking Privacy in a World of Geographic Information’ (Curry, 1997), a precursor for his later work ‘Digital Places: Living with Geographic Information Technologies’ (Curry, 1998) will be used. Curry has offered an understanding of GIS within different contexts and most importantly shows that they are limited in representing relationships, objects, places, and people that are most important to society (1998). Specifically focused on the consequences of using GIS, Curry argues that those systems change the environment in which they exist and the people who use them. This GIS usage causes a rethinking of concepts and general ideas in public life, e.g., scientific practice and privacy (Curry, 1998; Curry, 1997). Especially rethinking the changes in the nature of the basic idea of privacy will be prominent here since that connects with the findings of this research.

On privacy, Curry makes four interconnected arguments (1997). His first argument concerns the danger of the emergence of a cartographic grid by using GIS and serves as a steppingstone to introduce the issue of privacy. According to Curry, every person or place can be characterized by where they are located on that cartographic grid due to the developments in GIS. This causes people to rethink the nature of the world, seeing the world as a sphere, where every place looks like the other. Curry connects this with the means-based approach from the fourth amendment Constitutional literature, where the fourth amendment concerns *“the right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no warrants shall issue, but upon probable cause, supported by oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.”.* (U.S. Constitution, n.d.). Here, the fourth amendment has the goal of protecting the human right to privacy and freedom toward unreasonable trespassing by the government. Important here is the concern of entering a private space of an individual. When using GIS to locate houses and individuals, one tends to overlook the fact that that person’s private space is visualized. In that manner, a place is only a location on the cartographic grid and not a unique place, a private space of an individual. Hence, the right to privacy is violated by using GIS. More specifically, those who argue for a means-based approach to the Fourth Amendment ask if a specific incident or action considered the involvement of the use of proscribed means by the Constitution (Curry, 1997). The main idea here is that if humans follow the same set of rules, no structural effect occurs on the world the rules are applied. This again correlates with the view that every place looks alike. The danger that Curry addresses is that the special features that make a specific place unique decrease by locating everything on the cartographic grid. In turn, this makes it difficult for

people to develop their own personal identities in their private life, if everything is alike. It becomes apparent from this argument that the world becomes generalized when using GIS, resulting in a sphere consisting of locations on a grid. This can be related to one of the main issues found during this research, which concerns the generalizing of deprived urban areas. According to the participants, this issue occurs often when mapping deprived urban areas since there is a lot of diversity in the degree of deprivation, which results in more difficulty in accurately visualizing the deprived urban area. Also, they emphasized that indicating something as deprived is rather dangerous since this contributes to the generalization of an area by framing the area as deprived. As a solution, they proposed to define the notion of deprivation clearly before doing spatial analysis, yet this is oftentimes not the case when visualizing the area. In this way, a generalized map cannot capture the reality on the ground. Concerning the visualization designs, generalization was primarily found with the heatmap design since it covers the entire area in waste. However, this is not what is the case.

The second argument Curry makes is a consequence of the first one, which concerns the development of universal identifiers of a location, especially by using real-time data. In this manner, it becomes possible to continuously track individuals via one single identifier, such as their social security number, with remote surveillance tools. He calls this "data matching". The danger in data matching is, according to Curry, the emergence of a Benthamite panopticon[12], yet, not with a single surveillance point but with too many data points to keep track of. This violates the privacy of individuals since they are always watched, wherever they are. For the waste issue, this argument is somewhat more difficult to apply since no real-time tracking only existing data is used for the visualization designs. However, this can still be connected to this research in the way that the identity of the inhabitants of the deprived urban area relates to the waste piles. The waste piles are visualized at specific locations, these locations connect to a street name, and the street name is in turn connected to specific inhabitants. Thus, the inhabitant can be connected with the waste accumulation. This relates strongly to the third argument Curry makes and will be further explained in the next paragraph.

The author takes the notion of data matching one step further in his third argument and introduces the idea of "data profiling". Here, by matching data with specific GIS tools, profiles of digital individuals, digital places, and digital communities can be created. This creates multiple digital identities based on the context of using information and consequently, the individual is responsible for the actions of those other digital selves. In other words, you are responsible for the actions of that profile. In the second argument, an individual identifier was used, i.e., the social security number, to observe the inhabitants and connect them to certain locations. In this case, a geographical identifier is used to do the same. For example, by having someone's address, a lot of information can be gathered and stored for that single location. This is oftentimes the case when governments store data about neighborhoods or describe specific areas, which results in a certain image of that area. Again, it is overlooked that it is a private space that is talked about. Normally, individuals formulate their identity by being able to identify with a specific place, group, or in this case neighborhood. They feel strongly connected with other individuals that also belong to the same neighborhood. However, when looking at data profiling, the neighborhood is characterized by statistical relations instead of the connection between individuals. This idea of data profiling devaluates the individuals' nature of identity and again creates a generalized image. Thus, the relation between place and individual is not seen as something essential but rather as something contingent. In this manner, the role and power of individual privacy is undercut. Concerning the earlier mentioned example, inhabitants of the deprived urban area are connected to the waste piles by means of their social security number and by means of their geographic location. This infringes on one's privacy on an individual level, yet it connects the inhabitant also to the entire neighborhood of the deprived urban area. When governmental policy- and decision-makers need to act on the waste issue of Nairobi, they will look at the statistical relations of the neighborhood and forget the individual identity of the individuals. The area will be categorized as a deprived urban area, where the whole consists of waste. In this manner, the inhabitants lose their right to individual privacy since they are only seen as the whole of the neighborhood.

Building upon the earlier three arguments, Curry moves toward how the representation of data can validate the right to privacy of an individual but also of a group and place. When a visual representation is created, how can it be said that an individuals' privacy rights are related to the facts presented about them on the map? Can a visual representation violate the privacy rights of a place or a group by the way it is visualized? Moreover, if a visual representation is created, how can you be certain that the user understands it correctly? These are the questions Curry asks and show that the regulation of what becomes represented is a difficult process due to the

[12] The idea of the panopticon concerns a design of a building consisting of an inherent control system, where there is one guard that observes the people inside from one vantage point. His example is a prison. To read more on this idea of the panopticon readings from Foucault can be visited (Foucault, 1975).

complexity of interpretation. He states that people can read and interpret maps but that they do this in a predictable but variable manner. Thus, this complexity could cause interpretation issues to arise and especially for different users of the map. In terms of privacy, this again connects with the aspect of generalization. If the area is interpreted as a whole, yet, factual this is not the case and there is a higher level of diversity, which causes problems in the violation of privacy rights. Congruently, this was extensively discussed during the focus group sessions and the workshop with the Community Mappers. Here, they emphasized that specifically, the difference between academic users and laypeople relates to the possibility of interpretation issues. Thus, they argued that different maps serve different purposes and different users. Moreover, the aspect of generalization that was mentioned earlier, and the entire area is seen as deprived or covered in waste piles, violates the right to privacy of the entire neighborhood. They are merely seen as the data that is drawn up about them. All in all, the right to privacy may change by using GIS and one should be cautious when using locational data of individuals to acknowledge that it concerns individual private spaces and not only locations on a cartographic grid.

6.3. CONCLUSION PHILOSOPHICAL ANALYSIS

The arguments made in this philosophical analysis show that maps are interesting and worthwhile to be studied from a philosophical perspective, especially in the field of Philosophy of Technology. The arguments challenge the way we normally think about maps, which is solely as displaying facts, yet more on how maps can contribute to decision-making processes and corresponding actions. Specifically, what was seen is that maps can serve different purposes based on the context of use. It has been argued that maps contain scripts that can stimulate the user to behave in a certain manner and that maps mediate the relationship between the user and their world. Yet, maybe most importantly, it has been argued that maps can guide human action, broadening the argument of Borgmann. The analysis revealed that maps possess a unique quality in that they can simultaneously represent both actual and potential data, blurring the lines between information-about-reality and information-for-reality. This dual function of maps is particularly relevant when maps are used to prompt action and influence the behavior of their users. Ultimately, this research suggests that maps have the potential to prompt action and encourage responsible behavior. Maps are not only tools for conveying information but also instruments that guide individuals and organizations to act in a responsible and context-sensitive manner. In the case of the waste issue in Nairobi, the map serves as a guide for governmental policy- and decision-makers to address the problem, emphasizing the importance of creating maps that are tailored to the specific context, purpose, and user. Thus, the study of maps in the field of Philosophy of Technology sheds light on how technology can be harnessed to address real-world challenges, shape human actions, and influence responsibility. It underscores the intricate relationship between maps, technology, and human behavior, making it a rich and essential field of study for understanding the profound impact of technology on society and the environment. Moreover, the study of maps delves into complex ethical and philosophical implications, particularly concerning privacy and the impact of GIS on our understanding of the world. Maps, as powerful tools for representation, have the potential to shape our perceptions and impact our lives in profound ways. Especially, it impacts our perception of privacy, identity, and representation. By studying maps, the importance of thoughtful and responsible use of locational data and maps became apparent. Therefore, the study of maps in the field of Philosophy of Technology is essential for grappling with the complex ethical and philosophical implications of technological advancements in the field of geographic information.

7. CONCLUSION

In the introduction of this research, three sub-questions were defined. The results of this study and those sub-questions are answered in this chapter. The methodology that was used to provide an answer to these questions concerns focus group discussions and an online workshop (see Chapters three and four). Using the findings of this research, the research question: "*To what extent do different geospatial data visualizations of geospatial data influence the responsible actions of policymakers and their decision-making process in deprived urban areas?"* can be answered. Specifically, this research looked at three topics. The first topic concerned the current knowledge of various stakeholders on using geospatial data for deprived urban area mapping. The second topic was about the use of detail, images, and overlay mapping in a geospatial data visualization design. Lastly, the opinions of various stakeholders on how a map could potentially help to influence responsible actions were researched. The findings on these topics, and how they connect with what was found earlier in the literature review, will be discussed in Section 7.1. This will be followed by the limitations in Section 7.2 and the discussion of the practical and theoretical implications of the study in Section 7.3. Additionally, the recommendations for further research will be elaborated on. Finally, an overall conclusion will be provided in Section 7.4 to finalize this chapter and this research.

7.1. DISCUSSION OF THE RESULTS

7.1.1. Knowledge on using geospatial data for deprived urban area mapping

To answer the first sub-question: "*What do various stakeholders currently know about using geospatial data for deprived urban area mapping?*", the results from category one, and the results from the Community Mappers are used as input (Sections 5.1 and 5.4.). It was important to gather background knowledge of all participants on the topic for two reasons. First, it served to break the ice and delve into the topic, which influences the setting of the focus group and spikes discussion. Second, the background knowledge of the participants may influence the feedback provided on the visualization designs. The differences in perception may come forward from the background knowledge and thus, this question was important to ask.

It was found that the workshops revealed key insights into the knowledge of different stakeholders on using geospatial data for deprived urban area mapping practices. Important background knowledge is that the participants of the focus group discussion were familiar with mapping practices but have not gathered data themselves, or that they were not familiar with mapping practices at all. Comparing this to the background knowledge of the Community Mappers, it was found that they gathered geographical information but are not familiar with performing mapping practices. Thus, it is important to consider that this may influence the feedback provided by all participants. Additionally worth mentioning, is that the Community Mappers themselves call the deprived urban area just slums, which assumes that they do not feel any sensitivity towards that definition.

During the focus group discussions, they expressed concerns about accurately defining and visualizing deprivation, emphasizing the need for clear definitions in spatial analysis. They recognized the diversity and varying degrees of deprivation in such areas and highlighted the limitations of generalized maps in capturing reality. This emphasis on understanding the diversity in the level of deprivation was also found in the workshop with the Community Mappers. Specifically, they elaborated that deprived urban areas are often seen as entirely deprived, yet there are more nuances in the neighborhoods. Also, deprivation is something that is understood differently for different people, e.g., people living in those neighborhoods and people living more in suburban areas. When looking back at the literature, this is in line with the statements made by Oluoch (2022) and the concerns addressed by Heesen et al. (Heesen et al., 2014). According to Oluoch, GIS can be used to gain a better understanding of the spatial and temporal dynamics, yet it has been argued by Heesen et al. that when GIS is used for deprived urban area mapping the area is often standardized. In turn, Oluoch addresses that this could impact the accuracy of the map and consequently impact the decisions made from using the map.

Furthermore, the characteristics associated with deprivation, according to the focus group participants, included poverty, crime, drugs, low income, social housing, and a lack of facilities. The participants stressed the importance of understanding spatial variation and using geospatial data to adequately visualize these patterns. They aimed to move away from simplistic classifications of deprived or not deprived, focusing on nuanced mapping that considers the spatial and temporal dynamics of the area. The discussions also highlighted ethical considerations, such as privacy, biased maps, consent, accuracy, and the potential negative consequences of mapping. The participants emphasized the responsibility of mappers to think through the purpose and user of the

map, minimizing possible negative impacts. During the workshop with the Community Mappers ethical implications were shortly discussed, especially it was hinted towards the notion of privacy. However, they did not encounter any problems with visualizing deprived urban areas and privacy.

Moreover, ethics was recognized by the focus group participants as an integral part of the mapping process, influencing map creation and its effects. Privacy and accuracy emerged as significant concerns, with participants questioning the level of accuracy required and the impact of map accessibility on privacy. Moreover, the idea of generalization correlates with issues mentioned on privacy in the way that it changes and infringes on a person's individual privacy (see Section 6.2). Overall, ethics were deemed crucial at all stages of the mapping process. This can relate to what was found earlier in the literature review, where the consideration of geo-ethics was a crucial component of the deprived urban area mapping process (Owusu et al., 2021). The topic of ethics was not prevalently discussed during the Community Mappers workshop, due to them not encountering any specific ethical problems with the mapping process.

7.1.2. Visualization attributes

For the second sub-question: *"How does the level of detail, a picture, and overlay mapping in a geospatial data visualization stimulate engagement with the topic?",* the results from category two which concerns visualization techniques and attributes, and the results from the Community Mappers are used as input (Sections 5.2 and 5.4).

Despite the different participant groups, it was found that there are mostly similarities between the opinions of the focus group participants and the opinions of the Community Mappers. However, it was seen that the participants in the focus group discussions focused on the more technical aspects for usability, while the Community Mappers emphasized the usability of the map for ground-level workers. Another difference was found considering the ranking exercise. The ranking exercise with the focus group participants indicated no clear preference for a specific visualization, reflecting the diverse opinions and interpretations among users. Interpretation issues were also mentioned by the Community Mappers, but they were more focused on the user of the map. Also, the Community Mappers did have a clear preference for a suitable map. They believed visualization three would be the best fit for them to use on ground level and visualization five would work best for an academic audience. The difference between both participant groups on visualization preferences can be best explained through their background knowledge, which was mentioned earlier. In the focus group discussion, a diverse group of people with a higher level of education evaluated the visualization designs, compared to a less diverse group of Community Mappers unfamiliar with mapping practices.

Similarly, all participants value the inclusion of a high level of detail but argue that an information overload must be avoided. On the contrary, the Community Mappers valued a higher level of detail compared to the focus group participants. The Community Mappers were enthusiastic about the inclusion of a lot of details in the base layer, especially landmarks since they argued that this increased the usability of the map. There was a division between the focus group participants between showing problem awareness on the map and providing detailed information, which relates to usability as well. They emphasized that the purpose of the map connects with how much detailed information should be present. For example, if the purpose is to make users aware that there is a problem at hand, more detailed information can be left out. Yet, when the visualization is used for waste management services, i.e., collecting waste, more details are necessary to become useful. This indicates that the focus group participants were undecided on how much and which informational details were necessary to put on the map. However, all focus group participants and Community Mappers emphasized the need to include various relationships, factors, and attributes in the map. It must be taken into consideration that excessive details on the map led to information overload, requiring the inclusion of only necessary details or the creation of different maps for different purposes. Similarly, the Community Mappers also discussed not creating an information overload on the map, but they were more focused on how satellite images could create an information overload. The Community Mappers found the satellite images to detailed and difficult to process, which led to a decrease in usability.

The information overload discussed by the participants is a problem that emerged with the rise of the Internet (Carr, 1999) yet, is still a continuous and difficult problem nowadays (Arnold et al., 2023). Due to the digitization of information and the digitalization of the world, information overload is being aggravated. Specifically, this problem occurs by consuming information through screen displays (Arnold et al., 2023). One theory that can be linked to this human-computer interaction problem is the cognitive load theory (Sweller, 1988). This theory comes from the multi-store memory model, which revolves around the way memories are stored in the human mind (Atkinson and Shiffrin, 1968). More specifically, it has been argued that every human being has three types of memories, i.e., sensory memory, working memory or short-term memory, and long-term memory.

Each memory type is characterized by its way of precoding information, storage capacity, and duration. Moreover, information is processed similarly to the way a computer works, with input, processing, and output as a result.

However, when there is too much information to process for these memory stores, an information overload leads to a cognitive load, specifically on the working memory of the user. Sweller argues, that human beings have a limited capacity in short-term memory and visualization designs must be tailored with effective learning techniques (Sweller, 1988). In this way, cognitive load can be reduced from the working memory and knowledge can be transferred into the realms of the long-term memory store. Hence, for the visualizations to achieve their goal of prompting responsible actions to governmental policy- and decision-makers, the cognitive load should be reduced in the working memory and the information on the visualization must be stored in the user's long-term memory. This can be achieved by taking different audiences into account and designing each visualization design based on the audience of the map. This means that it is beforehand decided upon necessary and useful attributes that connect to the purpose of the map. Cognitive load theory is an important theory, specifically for instructional design, and connects with the way maps, or geospatial data visualizations, can be information-for-reality, as argued in the philosophical analysis of this thesis. When designing geospatial data visualizations without an information overload and while taking the cognitive load into account, the goal of prompting responsible actions to governmental policy- and decision-makers can be fulfilled. Hence, the level of detail is an important aspect of the deprived urban area mapping process, and incorporated effectively can stimulate engagement with the waste issue in Nairobi.

Moreover, the use of pictures was valued more positively by the focus group participants compared to the opinion of the Community Mappers. The reason why the focus group participants valued the addition of pictures was that this really stimulates engagement with the topic and lets the user "get hit with reality", to use the words of one of the participants. This was also discussed during the workshop with the Community Mappers, but this did not spike any enthusiastic opinions. They did feel that adding an image did not conflict with their values or infringe on the privacy of the inhabitants. Since the focus group participants expressed concerns about including too many symbols on the map, they also favored the inclusion of pictures to create a connection with the ground reality and prompt action. For the Community Mappers, there was no clear opinion on the use of a picture but a positive standpoint towards using many symbols or landmarks on the map, as mentioned before. Connecting this with the literature on psychological models and dual-coding theory (Dewan, 2015; Ganier, 2000; Krcmar & Haberkorn, 2020; Paivio, 1991) the findings are in line with the statement that images lead more directly to the fabrication of mental representations compared to text, where mental representations are necessary for a user to evoke action in the human mind. However, these mental representations should not be overloaded with information, hence a cognitive load can emerge (Sweller, 1988). Yet, no conclusive answer can be provided if textual processing is indeed different compared to image processing since no cognitive experiments have been performed. The conclusion that can be made is that the participants all stated the advantages of using symbols and images in the visualization and did not emphasize certain textual attributes or express enthusiasm about them. In summary, it can be argued that the combination of relevant text together with tailored symbology and images to the user of the map is most suitable to stimulate engagement with the topic and prompt action to its user.

Toward the use of overlay mapping, it was found that the focus group discussions, as well as the workshop with the Community Mappers, revealed the significance of overlay mapping for mapping deprived urban areas. Everyone emphasized specifically tailoring the map to the purpose and user of the map. This is congruent with what was earlier discussed in the literature review since Oluoch argued that it is important to take into consideration who does the mapping and representing of the deprived urban area (Oluoch, 2022). Moreover, the focus group participants recognized that overlay mapping allowed for effective decision-making by choosing different layers in different contexts. The focus group participants also recommended including more specific relationships, such as the link between waste and lack of services, livelihood assets, economic scales, flooding consequences, and neighboring areas without waste problems. The selection of map attributes, relationships, and design choices should be carefully assessed based on the audience and user of the map to avoid information overload and tailor it for its purpose, as shortly mentioned earlier. Congruently, the Community Mappers also discussed including more and different factors and relationships to the map, i.e., economic data or neighborhood data. Additionally, the focus group participants emphasized the broader societal impact of the map and the importance of understanding the underlying causes of waste accumulation. Both arguments were also mentioned during the workshop with the Community Mappers. Specifically, the Community Mappers highlighted the importance of context and the accommodation of the map to different users based on the purpose of the map. And again, they stated that this should be tailored to the purpose and user of the map by using the function of overlay mapping.

This tailoring of the map relates to earlier statements about overlay mapping since the end goal of performing spatial analysis by using overlay mapping is to find out which layer to display to which user (Herbei et al., 2011). Ultimately, engagement with the waste management issue in Nairobi can be stimulated by making use of overlay mapping effectively. However, there are many factors that should be considered before overlay mapping is deemed effective in prompting responsible actions to governmental policy- and decision-makers. Specifically, the concern arises in the decisions on which relationships and attributes to include in the map to achieve its purpose of action prompting. This can be connected to a statement by Monmonier, who argues that "*a single map is but one of an indefinitely large number of maps that might be produced for the same situation or from the same data*" (Monmonier, 1991, p. 2). This indicates that there are many possibilities in the visualization process of maps. Hence, many different types of geospatial data visualization designs can be created of the same data used, which was done during this research. In this way, overlay mapping could be a solution to the decision problem by tailoring its layers and output to its user and in turn stimulating engagement with a specific topic.

7.1.3. Responsible mapping

For the final sub-question *"What different opinions do various stakeholders have on how a map can influence the responsible actions of policymakers and their decision-making process in deprived urban areas?"*, the results from category three, and the results from the Community Mappers are used as input (Sections 5.3 and 5.4).

In the beginning of this thesis, the question proposed by Oluoch et al. was highlighted which considered the responsibility those who control the spatial data have over those who are represented in the data (Oluoch et al., 2022, p. 7). It was researched how responsible actions can be made based on the representation of data. In this way, it must not be forgotten that it concerns the living area of people in the deprived urban area and not only think of the visualizations of waste as data points. This came forward during this research, and specifically, it was found that the focus group participants as well as the Community Mappers discussed the importance of considering the context and purpose of the map. They recognized that different actors in the mapping and use process have responsibilities and highlighted the need to show the problem at stake and the potential for maps to reframe issues and prompt action. Maps were seen as a powerful tool for creating awareness and prompting governmental policy- and decision-makers to act on the waste issue. The focus group participants and Community Mappers emphasized the role of map users and their interpretation of the map in determining responsible actions. The focus group participants also identified different map actors, such as designers, data collectors, and validators, who have a role in ensuring responsible mapping. However, the focus group participants highlighted the need for accurate visualizations and the potentially misleading effects of certain map designs, such as the heatmap, on the responsibility of decision-makers. Specifically, interpretation issues and zooming problems were noted by the focus group participants, affecting usability and readability, which in turn impacted decision-making.

The misleading effects connect back with what was stated in the Introduction on distortion and Chapter two on telling lies with maps. Inherently to the map are the biases of its creator and thus a map tells only one way of a story and could fabricate lies by distortion of reality. The interpretation issues were also already elaborated on by Heesen et al. (2015), who stressed the possibility of misinterpretation, especially when mapmakers assume universal intelligibility. Additionally, both the focus group participants and the Community Mappers stressed that a map cannot be made responsibly without considering the context in which it is created. The audience, user, environment, and purpose of the map must be clear, and the map should be tailored to the specific user's context and needs. The broader responsible and political context in which maps are made was again highlighted as important. Ultimately, responsible mapping requires understanding the user's context, framing the problem appropriately, and considering the broader context in which the map is created.

7.1.4. Main research question

With these sub-questions, an answer can be provided to the main research question of this thesis "*To what extent do different geospatial data visualizations influence the responsible actions of policymakers and their decision-making process in deprived urban areas?"*. In conclusion, it can be argued that geospatial data visualizations have can influence responsible actions, yet this highly depend on the use context and purpose. In this way, the different actors in the mapping process should be considered, such as taking the user and the audience into account. By doing this, issues such as privacy and accuracy can be considered before creating the geospatial data visualization. Geospatial data visualizations should be tailored to all these factors to be able to influence and prompt responsible actions of governmental policy- and decision-makers. Here, many relational factors should be considered to stimulate engagement with the topic of waste management in Nairobi and overlay mapping can be used as a tool to increase the visualization's ability to influence and prompt action. Ultimately, mapping deprived urban areas requires understanding the user's context, framing the problem appropriately, and considering the broader context

in which the geospatial data visualization is created. Thus, to what extent do different geospatial data visualizations influence the responsible actions of policymakers and their decision-making process in deprived urban areas? They influence their responsibility to a certain extent, but the map is not the only contributor in this process. However, when designed with the context, purpose, user, and audience in mind, it does contribute to guiding the responsible actions that governmental policy- and decision-makers can take from the map.

7.2. LIMITATIONS

While this study brought fruitful insights concerning governmental map and GIS use, it was the first to touch upon the topic of responsible actions in governmental policy- and decision-making in deprived urban areas from a UCD perspective. Hence, this comes with several limitations.

First, this study did not provide a complete reflection of the population, especially since there were no actual governmental policy- and decision-makers that took part in one of the workshops. Yet, they were a central actor in this thesis. More specifically, only five focus groups with 5 to 10 people were performed, where four consisted of an academic participant group and one of a layman participant group. These workshops contributed to the basic understanding and evaluation of geospatial data visualizations for deprived urban areas yet are not able to gather all relevant opinions on this topic. By gathering more opinions bigger patterns can be identified and eventually, saturation can be accomplished. Now, there were still novel opinions that came around in the final workshop, which shows that there may be more to identify. Thus, this shows that there is no saturation yet and the group of participants may be too small. Especially, since this research had an exploratory goal, the performance of more workshops would be beneficial to the research process and outcome. However, this study still provides the first step in doing research on this topic and emphasizes the need to dig deeper.

A second limitation that can be found regards the way the visualizations are designed. During the focus group discussions, it oftentimes came forward that the visualization designs should be following the cartographic principles slightly more. These principles are aspects of color, figures, icons, etc. (see Section 3.3.1 on visualization design). If there was more time to perform this study, it would be ideal to iteratively go back to the designs of the geospatial data visualizations and incorporate the feedback that came forward from the focus group discussions. After the iteration phase, the designs could be evaluated again during an additional round of focus group discussions. In this way, the visualization designs can be tailored effectively to ensure their purpose of encouraging responsible actions of governmental policy- and decision-makers. Yet, it must be noted that many attributes of the geospatial data visualizations were evaluated positively, showing that the visualizations were sufficient for this first explorative study.

Thirdly, this study is limited in its usage of data on the waste management study in Nairobi. The input for the visualizations comes from an Excel file, i.e., static data. This data was gathered by the Community Mappers and only consists of minimal location-based information on the waste piles. It would be interesting to see how maps can be visualized using real-time data, especially since this is emphasized in existing literature on trends in governmental maps and GIS use. In this manner, more insights could be found regarding the actual problem of waste management in Nairobi and tailor the geospatial data visualizations to those real-time data.

Furthermore, it became apparent during the focus group discussions that the geospatial data visualizations were not completely applicable to the case study of the flooding issue in Jakarta. This concern was mainly raised by the geo-information specialists who took part in this study. It was argued that the waste management issue is more concerned with individual data points, while the flooding issue is more of a continuous problem over time. The ideal goal of the case study exercise was to investigate if the opinions gathered on the visualization designs, were coherent in different settings. However, this goal was not completely met since the applicability of the visualization designs was not sufficient. Thus, if there had been more time, more preliminary research would have been performed on different case studies to identify a more similar and, therefore, suitable case study to use in the focus group discussions. Still, this case study spiked many interesting discussions on deprivation and visualization designs in a different context, making it a relevant aspect of this thesis.

Finally, a limitation can be found in the philosophical analysis. While this analysis gives a comprehensive argument from a non-instrumentalist perspective, it still is a highly specific lens to shed light on the topic of encouraging responsible actions from governmental policy- and decision-makers.

7.3. PRACTICAL AND THEORETICAL IMPLICATIONS

This exploratory study yields both practical and theoretical implications. From a practical standpoint, the findings of this study have implications for the designing process in deprived urban area mapping. Specifically, it invites scrutiny into how geospatial data visualizations should be designed to be able to influence and prompt responsible actions towards governmental policy- and decision-makers. Notably, the integration of imagery relevant to the depicted issue becomes pivotal for establishing a tangible connection with reality, thereby engendering an awareness of the problem at hand. This awareness can lead users of the map to take responsible actions. However, it's important to note that these responsible actions depend on correctly understanding the visualized geospatial data, highlighting the significant role played by map users. Yet, there's a recognition that challenges in interpreting the visuals might arise, emphasizing the need for accurate visual depictions. Moreover, it's crucial to recognize the possibility of visuals having misleading elements that contribute to these interpretation challenges. For instance, in this study, the discussion about the heatmap illustrates how certain designs can have misleading elements that affect the map's usability and readability. These types of considerations should be included in the design phase and such map attributes should be critically evaluated to serve their purpose. Since the mapping process moved out of being solely in the hands of the state and more local ground knowledge is used during the process, many different actors are involved. Therefore, when designing geospatial visualizations, it's necessary to consider different contributors like designers, data collectors, and validators, each with distinct responsibilities within the context of creating maps for underprivileged areas.

The outcomes of this research emphasize that maps have the potential to reframe issues and prompt action by their design. Thus, the geospatial data visualizations used in this study can serve as a powerful tool for creating problem awareness and prompting governmental policy- and decision-makers to act on the waste issue in Nairobi. Yet, a map cannot be made responsibly without considering the context in which it is created. The audience, user, environment, and purpose of the map must be clear, and the map should be tailored to the specific user's context and needs.

From a theoretical standpoint, this study shows that mapping practices can benefit by incorporating cognitive load theory to process. Specifically, it was found during this research that before a map is made, attributes and relationships should be critically evaluated before being put on the geospatial data visualization and thus tailoring the map. By incorporating cognitive load theory into this phase, important components that help to reduce the load on the working memory and help to transfer knowledge to the long-term memory can be identified and added to the map. This indicates taking the principles of cognitive load for instructional design into account when creating the design. This, in turn, connects with the notion of information-for-reality and thus, also has implications for Borgmann's theory on information. While Borgmann only characterizes GIS as information-about-reality, this study has argued that GIS can also be information-for-reality. Thus, it adds to Borgmann's argument and changes the way maps are seen and consequently will be used. Maps for issues in deprived urban areas can benefit from this characterization since it shows that it will contribute to encouraging responsible actions from the user of the geospatial data visualization. It does not only show information and data about the issue but is also able to guide human actions from that data. Thinking about these theoretical implications impacts how these types of visualizations are going to be used.

Based on the limitations and implications of this study, the following directions for further research are recommended. Firstly, the visualization designs should be tailored more to the cartographic principles. Specifically, it would be recommended to make more use of the visual variables and consider cognitive load theory before the design phase. Secondly, to gather all relevant opinions and be able to accurately reflect the population, more focus groups should be performed with these novel visualization designs. It is advised to perform similar research as this current study and compare the results of the opinions on the visualizations with one another. In this way, the results of this study, with a smaller participant group and the original visualizations, can be compared to these new results without changing the research design and see if that stimulates more engagement with the topic. Thirdly, it is recommended to perform a longitudinal study with the Community Mappers. At this moment, they have received all the visualization designs, and they are free to use them for their own purposes. However, it would be beneficial to teach them how to create their own visualization designs and take more real-time data into account. In turn, those visualization designs can be implemented in Nairobi, and with longitudinal tracking, it can be seen if they contribute to creating problem awareness in practice and if they enforce responsibility by governmental policy- and decision-makers.

7.4. OVERALL CONCLUSION

This study has provided valuable insights into the use of geospatial data and visualization techniques for influencing responsible actions of governmental policy- and decision-makers in deprived urban areas. The research used a multi-faceted approach involving focus group discussions with an academic participant group and gathering insights from the Community Mappers during a workshop. The findings of this study shed light on the understanding of the role of geospatial data in mapping deprived urban areas by various stakeholders.

The investigation into the impact of the level of detail on stimulating engagement with the topic revealed an agreement among all participants regarding the value of including a high level of detail. However, caution was advised against overloading the user with information. Considerations of cognitive load during the design process emerged as pivotal for prompting responsible actions in governmental policy- and decision-makers. Moreover, the inclusion of pictures within geospatial data visualizations was evaluated positively by the focus group participants for stimulating engagement and connecting the users with reality. Also, overlay mapping emerged as a significant technique for mapping deprived urban areas, emphasizing the importance of tailoring maps to users' needs and purposes. Therefore, it has been argued that responsible mapping requires a careful selection of attributes and relationships based on the context, purpose, and map user to avoid information overload, ensuring that maps effectively create problem awareness and prompt action.

In conclusion, geospatial data visualizations possess the potential to mediate and guide responsible actions by governmental policy- and decision-makers in deprived urban areas. While this was the first effort to apply a UCD approach to this context, certain limitations were acknowledged. The study's scope of participants highlights the need for broader and more diverse participation to achieve saturation of opinions. Moreover, the potential for interpretation issues asks for accurate visualizations to avoid misleading attributes and distortion of the map. Theoretically, the study proposes the application of cognitive load theory to visualization design, offering insights into optimizing information presentation. It also extends the concept of geospatial data visualization from being information-about-reality to information-for-reality, aligning with the potential of maps to guide human actions.

For future research, it is suggested to include visualization designs incorporated with cartographic principles and cognitive load theory, to yield more effective outcomes. Additionally, conducting comparative research with a larger and more diverse participant pool would provide a comprehensive perspective on visualization preferences. Finally, longitudinal studies involving the Community Mappers, empowered with visualization skills, could offer practical insights into the real-world impact of visualizations on problem awareness and responsible actions by policymakers.

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9. APPENDICES

9.1. APPENDIX A. ADDITIONAL INFORMATION ON MAPS AND GIS

Table A1
Relevant definitions of maps

Definition	Elaboration	Relevant sources
A map is a graphic representation of the spatial relationships of entities within an area.	This definition shows that geographical data is used to accurately display the relationships between the data on a map.	(ESRI, n.d.-a)
A map is a true representation of reality.	This definition shows an essentialist perspective where maps were seen as ontologically secure and descriptive outputs of the real world.	(Robinson, 1952)
Maps are social constructions.	Harley's essay has been an influential piece of literature in the field of cartography, being one of the first to argue that maps are representations of power as opposed to the claim that maps are seen as a true representation of reality. In this way, he has proposed to change the way researchers interpret cartography's nature from maps and states that two definitions of cartography emerge, one for professionals and one for the general public. He uses deconstructionist strategies to argue for this claim and derives his information mainly from studies by Derrida and Foucault.	(Harley, 1989)
Maps are mutable and emergent and evolve from mapping practices.	The authors show that a shift is happening in the field of cartography. Maps can be seen as processual and emerge through practices in order to solve relation problems instead of solely representing science.	(Kitchin & Dodge, 2007).
Maps are constructed propositions that are ideologically loaded.	Wood and Fels discuss the prescriptive nature of maps and argue that maps can be seen as propositions, the medium through which specific actions are made On the map, inscriptions can be found, consciously placed there by its designer.	(Wood & Fels, 2008).
Maps are representations of power and knowledge.	Crampton and Krygier introduces the emergence of critical cartography, a *"one-two punch of new mapping practices and theoretical critique"*, to emphasize the political power of maps and link it to knowledge gathering. This indicates that mapmaking and cartography are no longer only saved for professionals in academics but are also made available for the public at large. In an earlier paper, the author makes the claim that cartography is going through a transformation and that maps should be recognized as social constructions instead of solely providing objective information as unproblematic communication devices. In this manner, Crampton emphasizes the ancestry of power found within mapping practices, enabling multiple, exploratory, and contingent standpoints of data.	(Crampton, 2001) (Crampton & Krygier, 2018, p. 11).
The production of a map influences how territory and space are experienced and defined.	The authors emphasize that maps mediate between the user/producer and the mapped world and shape the interpretation and experience of the world while changing the subject that produces and uses the map. They also mak the claim that maps are a tool to express state power. The perspective used to make this claim comes from the post-phenomenological perspective and especially the hermeneutic relation found in the readability of maps.	(Oluoch et al., 2022)

Table A2
Relevant definitions of GIS

Definition	Elaboration	Relevant sources
GIS has a powerful toolkit able to capture, store, process, and analyze large amounts of geospatial data that can be used to display representations from the real world.	Each feature in the geospatial data receives several descriptive attributes which are written down in spreadsheets. In turn, the data found in these spreadsheets can be layered to use for mapping and analysis. These systems have been around for quite some time already, where the field of GIS originates in the 1960s. While GIS was first mostly used for key geographic information science purposes, the systems became more widely available from the year 1981 onwards. Nowadays, GIS is used by many organizations globally to create digital visualizations of map layers in order to solve problems occurring in the real world. Geospatial data visualizations using GIS have had many different forms throughout the years, ranging from images resembling the real world to conceptual representations and models of spatial occurrences.	(Burrough et al., 2015; Conroy, 2006). (Dangermond, n.d.).
GIS maps are not solely a medium for displaying the final results of spatial analysis; they are integrated into the entire iterative process of handling geospatial data.	With the close link to new media technologies, geospatial data visualizations are influenced by many other disciplines. This indicates that maps now allow for more user interaction and the incorporation of dynamics into the visualization. Additionally, this resulted in the development of many customized mapping tools and the emergence of a wide range of design techniques for cartography. From the 1990s onwards, many developments occurred in the field of scientific visualization[13]. These studies have linked visualization to more advanced computer technology for making data visible to strengthen knowledge. In turn, this has led to the creation and definition of a map-based scientific visualization model which covers the thinking and communication attributes of a map. Altogether, this indicates that computer technology has become a more integral part of the process of visualizing real-time data, enhancing what the process of visualization actually entails.	(Gao et al., 2008; Kraak, 2004). (Peterson, 2020). (Zastrow, 2015)

[13] See McCormick B, DeFanti TA, Brown MD (1987) Visualization in Scientific Computing. *Computer Graphics* 21: 6 for more information on the developments found in scientific visualization.

Table A3
Relevant definitions of geospatial data visualizations

Definition	Elaboration	Relevant sources
The visualization of geographic information (spatial, temporal, or attribute, or a combination of all three), the process of creating interactive visualizations for geographic analysis, using maps, map-like displays, multimedia, plots and graphs (also in combination) to aid visual thinking and insight/hypotheses generation, and a perspective on cartography.	These geovisualizations, or geospatial data visualizations, can be performed in all sorts of ways, hence, there are many different visualization techniques that can be applied. The idea of visualizing data is to graphically represent information and data, which is in line with what a map entail. When looking at the visualization process in cartography several design principles can be found, which are visual contrast, legibility, figure-ground, hierarchical organization, and balance.	(Çöltekin et al., 2018). (Dent et al., n.d.; ESRI, n.d.-b; Robinson, 1995; Slocum & Slocum, 2009).

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9.2. APPENDIX B. PROTOCOL FOCUS GROUP

Introduction (duration of 10 minutes)
At the beginning of the workshop, the moderator and assistant of the focus group were introduced as well as doing a round of introduction for all participants present. After getting to know one another briefly, the Project Frame-PRO was introduced, elaborating on the purpose and focus of the research. This was followed by gathering informed consent from the participants and this was done by reading it out to the participants and letting them orally accept it. The informed consent that was gathered was the following:

The information in this study will be anonymized. All information shared by participants in this study will be handled confidentially. All participants are able to withdraw from the study at any given moment. The study is approved by the ethics committee of the UT. The session will be recorded. The data will be deleted after the summer break. Some demographic factors, i.e., age, gender, profession and highest level of education will be collected. If there are any problems after the study has been performed, the participant has the possibility to get in contact with the researchers to find a solution.

After the informed consent had been gathered, the topics and questions that will be discussed during the session were briefly touched upon.

Key concepts (duration of 10 minutes)
The primary goal of this topic was to explain all relevant key concepts concerning the research and especially what will be discussed during this workshop. This was done to ensure that all participants had a basic understanding of the concepts. The key concepts that were defined and elaborated on were geospatial data, deprived urban area and mapping, and responsibility and responsible mapping. The definitions and further information that was given were the following.

Geospatial data: Geospatial data is information about geographic locations that can be stored in and used with a geographic information system. This information can be represented in tabular form or specifically formatted dataset, stored in databases, and visualized using geographic visualization software. So this data is something that needs to be interpreted and curated, as just looking at it in "raw" form may not provide any useful insight. This was shown later using a spreadsheet of the data on trash piles.

Deprived urban area and mapping: Deprived urban areas can be seen as slums, informal settlements, and areas of inadequate housing. These areas can be mapped using geoinformation to inform urban policymaking by representing the social, political and environmental issues facing those living in deprived urban areas. These areas are mainly considered to be found and identified in the so-called Global South. The term deprived urban area is used instead of slum or informal settlement to avoid the historically prejudiced view of the term 'slum', and also to consider not just singular households (which is the way UN-Habitat considers classifies them) but looking at the economic, social and environmental situatedness that these areas are found. Over the past two decades, there has been an increased push to make use of geospatial data methods and technologies to identify and visualize these areas, which are often not very consistently represented in national census data or reference maps. Two examples were given for illustration.

Figure B1 + Figure B2
Examples of deprived urban area visualizations - Jeddah, Saudi Arabia

Source: (Fallatah et al., 2022)

Responsibility and responsible mapping: There is a responsibility that researchers have to the people that are being mapped, a responsibility that is not always overtly stated. More so, it is not always clear the extent to which communities living in deprived areas can even give their consent to the production of these maps. From the literature in the studies of critical geography and critical geoinformation science, it has become increasingly argued that maps are not neutral objects that we just see the world through. The choices made in the making of a map, making things visible that were not before and can make things invisible that should be visible. These choices are not always purely technical and are embedded in social as well as political relations that affect how those who are mapped end up being seen as well as treated (or remain unseen and forgotten). Thus, there is a need to consider the responsibility of those making maps and how the maps made can either speak for those being mapped or speak over and silence them.

Topic one: Knowledge about using geospatial data for deprived urban mapping (duration of 10 minutes)
The first actual item of the workshop served to break the ice and to get into the topic of using geospatial data for deprived urban area mapping. Post-its were used that were stuck to the wall so that the participants could always refer back to them. Afterward, an open discussion was held to discuss the similarities and differences found in the answers. The questions that the participants were asked and were also shown on the whiteboard were:

"Are any people familiar with using geospatial data?"
- **make the participants raise their hands**
- If yes, in what context?
- If no, do you think this data is similar to other kinds of data you might know and work with, or completely different?

"Is anyone concerned with deprived urban areas?"
- **make the participants raise their hands**
- If yes, in what context?
- If no, are you shocked to find out such places exist?

"What aspects can you think of when thinking about using geospatial data for deprived urban area mapping?"
- **use of post-its on the wall**
- Depending on the groups, this would be a good point to nudge some ethical concerns into the discussion.

Break (duration of 5 minutes)
After approximately 30 minutes, the participant had a small coffee and toilet break. This choice was made since topic two is more intense and interactive and therefore the participants needed a refreshed mind to fulfill the tasks.

Topic two: Nairobi waste management study and visualization techniques (duration of 30 minutes)
Before going into the tablet exercise, the context of the case studies from the project was introduced. This has been done with pictures of the waste problem (Fig. B3 + B4) and an elaboration on how the data was gathered. The data used was conducted by the Community Mappers team that is based in Kibera in the summer of 2021. A snapshot of the data in Excel was shown to the participants (Fig. B5).

Figure B3
Illustrations of the waste present in Nairobi.

Source: Nairobi Trash Study by Community Mappers and partners

Figure B4
Illustrations of the waste present in Nairobi.

Source: Nairobi Trash Study by Community Mappers and partners

Figure B5
Excel file of the data used for the visualizations.

start_t	end_ti	Team_ID	Date	Village	Latitude	Longitude	Altitud	Precisi	Size	Contents
2021-08-2	2021-08-2	Mathare - Orange	2021-08-2	3c	-1.2644427	36.857819	1606.912	9.648	Would fill 1-2 sacks	Textiles (e.g. old clothes) Plastic bags Plastic bottles or contain
2021-08-2	2021-08-2	Mathare - Blue	2021-08-2	No 10	-1.263836	36.8609877	1608.497	4.96	Would fill 1-2 sacks	Plastic bags Plastic bottles or containers Wool bags Polythene
2021-08-3	2021-08-3	Kibra - Orange	2021-08-3	Kibera	-1.3074523	36.7899704	1740.106	4.04	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Orange	2021-08-2	Kibera kianda	-1.3106683	36.7772183	1749.254	4.2	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Orange	2021-08-2	Kibera koanda	-1.3098718	36.777705	1746.492	3.9	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Orange	2021-08-2	Kibera ayany	-1.3074375	36.7771766	1748.897	3.9	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Pink	2021-08-2	Lindi	-1.3142442	36.7917845	1713.536	7.65	Would fill 1-2 sacks	Glass Polythene sheets Plastic bags Plastic bottles or containe
2021-08-2	2021-08-2	Kibra - Pink	2021-08-2	Mashimoni	-1.3095913	36.7916771	1727.361	4.2	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bottles or containe
2021-08-2	2021-08-2	Kibra - Pink	2021-08-2	Mashimoni	-1.3095705	36.7923182	1739.363	5.875	Would fill 1-2 sacks	Wool bags Wet organic waste (e.g. fresh food) Polythene shee
2021-08-2	2021-08-2	Kibra - Blue	2021-08-2	Mashimoni	-1.3106535	36.7916463	1717.139	4.66	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Blue	2021-08-2	Mashimoni	-1.309727	36.7913837	1720.945	3.9	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Blue	2021-08-2	Kambi muru	-1.3093621	36.7909287	1744.804	4.85	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Blue	2021-08-2	Kambi Muru	-1.310335	36.7896867	1730.053	3.9	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Blue	2021-08-2	Kambi Muru	-1.3113565	36.7871404	1848.711	4.9	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Blue	2021-08-2	Kambi Muru	-1.3120016	36.7859447	1847.099	4.933	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Kibra - Blue	2021-08-2	Gatwekera	-1.3137034	36.7837915	1750.705	5	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Mathare - Blue	2021-08-2	4a	-1.2608877	36.8610353	1610.211	5.466	Would fill 1-2 sacks	Polythene sheets Plastic bags Textiles (e.g. old clothes) Wool b
2021-08-2	2021-08-2	Mathare - Blue	2021-08-2	4a	-1.2625364	36.8583704	1605.696	7.525	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-09-(	2021-09-(	Kibra - Blue	2021-09-(	Gatwekera	-1.3165506	36.7811983	1757.467	4.9	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Mathare - Orange	2021-08-2	4b	-1.2633249	36.8561524	1604.322	8.833	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bottles or containe
2021-08-2	2021-08-2	Mathare - Orange	2021-08-2	4B	-1.2630812	36.8585221	1600.905	8.929	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles
2021-08-2	2021-08-2	Mathare - Orange	2021-08-2	4b	-1.2632287	36.8584542	1598.238	6.648	Would fill 1-2 sacks	Wool bags Textiles (e.g. old clothes) Plastic bags Plastic bottles

Source: Nairobi Trash Study by Community Mappers and partners

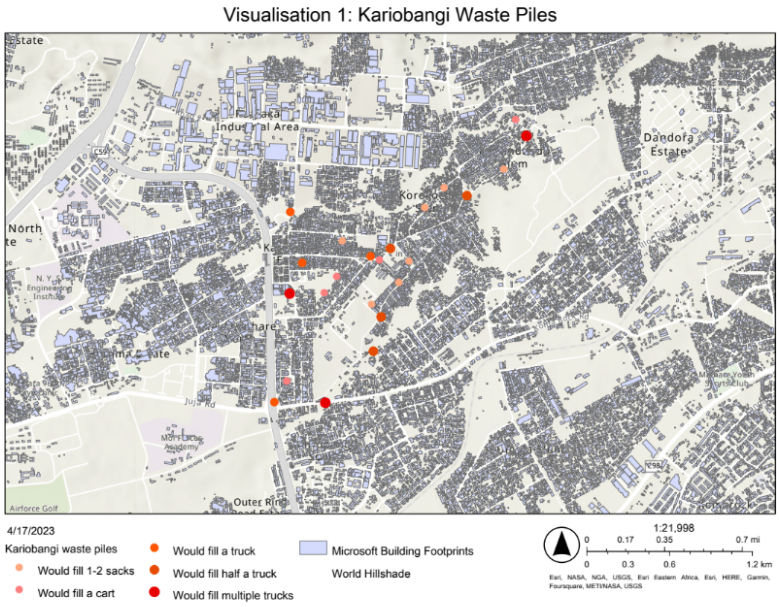
The idea of topic two was to show different map designs via tablets and discuss which maps the participants find useful, readable, and accurate in displaying the problem at stake. Here, the participants were asked to rank the seven map design from one to seven, where one is the lowest and seven is the highest. The variables for ranking were accuracy at identifying the problem, usability of the visualization, and readability of the visualization. The main purpose of the maps was to problem awareness of the waste issue to government policy- and decisionmakers to take action. The questions that the participants were asked and were shown on the white board were the following:

"How would you rank the following maps based on their usability, readability, and accuracy in displaying the problem at stake?"

"Which visualization shows the importance of looking into the problem of waste and why?"

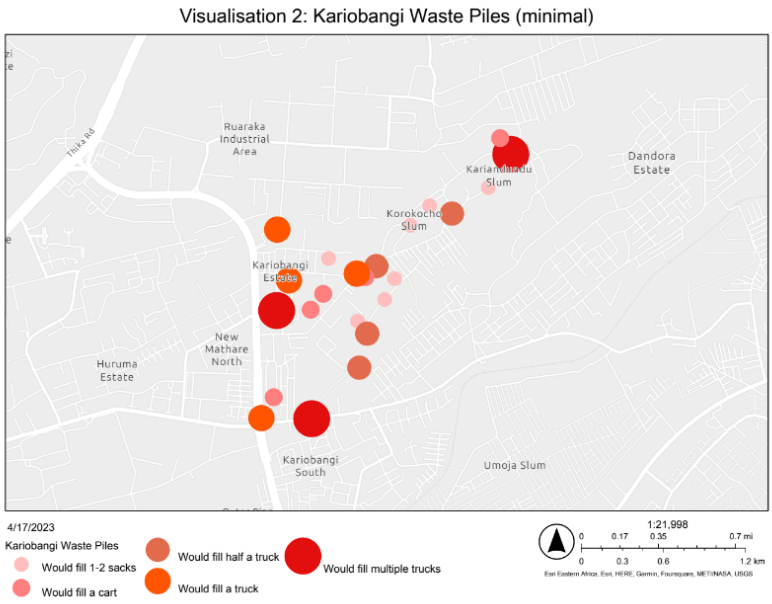
After explaining the exercise, the participants had approximately 20 minutes to explore all seven visualizations via the tablet and make their ranking. All visualizations were made from a low level of detail to a high level of detail. Also, image and text processing and overlay mapping were taken into account when designing the visualizations. This was followed by a discussion on the rankings, especially focusing on why the participants chose certain designs and design attributes over others. The first visualization used data from the Kariobangi area and contained minimal detail of the environment. It had a grey base layer background with Microsoft Building Footprints overlay of AI-generated geospatial data. The points of waste piles were in red colors gradient from light to dark. This indicated the least trash to most trash. Additionally, an image of a waste pile was attached to each waste point.

Figure B6
Visualization one.



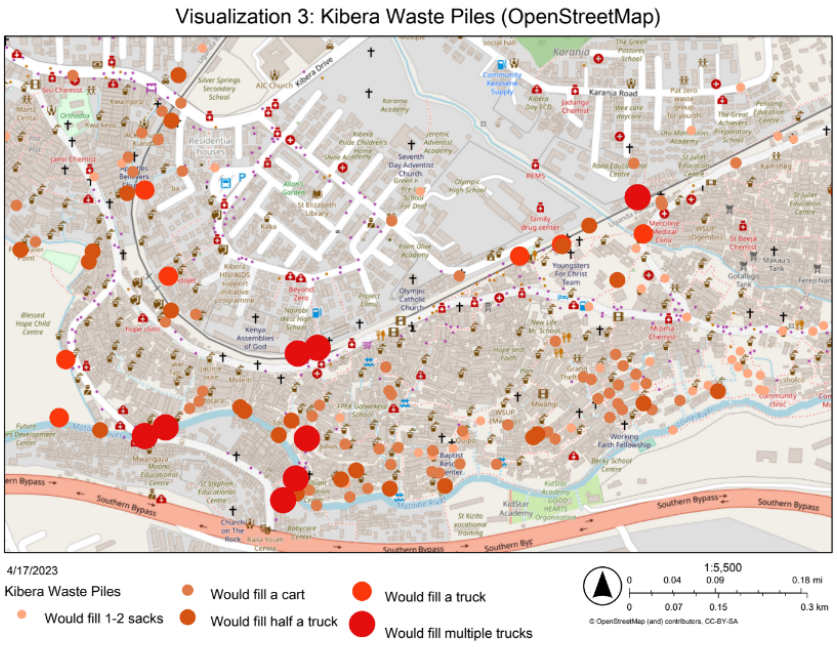
The second visualization also used data from the Kariobangi area and also contained minimal detail of the environment. It had a grey base layer background with no buildings shown. The points of the waste piles were also in red colors, gradient from light to dark. This indicated the least to the most trash. No image was attached to the waste piles.

Figure B7
Visualization two.



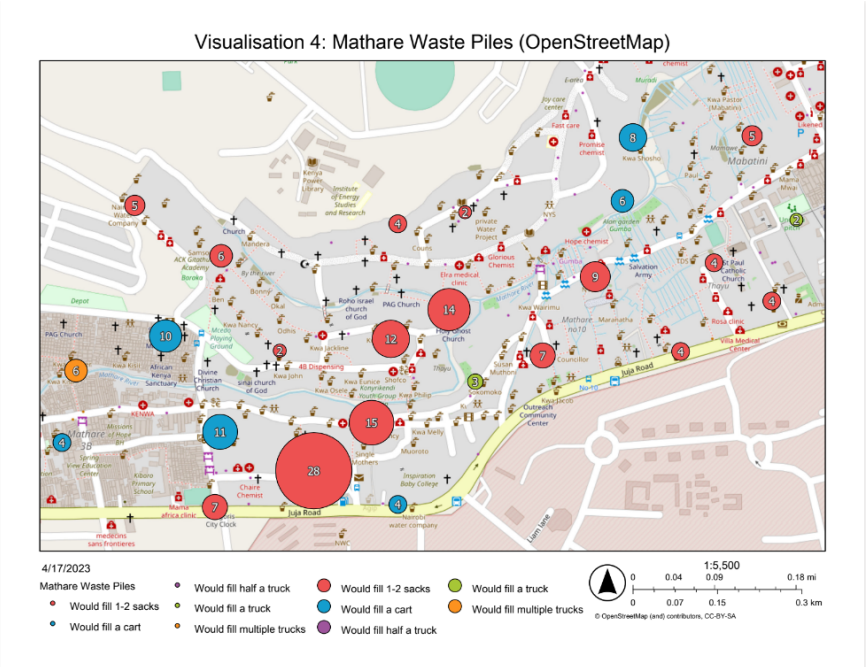
The third visualization used data from a different location, this was in Kibera and it contained highly detailed and labelled areas. It had a OpenStreetMap base layer. The points of waste pile were in red colors gradient from light to dark. This indicated the least trash to the most trash.

Figure B8
Visualization three.



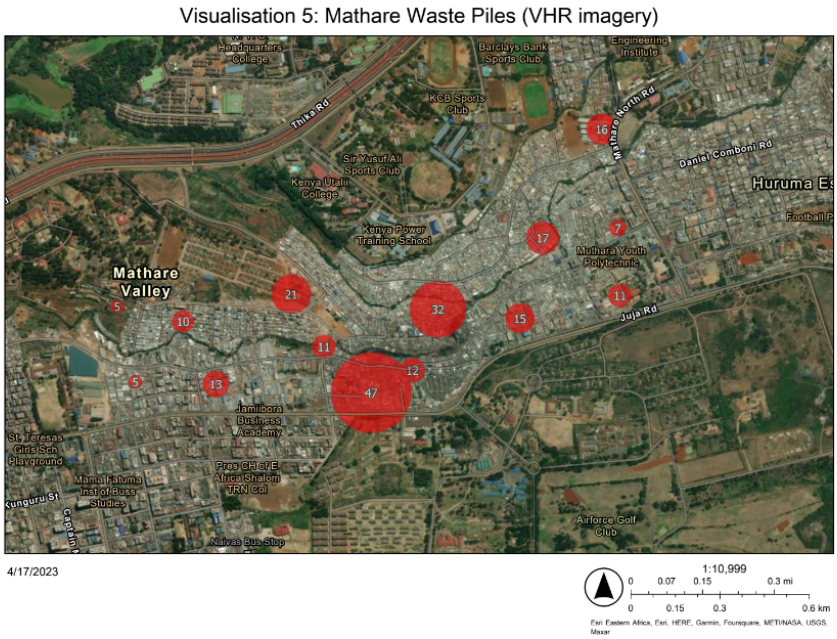
The fourth visualization also used data from a different location, i.e., Mathare, and it contained highly detailed and labeled areas. Again, the OpenStreetMap base layer was used. Here, aggregated points of the waste piles were visualized, which shows clusters based on proximity.

Figure B9
Visualization four.



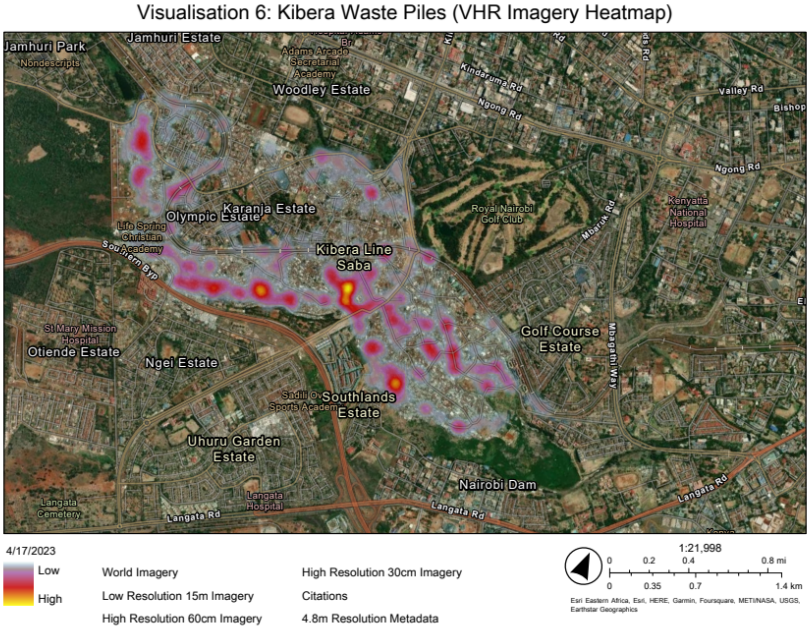
The fifth visualization also used the data from Mathare and contained a high-res satellite image where buildings are identifiable. Similar to visualization four, the aggregated points of waste piles are used, which shows clusters based on proximity.

Figure B10
Visualization five.



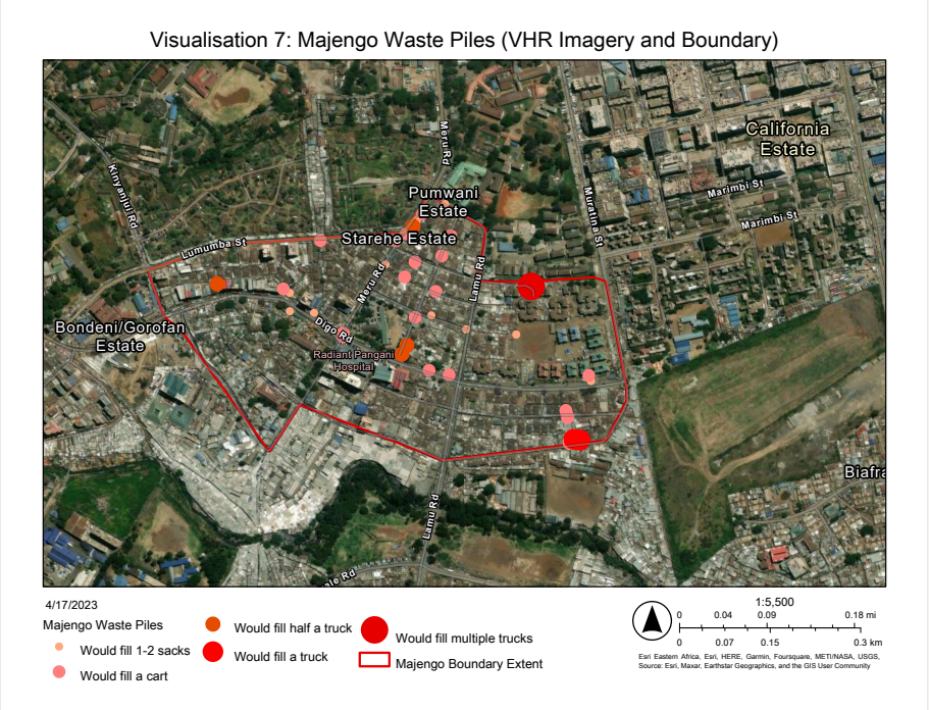
The sixth visualization used locational data from the Kibera region and it contained a high-res satellite image with identifiable buildings. This was designed as a heatmap showing the most concentrated areas of trash build-up.

Figure B11
Visualization six.



The seventh visualization used data from another region, i.e., Majengo, and it contained a high-res satellite image with identifiable buildings. It had points of the waste piles in red colours gradient from light to dark. This indicated the least trash to the most trash. Additionally, a boundary of the deprived area extent was drawn.

Figure B12
Visualization seven.



Topic three: Responsible mapping (duration of 10 minutes)
The third topic served to head into the topic of the case study. Here the maps from Isaac explored in the previous topic, were used as an example to introduce the topic of responsibility when mapping deprived urban areas. The following questions were asked to the participants and afterwards, an open discussion was held.

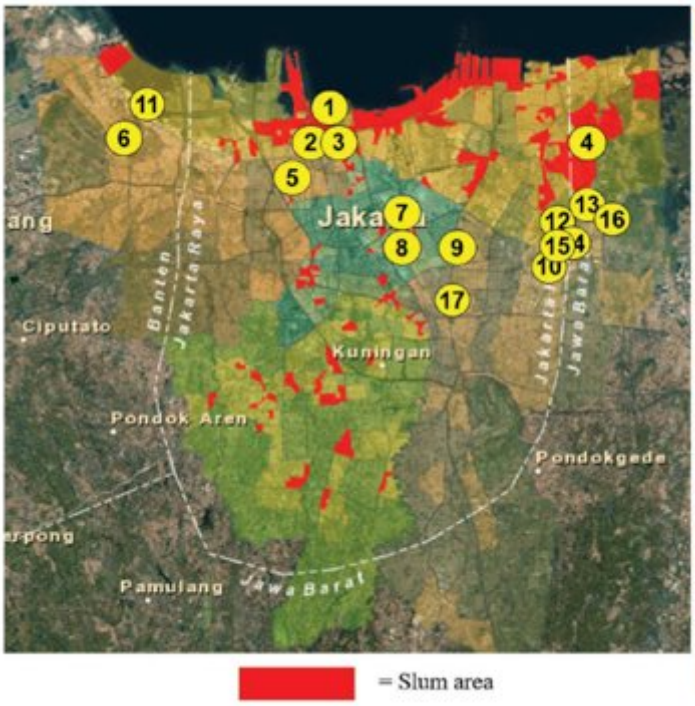
"What aspects do you think of when hearing the term responsible mapping?"

"Do you feel that responsibility is an important topic in deprived urban area mapping, why?"

Break (duration of 5 - 10 minutes)
After approximately 1 hour and 20 minutes, the participants again had a coffee and toilet break. This choice was made since topics two and three were quite intense and interactive and therefore the participants needed a breather before going into the case study. During the break, the moderator placed multiple print-outs of all visualizations as well as a print-out of the case study on the table in front of the participants.

Topic four: Case study for responsible mapping (duration of 20 minutes)
For the final topic of this focus group, the participants received a case study exercise on a different deprived urban area compared to the Nairobi waste study. This case study concerned the sinking problem of Jakarta and was introduced with an example of a deprived urban area map of Jakarta (see Fig. B13).

Figure B13
Deprived urban area map of Jakarta.



No	Rusunawa
1	Waduk Pluit (Muara Baru)
2	Penjaringan
3	Kapuk Muara
4	Sukapura
5	Tambora
6	Flamboyan
7	Karang Anyar
8	Jati Rawa Sari
9	Cipinang Besar Utara
10	Jatinegara Kaum
11	Daan Mogot
12	Komarudin
13	Tipar Cakung
14	Pinus Elok
15	Cakung Barat
16	Pulo Gebang
17	Jatinegara Barat

Source: (Sholihah & Shaojun, 2018)

The case study that was presented to the participants was the following:

Imagine you are part of the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration of the Indonesian government and are asked to look into mapping the sinking problem of the capital, Jakarta. Currently, this city floods often and is the world's most rapidly sinking city, which is due to the fact that it is built on a delta. Earlier governmental decisions have been made to prevent the city from sinking, such as a coastal wall. However, this wall did not solve the underlying problem of the rising of the sea – the over-extraction of groundwater due to a lack of adequate public water supply – and thus specific areas of Jakarta must currently live with chronic flooding. These areas are located around the coast, e.g., North Jakarta, and can be seen as urban deprived areas due to their living conditions and the flooding issue at play. These coastal communities experience floods daily which makes them highly vulnerable. The Indonesian provincial and national government has come up with a plan of constructing a new wall along the coastlines, yet, this is a temporary solution since the sea level will continue to rise. Moreover, the government decided upon the construction of the "Giant Sea Wall", an artificial island offshore in the bay of Jakarta. However, critics address that this island would also eventually sink since the underlying problem is not tackled. At last, the government plans to "move" the capital Jakarta and the government itself to Borneo, leaving the sinking problem and the vulnerable coastal communities behind. Therefore, the question arises of how to effectively aid the vulnerable communities that reside there. Problematic in this case is the lack of governmental responsibility. Instead of moving the problem, a first solution could be to use geospatial data for responsibly mapping urban deprived areas to visualize which areas are impacted by the sinking problem specifically and how badly they are impacted. In this way, you are asked to identify what problems are at stake in the affected areas and thus you are asked to answer the following question: ***"How would you visualize the deprived urban area of Jakarta by using geospatial data to be able to have effective and responsible decision-making on the flooding issue? "***

After introducing the problem of the case study, it was explained to the participants that they needed to discuss together as a group which attributes of the earlier shown geospatial data visualizations are necessary when performing responsible mapping. The idea here was to find out which attributes are most important, why is that the case, and how to present this in relation to choosing the visualization to use in the case study. The participants were asked the following questions to spike the discussion:

"Which attributes are the most important for a map of a deprived urban area to have?"

"How would you justify the choices you made?"

"Do you feel that these choices need to be communicated to the people being mapped?"

Closing (duration of 5 – 10 minutes)
When everything had been discussed during the exercises, the focus group was round of. However, participants were still asked about their final thoughts and ideas or their need for additional information. When that was provided, a thank word was given and the focus group was finished.

9.3. APPENDIX C. PROTOCOL COMMUNITY MAPPERS WORKSHOP

Introduction (duration of 20 minutes)
To start the workshop with the Community Mappers, an elaborate introduction was held. The reason behind this was to create a safe and familiar setting for all participants. According to Monika Kuffer, this is beneficial for the African affiliates since they value getting to know one another highly in their culture before feeling comfortable sharing more information. This was performed by introducing the researchers of the project as well as all participants. It was important to really take the time for this first segment of the workshop, for the reason mentioned above. Secondly, a bridge was made to the project where the details of the project until now were discussed. Afterward, the participants were asked if they agreed with recording the workshop and using the results of the workshop for the project. After the introduction of the participants and the informed consent, the participants were asked about their involvement in the project. Here, the participants have the space to share their experiences. To conclude the introduction, an explanation was provided on what will come forward during the workshop. This table of contents contains 1) How have we used the data?; 2) What did we find in the workshops?; 3) Gathering opinions on four visualizations via Google Jamboard. Important for the latter was to explain that their opinion is valued and not only the opinions from academics.

Data usage (duration of 10 minutes)
For the second item of the workshop, it was elaborately explained what happened with their data and how it was used in the project. More specifically, it was discussed how the Excel file with data was used as input for making seven geospatial visualizations. These visualizations differed primarily in the level of detail, which translates both to the background use as well as the use of signs and attributes in the design visualization. After the geospatial visualizations were fabricated, they were tested in four workshops. In this workshop, specialists in geospatial data, visualization techniques, and philosophy got together to share their opinions toward the visualizations. Here, the participants worked with tablets to interact with the visualizations. The goal of these workshops was to find out which visualization works best to create problem awareness of the waste issue to policy- and decision-makers in deprived urban areas and to find out how to perform responsible mapmaking.

Feedback exercise via Google Jamboard (duration of 60 minutes)
The idea of the feedback exercise was to also gather opinions of the people who gathered the data used for the visualization on the visualizations. The participants were asked to get their mobile phones and open four separate links. Following each link, a different visualization was displayed. The decision has been made to choose four visualizations (two with OpenStreetMap and two with satellite due to the amount of time). An explanation was provided on how the Google Jamboard application works and the participants were asked what they like and do not like about each visualization. The participants were asked to add green sticky notes with positive comments on the visualization and red sticky notes with negative comments on the visualization. If the internet disconnects, the participants are able to add offline comments. After each visualization, the participants got the opportunity to have an open discussion on the answers. These images are used as input for the results section.

Results of the workshops (approx. 10 minutes)
In this segment of the workshop, the main findings of the focus group discussion were elaborated on. These include the results of the ranking as well as the qualitative results. Both can be found in chapter four. Again, there is space available for the participants to ask questions.

Closing
After the participants have given their opinion it is time to round off the meeting. The participants were asked if they want to add anything or have any advice or suggestions for the project. Finally, the participants were thanked for their participation, their time and their inputs. At last, Nicera was thanked for organizing the meeting.

9.4. APPENDIX D. CODEBOOK

Table D1
Code group "Deprived urban area"

Code	Name	Description	Example
DUA1	Deprivation in deprived urban areas	This code is used when the piece of text was concerned with specific aspects of deprivation that can be found in deprived urban areas.	"How is deprivation actually framed?"
DUA2	Deprived urban area issues	This code is used when the focus of the fragment was on the issues that are connected with deprived urban areas.	"Usually one sees that those places are in places that are quite vulnerable to, for example, floods or bushfires."
DUA3	Deprived urban area characteristics	This code is slightly different compared to the previous code since it relates more to the general attributes of deprived urban areas.	"Because it's mostly social housing. So it's the lower socioeconomic status relatively."

Note: This code group contains all codes that relate to the concept of a deprived urban area.

Table D2
Code group "Deprived urban area mapping"

Code	Name	Description	Example
DUAM1	Aspects of deprived urban area mapping	This code is assigned to fragments of the transcription when it concerns attributes of the process of mapping and visualizing deprived urban areas.	"So, there was a lot of working with people on the ground to understand the informal land markets and where they were, how they were operating, and so on."
DUAM2	Consequences of mapping	This code relates to all fragments in the transcriptions that are concerned with the consequences of everything that is related to making a map and using geo-data.	"So, who has access to that data? To what extent can it be used, you know, to implement whatever you want to do?"
DUAM3	Goal of deprived urban area mapping	This code is used when the participants specifically mentioned the goal or output of deprived urban area mapping.	"And so, like actually drawing like this blobby area of like where trash is being produced and underserved and that this garbage map in relation to like, what kind of municipal garbage pickup is available seems really important."
DUAM4	Mapping in the Netherlands	This code is used when specific characteristics of the mapping process in the Netherlands are mentioned.	"Of course, maybe here we have, but only when you know, easier access to the data and more offices where you can complain."
DUAM5	Vulnerability in mapping	This code is used when the concept of vulnerability in light of deprived urban area mapping is mentioned.	"Because there's lots of vulnerability maps. That's what usually is done, you know, risk and vulnerability."

Note: This code group contains all codes that relate to the concept of deprived urban area mapping in general.

Table D3
Code group "Deprived urban area mapping issues"

Code	Name	Description	Example
DUAMI1	Ethical concerns	This code is used when ethical issues related to deprived urban area mapping are mentioned.	"So, I also thought about the question of consent. Do people know that they are being mapped? Do they agree that it should be happening?"
DUAMI2	Practical concerns	This code is assigned to fragments where participants discussed the more practical issues that relate to deprived urban area mapping.	"And the problem here is not really sea level rise. It's not negligible here because it's only, let's say, a centimeter a year. But it's the groundwater extractions which are usually not taking place directly in the slums."
DUAMI3	Societal concerns	This code is assigned to fragments where participants discussed the more societal issues that relate to deprived urban area mapping.	"And even as you say, people might be willing to go, but then where can they go, as you said."

Note: This code group contains all codes that relate to concerns found when performing deprived urban area mapping.

Table D4
Code group "Examples"

Code	Name	Description	Example
E1	Case study examples	This code is used for examples that were given that relate to the case study exercise (flood problem Jakarta).	"Because I think it was in Hong Kong, over the years you could also see that the city was desperately subsiding into the sea. And then at one point they stopped extracting groundwater or something and then it stalled basically."
E2	Deprived urban area examples	This code concerns examples of different deprived urban areas compared to the deprived urban areas in Nairobi and Jakarta.	"I was thinking because if we apply these the ESRI one and the Microsoft one in areas like slums of Mumbai, I don't think you will probably get to visualize much. It would be like cluster of like rectangular plots because it's very narrow and so much goes in there."
E3	Visualization examples	This code is assigned to examples that specifically emphasize the visualization of geo-data, but in a different context than the waste study discussed.	"If we look at this particular map and you see the red circle on the map, thick, red, black edge, that gives you a sense of urgency, something is going on. So, if you were to play down the problem, you would make a nice light green circle without an edge and then the problem already seems far less problematic."

Note: This code group contains all codes that relate to examples mentioned by the participants during the workshop.

Table D5
Code group "Flow of the workshop"

Code	Name	Description	Example
F1	Clarification	This code is assigned to all the pieces of text where the participant asked for a clarification of information.	"So here we write down the visualizations?"
F2	Questioning	This code relates more to the flow of the focus group since it concerns fragments where participants have their doubts about anything.	"So how do I conceptualize risk? Before I can say how I map it."

Note: This code group contains all codes that relate to the structure of the workshop and not to the content talked about in the workshop.

Table D6
Code group "Geo-data"

Code	Name	Description	Example
G1	Issues in using geo-data	This code is used when the participants mention any concerns about the use of geo-data.	"But also mapping areas that are difficult to map and using those maps for local benefits."
G2	Purpose of using geo-data	This code is given to all pieces of text that talk about why and for what goal geo-data is used.	"Specifically for deprived areas, it enables to quantify the areas that are deprived."
G3	Use of geo-data	This code relates to fragments of the transcriptions that discuss how geo-data can be used.	"Well, among others, we use them to analyze deprived areas, but we also use them to analyze public space or, um, analyzing access to transportation."

Note: This code group contains all codes that relate to how and why geo-data is used and its corresponding concerns.

Table D7

Code group "Purpose of the map"

Code	Name	Description	Example
P1	Choice of approach	This code does not necessarily relates to a specific purpose of the map but is used when the fragment is about the choices made before defining the purpose of the map or the approach taken for mapmaking.	"Yeah, I think it does. It depends on a bit if you're proactive or reactive in your approach."
P2	Connection with inhabitants	This code is used when a participant talked about there being a connection between inhabitants and geo-data and/or governmental decision-makers when performing mapmaking.	"So, again, if the purpose of this mapping is, let's say, to improve the circumstances of the people living there."
P3	Decision-making	The code decision-making is used when the participant mentions that the purpose of the map is to make decisions (governmental decision-making).	"You said we should think of decision makers looking at that and how decision makers use the information for making decisions."
P4	Explaining relationships	This code is assigned when a piece of text is about explaining relationships as a purpose of the map.	"I think you can use mapping to call attention to the relationality inherent to the problem."
P5	Problem awareness	This code is assigned when the participants discuss how to make policy- and decision-makers aware of the problem with the visualization and how the visualization shows that there is a problem.	"The goal is to show this to policymakers and you want them to see there is a problem and they want them to act."
P6	Storytelling	This code is used when the piece of text concerned talking about the fact that maps can be used for storytelling as a way of bringing a certain message across.	"Yeah, I think you can use maps to tell these different stories. They reframe the problem in different ways, right? Based on the attributes that you're choosing to represent and the relationships that you're choosing to represent."

Note: This code group contains all codes that relate to possible purposes and goals of using a map in light of humanitarian aid and deprived urban areas.

Table D8
Code group "Responsibility"

Code	Name	Description	Example
R1	Governmental responsibility	This code concerns pieces of text where the responsibility of governments/policy- and decision-makers towards deprived urban areas is discussed.	"And as politicians usually have the urge to not do anything about things that are not in their specific area. And it might not be good to have such an administrative border in it."
R2	Important to consider context with mapping	This code is assigned when the participant explained that the context is important to take into consideration when talking about mapping and responsibility.	"So I agree, before you can make a map, you need to know better the context and also the possibilities of using which types of maps."
R3	Neutrality in maps	This code concerns all fragments of the transcription where the participants discussed if a map is neutral or not.	"I think a map can never be neutral. You can try to make it as neutral as possible."
R4	Responsibility in map actors	This code is used when the participants discussed how specific actors in the mapping process have a responsibility.	"You have to be responsible towards the audience that you are mapping."
R5	Responsibility issues	The code responsibility issues relates to all fragments where the participants see any problem on how to be responsible in mapmaking.	"I think there were some people with good intentions involved in that sort of process of the mapping. And they were just completely oblivious or chose not to think about the broader sort of political context of the conversations going on in the area about how the problem is framed and about how the different interests involved."
R6	Responsible mapping	This code is assigned when attributes or characteristics of how to create maps in a responsible manner are mentioned.	"So here, one of the responsible kind of aspects that I think is good is to represent error, because all these things are going to be based on historical type of data and they're going to be predictions, but they're not necessarily going to be reality."

Note: This code group contains all codes that relate to the notion of responsibility, which was discussed earlier in the keywords section. In this manner, responsibility is connected with deprived urban area mapping.

Table D9
Code group "Visualization issues"

Code	Name	Description	Example
VI1	Heatmap negative	This code is assigned when issues or negative opinions towards the heatmap design of one of the visualizations are mentioned.	"Yeah, no, I put visualization one, the heat map as the worst one."
VI2	High level of details negative	This code relates to all pieces of text where one of the participants showed a negative opinion towards a high level of details found in the visualizations.	"I think the maps with satellite data, the last three I think, they like overlay data, let's say overlay maps, I found them the least usable and readable, because there's information overload, especially like all the tiny details are there. And in terms of, let's say the location and also the road names, maybe it's useful, but still, I found it a bit too much of information."
VI3	Interpretation issues	This code was assigned when difficulties in the interpretation of the visualization or map design are mentioned.	"What should I interpret? Because most of the policymakers are not somebody who is very much knowledgeable in this domain, and they wouldn't be interpreting it the way our technically apt person would be."
VI4	Low level of details negative	This code relates to all pieces of text where one of the participants showed a negative opinion towards a low level of details found in the visualizations.	"I disagree maybe just a little bit about the point of the satellite imagery, because for me, the very simple visualizations tended to rank a little bit lower because I did not think about so much like, how does this show me that this is a problem?"
VI5	Misleading visualization attributes	This code is assigned when attributes or specifics of the map visualizations mislead the user in any way.	"But when you look very carefully at it, then you are completely misled because some very strong colors seem to be just a little bit of trash when you are zooming in."
VI6	Privacy issues	The code privacy issues is used when anything related to privacy concerns and the visualization of deprived urban areas was mentioned.	"And also for me, when I zoom in on the satellite, I see the specific house and I see the dot. And for me, maybe it connects to the people living there more."
VI7	Symbology use negative	This code relates to all pieces of text that concern the use of specific symbols on the map in a negative way.	"I agree that map three with the crosses, the red crosses, that is confusing because I don't know what they are. They're not part of it. It's part of the base layer. But they're not part of the other dots. But they are red as well. When I first looked at it, I was wondering what they these were."

VI8	Use of a border negative	This code is used for pieces of text that concern a negative opinion towards the use of a border in the visualizations.	"But when it was zoomed out and there was kind of a border around this space, I think that sends a wrong message, that this area is all trash, right? It sort of encompasses the entire area."
VI9	Use of color negative	This code concerns all fragments of text that talk about issues in the color use of the visualizations.	"The colors are a bit arbitrary."

Note: This code group contains all codes that emphasize any negative opinion toward specific visualization attributes of the designs presented in the workshop.

Table D10
Code group "Visualization remarks"

Code	Name	Description	Example
VR1	Design remarks	The code design remarks is used when the participants mentioned specific advice on how to improve the design of the visualization. This does not concern the specific attributes on the map but is more about the actual design and visual outlook of the map.	"From a static map or even an animated map, well definitely an animated map is probably more stimulating than a static map."
VR2	Important to use overlay mapping	This code is used when one of the participants mentioned anything related to the importance of using overlay mapping or the specifics of the layers of overlay mapping.	"You could first present maps that just present facts so to say. So, you have now already made slum maps where they are. So that would be layer number one, so to say. And then then you would probably create a kind of risk map of the flooding and you overlap them and of course they will overlap, but then you will see the urgency of the problem."
VR3	Important to visualize relationships	This code was given to all pieces of text that were related to the importance to visualize relationships on the map, besides only visualizing the data.	"You can see sort of housing, but you can see, you know, churches, of course, and libraries and all these other sites. I think for me, that highlights the sort of human connection, the sort of human toll of the waste in a way that I found effective in terms of highlighting the problem. The problem isn't just that there is waste, the problem is that there is waste in people's everyday spaces, right? So that for me was, was effective."
VR4	Inclusion of specific relationships	This code relates to all specific relationships mentioned by the participants that would be beneficial to add to the visualization.	"I mean sort of relating to this. I think something that I was missing, and I don't know if you have this data, but I was sort of wondering if there are sites of sort of waste disposal services that could be mapped here so that it's not just showing that there's the waste, but that it's showing that there's the waste because there's a lack of services."
VR5	Symbology use remarks	This code is assigned when advice was given by the participant about adding specific symbology to the map.	"For example you could bin the whole place with hexagons or squares and you could color the hexagons for how bad the trash is in each hexagon."

Note: This code group contains all codes that are given towards specific remarks or advice on the attributes and design of the visualizations presented in the workshop

Table D11

Code group "Visualization strengths"

Code	Name	Description	Example
VS1	Heatmap positive	This code is used for positive opinions mentioned regarding the heatmap design of one of the visualizations.	"So, I like ones that look like heat maps like visualization one, because it should be able to give an indication of the size of the problem in a certain area."
VS2	High level of details positive	This code relates to all pieces of text where one of the participants showed a positive opinion towards a high level of details found in the visualizations.	"But the maps I preferred most, more related to decision making, are the maps three and four, because they have functions, for example, hospitals and churches are also displayed on the map, which makes it maybe easier for the solution aspect."
VS3	Low level of details positive	This code is the opposite of the previous code and relates to all pieces of text where one of the participants showed a positive opinion towards a low level of details found in the visualizations.	"And visuals two is on place six. It's simple. I like it. I like simple things. It's comparable to, let's say, the previous one, because this is so pure. Like it only gives the information where it is, you know, these dots. It's easy to point out where we can find these areas."
VS4	Symbology use positive	This code relates to all pieces of text that concern the use of specific symbols on the map in a positive way.	"What I really liked about visualization one, for example, even though I put it on place three, was that you added the pictures."
VS5	Use of a border positive	This code is assigned when the participant discussed the border as a positive design attribute.	"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."
VS6	Use of color positive	This code concerns all the pieces of text where positive comments are made about color use in the visualizations.	"And the third place is visual five. I found it a bit, compared to the other ones, less confusing because it's monochrome. So, this is monochrome, which means that the color is just the same."

Note: This code group contains all codes that emphasize any positive opinion toward specific visualization attributes of the designs presented in the workshop.

9.5. APPENDIX E. RELIABILITY ANALYSIS

Table E1
Intercoder reliability

Citation	Original code	Second coder	After consultation
1	VR1	VR1	
2	VI5	VI5	
3	VI9	VI9	
4	VI5	VR3	VI5
5	VR1	VR1	
6	VS6	VS6	
7	VI5	VI5	
8.1	VR4	VR4	
8.2	VI7	VI4	VI7
9.1	VR4	VR4	
9.2	VI7	VI4	VI7
10	VI5	VI3	VI5 +VI3
11.1	VI5	VI5	
11.2	VI1	VI1	
12	VS1	VS1	
13	VI5	VI5	
14	VS1	VS1	
15	VR5	VR5	
16	F2	F2	
17	VI5	VI1	VI5 + VI1
18.1	VS1	VS1	
18.2	P3	P3	
19	G2	G2	
20	P5	P5	
21	R2	R2	
22	P1	P1	
23	VI3	VI3	
24	P5	P5	
25	VI1	VI1	
26	VI3	G3	VI3
27	VS4	VS4	
28.1	VR1	VR1	
28.2	VI5	x	VI5
29.1	VR1	VR1	
29.2	VR5	x	VR5
30	VI5	VI2	VI5
31.1	VI3	VI3	
31.2	P5	VI2	P5
32	VR5	VS4	VR5
33	VS5	VS5	
34	VS5	VS5	
35	P5	P5	
36	VI5	VI5	
37.1	VR5	VR5	
37.2	VI9	x	VI9
38	VR1	VR1	
39.1	R2	R2	
39.2	VI3	VI3	
40.1	P5	P5	
40.2	VR1	VR1	
40.3	VS2	x	VS2
41	VS5	VS5	
42	VI1	VI1	

43.1	VI3	VI3	
43.2	F2	F2	
44	VS2	VS2	
45	VI2	VI2	
46	VI7	VI7	
47	P6	P6	
48.1	VI5	VI5	
48.2	VI2	VI2	
49	VI2	VI2	
50	VI2	VI2	
51.1	P2	VR1	P2
51.2	VS2	x	VS2
51.3	VR3	x	R3
52.1	VI3	VI3	
52.2	R2	x	R2
53	VI3	VI3	
54	VS3	VS3	
55.1	R2	R2	
55.2	VS2	x	VS2
56	VI6	VI6	
57	VI6	VI6	
58	VI6	V16	
59	VI6	P4	VI6
60.1	F1	F1	
60.2	F2	F2	
61	P3	P3	
62	P5	P5	
63	P3	P3	
64	VS3	VS3	
65.1	VS3	VS3	
65.2	VR1	VI3	VR1
66.1	VS3	VS3	
66.2	VS2	x	VS2
67.1	P3	P3	
67.2	VS2	VS2	
68.1	P3	P3	
68.2	VS2	VS2	
68.3	VS3	VS3	
69	VS3	VR1	VS3
70.1	P3	P3	
70.2	P5	P5	
70.3	VI1	x	VI1
71	VI1	VI1	
72	VI4	VI4	
73.1	VI1	VI1	
73.2	P3	P3	
74.1	VI3	VI3	
74.2	VI4	VI4	
75	VS1	VI3	VS1
76.1	VS5	x	VS5
76.2	VR5	VR5	
77	F2	F2	
78	VI5	VI5	
79.1	VI5	VI5	
79.2	VI3	VI3	
80	VS6	VS6	
81.1	VR5	VS4	VR5
81.2	x	VS6	x
82	VR5	VR5	
83	VR5	VR5	

Table E2
Cohen's Kappa Symmetric Measures

		Value	Asymptotic Standard Error	Approximate T	Approximate Significance
Measure of Agreement	Kappa	.740	.042	35.842	<.001
N of Valid Cases		113			

9.6. APPENDIX F. OUTPUTS OF THE COMMUNITY MAPPERS WORKSHOPS

Figure F1
Visualization Two

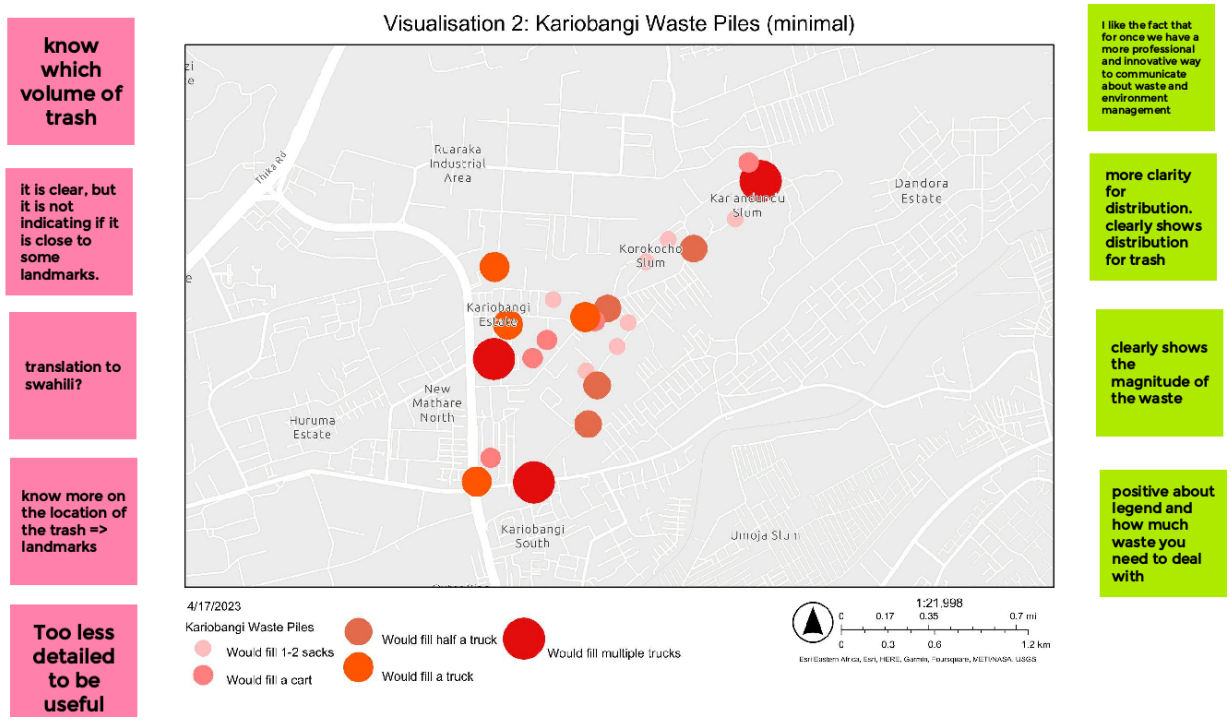


Figure F2
Visualization three

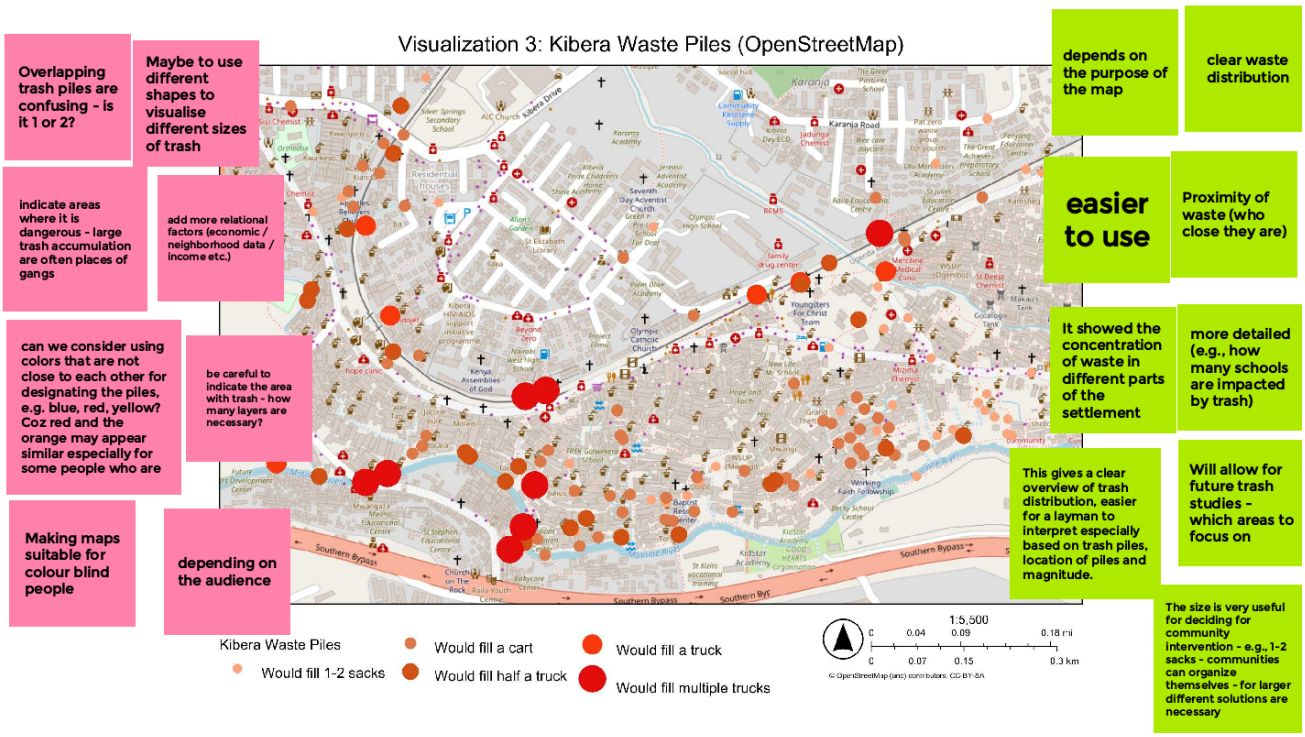


Figure F3
Visualization 5

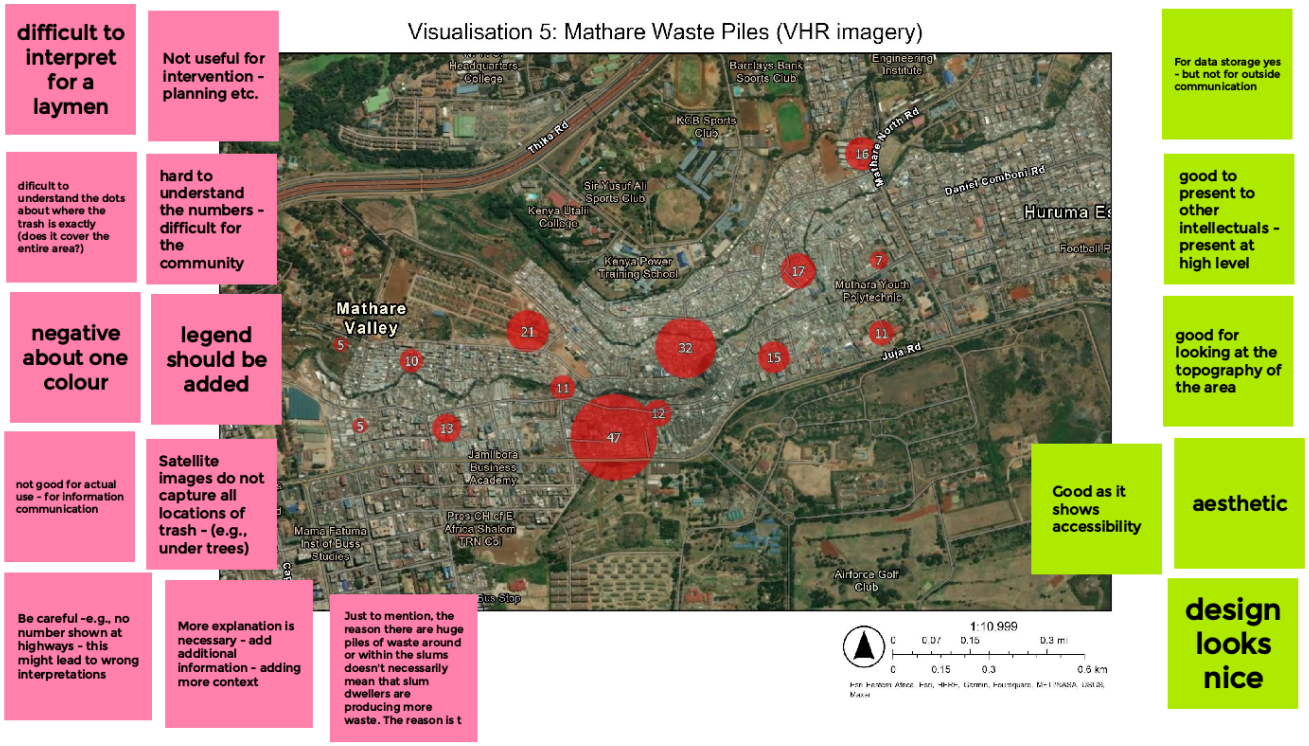
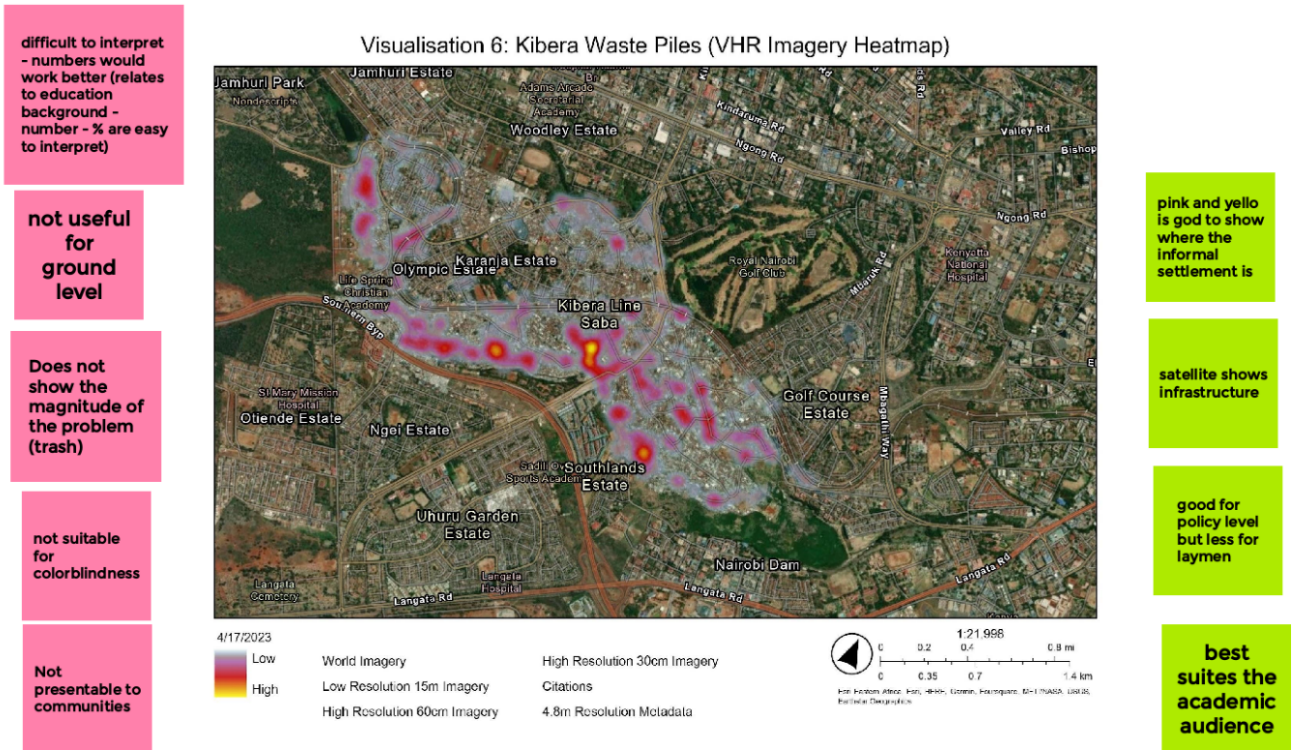


Figure F4
Visualization 6



9.7. APPENDIX G. OVERVIEW OF ALL POST-ITS

Topic	Post-it
Maps made for good use	How maps "travel". Maps made for "good" do not necessarily say within that context. And who decides what is "good"?
	Assumptions of what is better
Cooperation with inhabitants	How the voices and perspectives of local residents can be represented
	Co-creating with citizens: How to communicate results for them to easily understand?
	Participation of people living in the area
	Citizen science: Combining existing data with new citizen data
Limitations	What are the limitations of geo-data knowledge in "knowing" deprives urban areas?
Geometry	Geo-data: source, scale, age => seems mostly geometry
Purpose and user of the map	User/purpose -> who will use the map?
	By whom will the data be used and for what purpose
	Misinterpretation fot the meaning of data by the end user
	What uses does the map afford?
	Who are the mapmakers and audience for the map? Their characteristics
	Who makes the map and who uses them and to what purpose? Way to empower people with the technology
	Deprived urban mapping can be obtained from multiple sources and used for multiple aims
Flood plain mapping	Population density => correlation with services and community life surrounding
	Economic mapping
	Alternative area
	Attachment to land
Spatial information	Spatial resolution
	Spatial information useful to define actions
	Deprived area mapping facilities to analyse spatial context and temporal evolution
	Tool to visualize all kinds of things
	Create insight in spatial patterns
	Geo data is Necessary for mapping any spatiotemporal phenomena and Enables analysis of topic space and time
Bias	Mapping: cartographer makes all kind of decision that will gave influence on results. Projection/symbology/colour/etc
	Discrimination & bias. The way a map visualization can be biased and that results in more bias in peoples minds. This can also result in unethical discrimination results
Details	Level of detail of maps might be used in a negative way
Accuracy	Accuracy
	Accuracy
	Accuracy
	What are the consequences of accuracy aspects?
	Input data => accuracy
	To what extent does the data capture the lived reality on the ground
Data scarcity	Data scarcity
Privacy	Privacy
	Privacy issues
	False negatives or false positives (privacy)
	Scale factor. An issue with privacy rules
	Privacy of the affected population
Visibility	Visibility
	Ethics of visibility
Accessibility	Access
	Accesibility of the maps
	o What if the people can easily identify deprvied areas
	Who has access to the data and to what exten can this be used?
Availability of facilities and attributes	Availability of public facilities
	Essential facilities, e.g., hospital and infrastructure
	Available socio-economic infrastucture
	Given indication about informal settlement population and potential need of facilities
	What about attributes (people/housing)?
	Poor schooling options
Validity	Validity for a certain moment in time
	How to validate the geo data
Rehabilitation issues	Risk of communities to be evicted
	Slums are bad: Mapping slums has a concussion of redevelopment/forceful relocation
	In context of rehabilitations => what if the people living there are not interested in moving out but policy maker are using the map for the same
Census	Census
Dynamic	How dynamic is the map
Control vs support	Control vs suppport
Consent	Consent
	Consent => do they know they are being mapped
	Consent of the affected population
Security	Public safety/security: Inaccurate data/map can result in biased public unsafety
Stigmatization	Stigmatization
Afterlife of data	Afterlife of the data