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Data Justice in Disaster Displacement Research - Evaluating Ethical Practices in Call Detail Record Analysis

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Title and Abstract: Data Justice in Disaster Displacement Research - Evaluating Ethical Practices in Call Detail Record Analysis

The potential of using Call Detail Records (CDR) in displacement research should ideally be met with the development of comprehensive ethical frameworks to guide its application. While CDR data offers unprecedented insights into population mobility patterns during crises, its use raises important concerns about Data Justice, especially considering displaced populations who often have minimal control over how their mobility data is collected, analyzed, and applied. Through systematic analysis of six representative studies spanning 2018-2023 across diverse geographic contexts (Myanmar, Senegal, Haiti, Nepal, The Gambia, Italy), this thesis examines how current academic research using CDR data for disaster-induced displacement addresses Data Justice principles, applying Linnet Taylor's Data Justice framework consisting of the dimensions visibility, engagement, and non-discrimination, to evaluate ethical practices in the field. The research analyzes how current ethical approaches reflect academic and institutional culture and regulatory constraints.

Ultimately, this research tries to demonstrate that realizing the potential of CDR technology requires commitment to Data Justice principles that position displaced communities as partners rather than subjects in research processes. The findings have implications for broader debates about big data applications in humanitarian contexts and the responsibility of academic institutions to ensure that research serves rather than exploits exposed populations.

Das Potenzial der Nutzung von Call Detail Records (CDR) in der (Zwangs-)Migrationsforschung sollte idealerweise mit der Entwicklung umfassender ethischer Strategien zur korrekten Anwendung verbunden werden. Während CDR-Daten einzigartige Einblicke in Mobilitätsmuster während Krisen bieten, wirft deren Nutzung wichtige Überlegungen bezüglich Data Justice auf, insbesondere unter Berücksichtigung verdrängter Bevölkerungsgruppen, die oft weniger Kontrolle darüber haben, wie ihre Mobilitätsdaten gesammelt, analysiert und angewendet werden. Durch systematische Analyse von sechs repräsentativen Studien aus dem Zeitraum 2018-2023 in verschiedenen geografischen Kontexten (Myanmar, Senegal, Haiti, Nepal, Gambia, Italien) untersucht diese Forschungsarbeit, wie aktuelle wissenschaftliche Studien unter Verwendung von CDR-Daten für katastrophenbedingte Vertreibung Data Justice-Prinzipien behandelt, wobei Linnet Taylors Data Justice-Rahmenwerk angewendet wird, das aus den Dimensionen Visbility (Präsenz), Engagement und Anti-Diskriminierung besteht, um ethische Praktiken im Feld zu bewerten. Diese Thesis analysiert, wie aktuelle ethische Ansätze akademische und institutionelle Kultur sowie regulatorische Beschränkungen widerspiegeln.

Letztendlich versucht diese Arbeit zu demonstrieren, dass die Realisierung des Potenzials der CDR-Technologie eine Hingabe zu Data Justice-Prinzipien erfordert, die vertriebene Gruppen als Forschungspartner und nicht als Subjekte in Forschungsprozessen positionieren. Die erforschten Erkenntnisse haben Auswirkungen auf breitere Debatten über Big Data-Anwendungen in humanitären Kontexten und die Verantwortung akademischer Institutionen, sicherzustellen, dass Forschung betroffenen Bevölkerungsgruppen dient, anstatt sie auszubeuten.

1 Introduction

The aftermath of disasters often reveals the constraints of traditional data collection methods in understanding human mobility patterns. When Hurricane Matthew struck Haiti in 2016, humanitarian organizations had a hard time tracking population movement instantly, limiting their ability to distribute aid effectively (Bengtsson et al., 2011). However, an innovative solution was accomplished through the analysis of Call Detail Records (CDRs), which provided extraordinary insights into how people moved in response to the disaster. This example showcases the potential but also the ethical considerations surrounding the use of CDR data in displacement research.

Call Detail Records represent metadata generated whenever mobile phone users make calls, send messages, or access data services (IOM, 2021). When anonymized and aggregated, these records can reveal population movement patterns at a scale as well as speed impossible with traditional survey methods. For displacement researchers, CDRs offer a solution to an increasing concern: understanding how populations respond to environmental crises. Environmental and Climatic changes have intensified patterns of human displacement through natural disasters globally, creating a higher need for more insightful and rapid data availability (IOM, 2010).

The main attraction of CDR data lies in its practical advantages. Unlike household surveys that may take several weeks to complete and analyze, CDR analysis can provide close to real-time insights into population movements (Gething & Tatem, 2011). This potential proved practical during the COVID-19 pandemic, when CDR data supported governments in monitoring mobility restrictions and planning public health responses in African and Asian countries, where traditional data sources were sparse (Milusheva et al., 2021). CDR technology can capture movements across entire populations rather than small samples only, offering extensive coverage that includes marginalized groups often missed by conventional surveys. For instance, while the number of mobile subscribers in Sub-Saharan Africa reached 45% in 2019, only 23% of the population had access to mobile

internet, yet mobile connections reached 77% of the population, which were all capable of generating CDRs (GSMA, 2020).

Nevertheless, the use of CDR data for displacement research raises essential questions about data privacy and consent. The main populations that researchers seek to understand are displaced and vulnerable communities, which often have the least access and control over how their data is collected, analyzed, and used (Taylor, 2017). While mobile network operators anonymize CDR data before sharing it with relevant stakeholders, studies have demonstrated that individual mobility patterns can be re-identified with surprising accuracy when combined with other data sources. Research by de Montjoye et al. (2015) demonstrated that only four geotemporal points from anonymized CDR data are sufficient to uniquely identify 95% of individuals in a dataset.

This probability of re-identification becomes particularly critical when applied to displaced communities. Refugees fleeing conflict, internally displaced persons seeking safety, or migrants moving due to environmental pressures face increased vulnerabilities when their movements become visible to actors who might exploit this information (Migration Data Portal, 2024). The consequences of data misuse in these contexts transcend privacy violations, since they can endanger lives, facilitate persecution, or undermine the very protection that displaced populations seek.

Global inequalities in data protection frameworks exacerbate the ethical challenges surrounding the use of CDRs in displacement research. While the European Union's General Data Protection Regulation (GDPR) provides extensive privacy safeguards, various regions experiencing high levels of displacement operate under less robust data protection regimes (Makulilo, 2012). This imbalance creates an uneven environment where vulnerable populations in crisis-affected regions may have fewer protections for their personal data than those in more developed countries.

Despite these concerns, the potential benefits of CDR analysis for understanding and responding to displacement should not be dismissed. Improved insights into mobility

patterns can enhance humanitarian response, inform policy decisions, and most importantly save lives (Beyer & Milan, 2023). The main challenge is to make use of these benefits while ensuring that the rights of affected populations remain predominant. This discrepancy between utility and protection highlights the need for frameworks that not only investigate traditional privacy approaches but also address broader questions of Data Justice.

Data Justice, as conceptualized by Taylor (2017), offers a more thorough approach to analyzing and evaluating the ethical implications of data use. Rather than focusing on individual privacy rights only, Data Justice investigates how data practices affect different groups, whether they reproduce existing inequalities, and how they distribute benefits and harms across society. This framework is particularly relevant for displacement research, where the populations being studied often experience multiple, intersecting forms of marginalization (Cho et al., 2013).

The application of Data Justice principles to CDR-based displacement research involves examining several important dimensions. Firstly, the question of **visibility** and how displaced groups are represented in the data, and whether these representations accurately reflect their experiences and needs, must be evaluated. Secondly, the issue of **engagement** and whether affected communities are involved in decisions about how their data is used, or whether they are just passive subjects of analysis, must be examined. Thirdly, the questions of **non-discrimination** and whether data practices actively challenge existing inequalities affecting displaced populations or reproduce and reinforce discriminatory outcomes that further marginalize vulnerable communities must be addressed (Taylor 2017).

These questions are particularly substantial in the context of disaster-induced displacement, where the urgency of humanitarian needs must be weighed against the importance of protecting individuals and communities from data misuse (Durand-Delacre et al., 2021). Existing academic literature using CDR data to study a variety of human mobility patterns provides an opportunity to examine how researchers are addressing these ethical challenges and where significant gaps remain.

1.1 Research Gaps, Questions and Approach

The frequent use of CDR data in displacement research has outpaced the development of comprehensive ethical frameworks to guide its application (Kitchin, 2016). While some studies may address specific privacy concerns or acknowledge the exposed status of displaced populations, there has been no systematic examination of how the academic community is engaging with Data Justice principles in this context. This gap is especially concerning given the growing application of data analysis techniques that increase both the potential benefits and risks. Conducted Studies often mention privacy protections casually, by noting that data was "anonymized" or "aggregated", without engaging deeply with the components of these measures or their implications for the subjects of research. Even fewer studies consider broader questions of Data Justice, such as whether displaced communities benefit from the research conducted using their data or whether they have any voice in how such research is designed and implemented. This ethical gap is combined with disciplinary separation in research. Computer scientists developing new CDR analysis techniques may have limited engagement with the humanitarian and migration studies communities that understand the vulnerabilities of crisis-affected communities (United Nations, 2014). On the contrary, displacement researchers may lack the technical expertise to fully understand the privacy implications of analytical approaches. This division can result in studies that are technically sophisticated but ethically underdeveloped, or vice versa.

The absence of systematic ethical guidance specifically designed for CDR analysis creates risks for both researchers and the populations they study. Researchers may unintentionally cause harm through practices that seem benign but have serious implications for vulnerable groups (Lyon, 2003). Meanwhile, displaced populations in particular regions remain largely invisible in debates about how their data should be used, despite being the primary party affected by these decisions.

Against this situation, this thesis seeks to address a fundamental question: **How do current academic studies using CDR data for disaster-induced displacement research address**

the dimensions of Data Justice, and what gaps exist in protecting vulnerable populations? This research question is designed to move beyond general discussions of privacy and ethics to examine systematically how the academic community is engaging with Data Justice principles in practice.

The approach taken to address these questions involves a systematic review of academic literature that uses CDR data to study disaster-induced displacement. This review applies a Data Justice framework introduced by Linnet Taylor (2017), examining how current studies address key dimensions of Data Justice in their design, implementation, and reporting. Rather than simply categorizing whether studies mention ethical considerations or not, the analysis evaluates the depth and efficacy of ethical engagement and identifies patterns of strength and weakness across the literature.

This research contributes to several important conversations within academia and policy communities. For the displacement research community, it provides a critical assessment of current ethical practices and identifies areas where stronger implementations of protections are required. For the broader data science community, it demonstrates how Data Justice principles can be applied in a specific research context, potentially inspiring ethical frameworks for other applications involving vulnerable populations. For policymakers and humanitarian organizations, the research offers insights into how CDR data can be used more responsibly to support displaced populations while avoiding unintended harms. Finally, for displaced communities themselves, this research aims to make visible current practices affecting them and advocate for more inclusive and protective approaches to data use.

The goal is not to argue against the use of CDR data in displacement research, but rather to promote more thoughtful, inclusive, and protective approaches that realize the technology's potential benefits while safeguarding the rights and dignity of exposed populations. In an era where data increasingly influences and shapes humanitarian response, ensuring that these data practices encompass principles of justice becomes not just an academic responsibility but a moral necessity.

2. Literature Review

The use of Call Detail Records in displacement research represents a field that intersects telecommunications technology, data science, and humanitarian studies. This literature review assesses how CDR data has been applied to understand displacement patterns, particularly in disaster contexts, while additionally analyzing the ethical frameworks that researchers have employed. Through this assessment, significant gaps in how the academic community addresses Data Justice concerns when working with vulnerable populations, are examined.

2.1 Understanding Call Detail Records: Technical Foundations

Before investigating the application of CDR data in displacement research, it is essential to understand the technical nature of this data source and its capabilities. Call Detail Records represent digital metadata automatically generated by mobile network operators whenever subscribers interact with telecommunications services (IOM, 2021). These interactions include voice calls, text messages, and data usage, creating a vast record of mobile phone activity across entire populations. Each CDR entry contains several key data elements crucial for mobility research, such as a subscriber identifier (usually the SIM card number), timestamps indicating when interactions occurred, duration of calls or volume of data transferred, and the cell tower or base station that handled the communication. This spatial component derives from cellular network infrastructure, as mobile phones automatically connect to the nearest available cell tower, creating a geographic footprint of user activity (Gething & Tatem, 2011).

The processing of CDR data for research purposes involves several steps. Raw telecommunications data contains highly sensitive personal information that must be anonymized through removing direct identifiers like phone numbers, replacing them with anonymous codes, aggregating data across time periods and geographic areas, and applying filtering techniques to reduce re-identification risks. The resulting datasets retain statistical properties needed for population-level analysis, while theoretically protecting

individual privacy (Cecaj et al., 2015). However, as later research has shown, this protection may be insufficient (de Montjoye et al., 2013).

CDR data offers significant advantages over traditional mobility research methods since the scale and coverage far exceed household surveys or census data, potentially capturing movement patterns across entire national populations. The temporal accuracy provides near real-time insights, rather than the longer time periods required for traditional data collection. Additionally, CDR data encapsulates mobility among populations that may be difficult to reach through conventional surveys, including displaced populations and marginalized groups who might avoid formal data collection (Milusheva et al., 2021).

However, CDR data also presents important limitations. Location accuracy varies depending on telecommunications infrastructure density, with urban areas providing neighborhood-level precision while rural areas may offer only imprecise spatial resolution. Representativeness issues arise from systematic variations in mobile phone ownership and usage across demographic groups, potentially creating biases in displacement analysis. The data reflects only mobility corresponding with phone usage rather than all travel behavior, and technical complexity requirements may limit accessibility to specialized institutions only (Blumenstock, 2012).

2.2 CDR Applications in Displacement Research

2.2.1 Pioneering Studies and Methodological Foundations

The academic application of CDR data to displacement research began with pioneering work following major disasters in the early 2010s. Bengtsson et al. (2011) conducted one of the first extensive studies using CDR data to track population movements after the 2010 Haiti earthquake and the following cholera outbreak. Their analysis of anonymized data from Haiti's largest mobile network operator, Digicel, covered approximately 2.9 million subscribers over a 19-week period, demonstrating that CDR data could provide near real-time insights into displacement patterns.

This foundational work established several methodological principles that continue to influence CDR-based displacement research. Bengtsson et al. (2011) emphasized data aggregation to protect individual privacy, spatial generalization to prevent precise location tracking, and temporal delays in data release to reduce surveillance risks. However, their analysis focused primarily on demonstrating technical viability rather than engaging deeply with ethical implications, establishing a pattern that would persist in subsequent literature.

Building on this foundation, Blumenstock (2012) analyzed CDR data from Rwanda spanning from 2005 to 2009 in order to understand long-term migration patterns, revealing that mobile phone data could capture not just emergency displacement but also gradual population movements. This study introduced important methodological innovations, including machine learning techniques to predict migration flows and integration of CDR data with socioeconomic indicators, highlighting potential for informing development planning while raising unaddressed questions about long-term data storage and use.

2.2.2 Real-Time Disaster Response Applications

The use of CDR applications in disaster response has created more sophisticated approaches to real-time displacement monitoring. Giardini et al. (2023) analyzed aggregated CDR data following earthquakes in central Italy, displaying how telecommunications data could be combined with socioeconomic indexes and reconstruction funding data to understand community resilience and recovery patterns. Their cross-disciplinary approach represented an important methodological improvement by moving beyond simple mobility tracking to examine the correlation between displacement, economic factors, and recovery processes. This study introduced "displacement indicators" derived from CDR data used by emergency responders and policymakers, demonstrating that changes in mobile phone activity patterns could predict which communities would experience extensive displacement versus rapid return. However, while the focus on aggregated data protects individual privacy, it raises questions about whether such procedures have the capability of obtaining experiences of extremely vulnerable subgroups within displaced populations.

Flowminder, a nonprofit organization specializing in CDR analysis for humanitarian purposes, has conducted widespread efforts to track displacement following major disasters. Their collaborations with mobile network operators in Haiti, Nepal, and the Democratic Republic of Congo have produced valuable insights into disaster-induced mobility patterns, highlighting partnerships with humanitarian organizations and government agencies to ensure CDR analysis directly encourages response efforts rather than remaining purely academic.

The organization's work during the 2015 Nepal earthquake demonstrated both potential as well as challenges of real-time CDR analysis for disaster response. Flowminder provided daily updates on population movements to humanitarian agencies, helping inform relief supply distribution and evacuation route planning. However, this rapid deployment raises concerns about whether sufficient ethical review processes could be maintained during emergencies and whether affected populations had any voice in how their mobility data was being used.

2.2.3 COVID-19 and Expanded Mobility Monitoring

The COVID-19 pandemic marked a significant growth in CDR data use for mobility monitoring, providing new insights while drawing attention to persistent ethical challenges. Milusheva et al. (2021) conducted extensive analyses of CDR-based mobility indicators across multiple developing countries during the pandemic. This research demonstrated that mobile phone data could deliver more representative insights than smartphone-based applications, especially in regions with low smartphone penetration.

Their study showcased important technical advantages of CDR data over alternative mobility tracking methods. In various Sub-Saharan African regions, where smartphone penetration remains scarce, CDR data captured mobility patterns across broader demographic groups than GPS-based applications that mainly tracked wealthier, urban populations (GSMA, 2020). This value of representativeness has significant implications for displacement research, where understanding movements of marginalized and vulnerable populations is often most essential.

Despite this technical progress, the swift deployment of CDR-based mobility monitoring during COVID-19 exposed crucial gaps in ethical frameworks and supervisory mechanisms. Milusheva et al. (2021) mentioned that while data sharing agreements between mobile network operators and government agencies thrived during the pandemic, these agreements often lacked substantial privacy protections or clear restrictions on data use, documenting cases where mobility data collected for public health purposes was subsequently used for broader surveillance activities.

As noted by Oliver et al. (2020), there are major differences in privacy protections, data governance frameworks, and transparency measures across different national contexts, implying that ethical standards for CDR use may depend heavily on local regulatory environments rather than universal principles or professional standards.

2.2.4 Urban Planning and Cross-Border Applications

Other than emergency response, CDR data has also been applied to understanding urban mobility patterns, which can prevent the formation of displacement and can support preparedness strategies. Lwin et al. (2018) analyzed CDR data from Yangon, Myanmar, to understand daily commuting patterns and urban mobility dynamics, showing how mobile phone data could enhance traditional transportation surveys and support urban planning decisions affecting displacement risk.

This field of application raises important views about the dual-use nature of CDR analysis. While understanding urban mobility patterns can support an improvement of transportation planning and disaster preparedness, the same techniques could potentially be used for surveillance or control purposes (Lyon, 2003). Lwin et al. (2018) acknowledged these dual-use concerns but did not provide a detailed analysis of risk mitigation or community access, as well as control over mobility data use.

2.3 Current Ethical Approaches in CDR Displacement Research

2.3.1 Privacy Protection Strategies

The analyzed academic literature reveals diverse approaches to privacy protection in CDR displacement research. The majority of studies employ combinations of data anonymization, spatial aggregation, and temporal delays, but concrete application and adequacy for protecting marginalized groups remain inconsistent.

Data anonymization represents the most cited privacy protection measure. Bengtsson et al. (2011) described removing personally identifiable information from CDR data before analysis, replacing unique subscriber identifiers with anonymous codes. However, their study provided limited detail about specific anonymization procedures or assessment of re-identification risks, a lack of technical detail common across most literature, which makes the evaluation of sufficient privacy protection difficult.

Since the role of institutional ethics review in CDR displacement research varies significantly across studies as well as jurisdictions, this observation reveals substantial gaps in mechanisms overseeing adequate data privacy. Most academic studies employing CDR data do indeed report obtaining ethics approval from university institutional review boards, however standards and procedures applied by these boards for telecommunications data analysis appear to vary widely.

Bengtsson et al. (2011) stated receiving ethics approval for their Haiti earthquake study, but provided no details about the review process or specific ethical standards applied. This lack of transparency about ethics review procedures is common across most literature, making it difficult to assess whether appropriate safeguards are in place or whether review processes are adequate for the unique challenges posed by CDR data.

The situation is further complicated by the involvement of commercial mobile network operators as data providers, who may have their own data governance policies and commercial considerations influencing how CDR data is shared with researchers (Milusheva et al., 2021). The interaction between ethical examination processes in academics and

commercial data governance frameworks remains poorly understood and inadequately addressed in most studies.

Some researchers have demanded more powerful institutional frameworks specifically tailored to CDR research. Oliver et al. (2020) argued that traditional ethics review processes, designed for survey-based research with explicit consent, may be insufficient for challenges brought on by large-scale telecommunications data analysis, proposing specialized review procedures that could better address issues like re-identification risks and data security.

2.3.2 Consent and Community Engagement Challenges

One of the most considerable flaws in current CDR displacement research relates to consent and community engagement. Traditional research ethics prioritize informed consent, where participants understand what data is being collected, how it will be used, and what risks they may face. However, CDR data is typically collected passively through normal mobile phone use, without explicit consent for research purposes.

Most studies acknowledge this consent challenge but provide limited solutions. Bengtsson et al. (2011) noted that their Haiti study used data collected for commercial purposes without specific research consent, arguing that humanitarian rewards justified this approach. However, they provided no analysis of whether affected populations would have agreed to such data use if asked, or whether alternative methods to obtaining consent might have been attainable.

The topic of consent becomes more complicated when considering the exposure of affected communities. People fleeing disasters or conflicts may have limited capability to provide meaningful consent to data use, especially when facing immediate threats to safety and well-being (Durand-Delacre et al., 2021). Moreover, displaced populations often have insufficient understanding of how mobile phone data can be analyzed or what information it can reveal about their movements and behaviors.

A small number of studies report any form of community engagement or consultation with affected populations. Flowminder's work represents one of the few examples of

organizations attempting to involve individuals in decisions about CDR data use, with community engagement guidelines emphasizing transparency about data collection and analysis purposes, nontheless the implementation in emergency contexts remains challenging (Flowminder, 2020).

2.4 Identified Gaps and Limitations

2.4.1 Limited Ethical Framework Application

Despite increasing recognition of Data Justice as an important framework for evaluating ethical implications of big data research, particularly highlighted in SDG 16's emphasis on "peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels" (United Nations, 2015), the application of these principles to CDR-based displacement research remains insufficient in practice. While most studies acknowledge privacy concerns and some discuss broader ethical considerations, systematic application of all-inclusive ethical frameworks remains rare.

Most of the research focuses primarily on technical and methodological considerations, with ethical analysis often consigned to brief mentions of privacy protection measures. Specifically, the representation of displaced populations in data and research findings receives limited attention, with CDR studies often presenting aggregate statistics about population movements without exploring whether these representations accurately reflect experiences and perspectives of displaced communities or instead, reinforce stereotypes about displacement (Taylor, 2017).

Community engagement is almost absent from current CDR displacement research. Some studies report consultation with affected communities about research priorities, methods, or findings, meaning research priorities are typically defined by researchers, technology companies, or humanitarian organizations rather than by communities directly affected by displacement.

2.4.2 Inadequate Re-identification Risk Assessment

While most CDR displacement studies acknowledge re-identification as a theoretical concern, few provide a careful assessment of these risks. People fleeing disasters or conflicts may move in routes that make them more easily identifiable in mobility datasets (Migration Data Portal, 2024). The probability, that individuals can be uniquely identified from anonymized mobility data has clear consequences for displacement research, yet most studies have not adequately addressed these implications (de Montjoye et al., 2013). The probability that individuals can be uniquely identified from anonymized mobility data has clear consequences for displacement research, yet most studies have not adequately addressed these implications (de Montjoye et al., 2013).

Moreover, a combination of CDR data with other available datasets could additionally increase re-identification risks. Few studies assess these combinatorial hazards or implement safeguards against data linking that could expose individual identities. The consequences of re-identification for mobile populations could be severe, potentially exposing them to persecution, discrimination, or other harms.

2.4.3 Absence of Long-term Impact Analysis

Current CDR displacement research draws limited attention to the long-term impacts of data collection and analysis practices. Not many studies examine how CDR analysis might impact displaced communities over time, or whether insights generated improve outcomes for affected populations. The assumption that CDR analysis benefits displaced populations through improved humanitarian response or policy decisions is rarely tested empirically. While researchers often claim their findings could support better planning or resource distribution, few provide evidence that such improvements actually come to pass or reach the most vulnerable populations (Kitchin, 2016).

There is also insufficient consideration of how CDR data collection and analysis might affect community trust in mobile telecommunications services, which could have important implications for digital inclusion and access to communication technologies. Questions

about long-term data storage and potential future use represent another under-examined area, with concerns about data retention periods, long-term access, and future use purposes remaining largely unaddressed.

3. Theoretical Framework

This chapter demonstrates the analytical framework that will guide the evaluation of ethical practices in CDR-based displacement research. The framework focuses on Data Justice as conceptualized by Linnet Taylor (2017).

3.1 Data Justice: Conceptual Foundations

Data Justice emerges from the realization that conventional approaches to data ethics, focused primarily on individual privacy rights and informed consent, are inadequate for addressing the complex social implications of big data technologies. As described by Taylor (2017), Data Justice provides a contemplative framework to evaluate how data practices affect different social groups, whether they reproduce existing inequalities, and how they distribute benefits and disadvantages across society. Unlike privacy frameworks that focus on protecting individuals from unwanted data exploitation, Data Justice examines the structural and systemic ways in which data collection, analysis, and application shape social differences and power dynamics.

Data Justice recognizes that the influences of data technologies are unevenly distributed across society, with marginalized communities often undergoing disproportionate costs while receiving fewer benefits. This acknowledgement is crucial for understanding the ethical implications of CDR displacement research, where vulnerable populations provide the data that enables research while potentially having insufficient agency in how that research is conducted or how its benefits are distributed (Eubanks, 2014).

The framework appreciates that data practices are never neutral but rather embed values, assumptions, and power relations. These embedded values shape how social problems are determined, what solutions are considered most applicable, and whose interests are

prioritized in data-driven decision-making. For displacement research, this means examining not just whether CDR analysis generates efficient results, but whose perspectives and priorities shape research questions, methodological choices, and application of findings (O'Neil, 2016).

3.2 Taylor's Three Pillars of Data Justice

Taylor's framework identifies three core dimensions of Data Justice that provide analytical instruments for evaluating data practices: visibility, engagement with technology, and non-discrimination. These pillars are interconnected and must be understood relationally, as power imbalances shape data practices across all three dimensions. Each pillar offers insights into the ethical implications of CDR displacement research while drawing attention to areas where current practices may fall short of justice principles.

Visibility embodies both access to representation as well as informational privacy, addressing how different groups are represented in data and whether individuals can control their visibility in data systems. In CDR displacement research, visibility involves examining if displaced populations are represented in ways that portray their diversity, agency, and experiences rather than reducing them to statistical patterns. It also takes into account which groups are made visible through data analysis and which remain unseen, and whether this visibility serves the interests of the data subjects themselves (Taylor, 2017). The visibility dimension considers both over-representation and under-representation in data analysis, as well as people's ability to maintain data confidentiality. Specific groups may be hyper-visible in datasets due to intensive use of mobile technologies, while others may be excluded due to limited access to phones or different manners of use. For displacement research, ensuring proper visibility means examining whether CDR analysis accurately captures the diverse experiences of various subgroups within displaced persons, whether these representations support or compromise their interests, and whether affected communties have any control over how they appear in data systems.

Engagement with technology addresses whether and how data subjects are involved in decisions about data collection, analysis, and application, while also dealing with self-determination in technology choices and data sharing. Conventional research ethics highlight informed consent as the main approach for ensuring appropriate engagement, but Data Justice recognizes that meaningful engagement may require more comprehensive participation in research design, implementation, and data distribution, as well as agency over how to engage with data-producing technologies (Taylor, 2017). In displacement contexts, meaningful engagement faces challenges due to the crisis circumstances that exposed communities populations face as well as unequal power relations between researchers, institutions, and affected communities. However, these challenges do not eliminate the need for engagement; rather, they require the development of creative approaches that respect the representation and perspectives of displaced populations. This dimension also necessitates examining whether displaced communities benefit from the value created by their data or whether these benefits are concentrated on the interests of researchers and institutions.

Non-discrimination focuses on whether data practices actively challenge existing inequalities and forms of discrimination rather than simply avoiding discriminatory outcomes. This dimension requires an examination of whether data collection and analysis avoid direct discrimination, but also if they contribute to structural inequalities or reinforce structures of marginalization (Taylor, 2017). For CDR displacement research, non-discrimination analysis involves investigating whether research practices enhance stereotypes about displaced populations, whether they contribute to surveillance or control systems that further marginalize vulnerable groups, and whether they actively challenge or reproduce existing power structures that contribute to displacement and vulnerability. This pillar emphasizes the need for data practices to serve as tools for social justice rather than maintaining existing inequities for analysis motives only.

The relational nature of these pillars means that visibility without meaningful engagement can lead to exploitative research practices, while engagement without non-discrimination safeguards may fail to protect exposed populations from harmful data uses. The

awareness of power relations is fundamental to all three dimensions, since different levels of authority shape who gets represented, who participates in data governance, and whose interests are prioritized in data analysis.

3.3 Application to Literature Analysis

The application of this Data Justice framework to CDR displacement research literature includes a systematic analysis of how selected studies address each dimension of the framework. This analysis explores not only whether ethical considerations are mentioned, but also how deeply they are engaged with and implemented in research practice. The literature analysis will identify patterns across studies by evaluating common strengths and weaknesses in ethical approaches, variations in ethical practices across different research settings, and gaps where Data Justice principles are insufficiently addressed. This systematic application of the framework will provide a factual assessment of current ethical practices and solid guidance for improving future research.

The framework also provides the identification of contextual factors that influence ethical practices, such as regulatory environments, institutional capacity, and cultural considerations. Understanding these circumstantial impacts is crucial for developing realistic and feasible recommendations for improving ethical practices in CDR displacement research.

Through this systematic application of Data Justice principles, the research aims to move past general calls for more ethical data practices and provide guidance for researchers, institutions, and policymakers working at the intersection of data science and displacement research. The goal is to support the development of research practices that recognize the potential benefits of CDR analysis while endorsing the rights and dignity of displaced groups of indidivuals.

4. Methodology

This chapter outlines the methodological approach employed to address the research question: "How do current academic studies using CDR data for disaster-induced displacement research address the dimensions of Data Justice, and what gaps exist in protecting vulnerable populations?" The study employs a narrative literature review methodology combined with qualitative content analysis using Taylor's Data Justice framework.

4.1 Research Design and Approach

This research adopts a qualitative narrative literature review design to examine how current academic research using Call Detail Records for disaster-induced displacement addresses Data Justice principles. The narrative review methodology is particularly suitable for exploring emerging ethical issues in a developing field such as CDR analysis, allowing for comprehensive examination of a variety of approaches and contextual factors (Green et al., 2006).

The choice of a literature-based approach reflects both methodological advantages and practical considerations. While direct engagement with displaced communities or analysis of CDR datasets would provide valuable insights, such approaches raise significant ethical and logistical challenges for a thesis project. A narrative review of existing literature allows for in-depth analysis of current practices while avoiding the risk of causing additional harm to vulnerable populations through imperfect direct data collection due to a lack of expertise in data analytics.

The research employs an interpretivist epistemological position, recognizing that the evaluation of ethical practices involves subjective judgments about values, power relations, and social justice that cannot be reduced to purely objective measures. This interpretive approach is essential for applying the Data Justice framework, which requires a delicate assessment of how research practices affect different social groups and whether they reproduce or challenge existing inequalities (Taylor, 2017).

The narrative review emphasizes qualitative synthesis and thematic analysis rather than exhaustive coverage, focusing on representative studies that display the range of ethical approaches and challenges present in CDR displacement research.

4.2 Literature Selection Strategy

4.2.1 Database Search and Search Terms

Literature detection was conducted using two complementary academic databases:

Scopus was selected for its coverage of peer-reviewed literature across multiple disciplines, including engineering, computer science, and social sciences, capturing interdisciplinary research on CDR applications from technical, humanitarian, and social science perspectives.

u:find (University of Vienna) was utilized as the institutional discovery system, providing access to the university's collection of academic resources and relevant literature available through institutional subscriptions.

The search strategy was developed to capture literature at the intersection of CDR research, displacement studies, and ethical considerations. The search was filtered by Years (2010–2024), Document type (Article, Review), and Language (English)

- Field 3 (Context & Ethics): disaster OR "natural disaster" OR conflict OR war OR crisis AND ethics OR ethical OR "Data Justice" OR "data governance" OR "data privacy" OR "data protection"

Search Strategy for Scopus: TITLE-ABS-KEY ("Call Detail Record" OR cdr OR "mobile phone data" OR "telecom data" OR "cellphone metadata") AND TITLE-ABS-KEY (migration OR displacement OR "forced migration" OR "human mobility" OR "climate migration") AND TITLE-ABS-KEY (disaster OR "natural disaster" OR conflict OR crisis OR war) AND TITLE-ABS-KEY (ethics OR ethical OR "Data Justice" OR "data governance" OR "data privacy" OR "data protection")

Search Strategy for u:find:

- Field 1 (CDR Data): "Call Detail Record" OR CDR OR "mobile phone data" OR "telecom data" OR "cellphone metadata"
- Field 2 (Migration & Displacement): migration OR displacement OR "forced migration" OR "climate migration" OR "human mobility"

From the literature identified through database searches, six representative studies were selected using purposive sampling criteria designed to capture the diversity of approaches in the field. Selection criteria included Methodological diversity which includes studies representing different CDR analysis approaches and techniques; Geographic representation which focuses on research covering different regions and displacement contexts; Temporal coverage, which explores studies spanning different time periods to capture field evolution; Ethical engagement, which incorporates variation in how studies address or neglect ethical considerations; research focus which presents different aspects of displacement research (prediction, monitoring, response) and institutional diversity which concentrates on research from different types of establishments and research contexts.

This purposive selection enables detailed examination of how Data Justice principles are displayed across varied research settings while providing enough diversity to identify patterns and gaps in current ethical practices. The sample size of six studies allows for thorough analysis while remaining manageable for detailed qualitative assessment.

4.2.2 Selection Criteria and Considerations

Study selection emphasized geographic diversity to examine how Data Justice considerations are realised across different regulatory, economic, and cultural contexts. The six studies were selected to represent various regions (Southeast Asia, West Africa, South Asia, Europe) and development contexts, enabling examination of how contextual factors influence ethical implementation in CDR displacement research. This geographic approach recognizes that data governance frameworks, mobile phone penetration rates, institutional capacities, and cultural approaches to privacy vary significantly across

different regions and circumstances, potentially affecting how Data Justice principles can be implemented in practice. However, since the selection is limited to English-language publications, it may not capture all relevant research carried out in other languages or published in regional journals. Additionally, the focus on peer-reviewed articles may exclude relevant work published in grey literature or policy reports.

4.3 Analysis Method Using Data Justice Framework

4.3.1 Data Justice Assessment Framework

The analysis applies a structured evaluation framework derived from Taylor's pillars of Data Justice (visibility, engagement, and non-discrimination) to evaluate each included study. Each pillar uses evaluation criteria specifically fitted to displacement contexts, assessed on a three-level Likert scale: Inadequate, Limited, and Comprehensive (Joshi et al., 2015).

Pillar	Assessment Criteria	Assessment Scale
Visibility	Does the study examine how displaced populations are represented in CDR data? Are issues of informational privacy addressed? Do representations serve displaced populations' interests?	Inadequate / Limited / Comprehensive
Engagement	Are displaced communities involved in research processes? Do populations benefit from research using their data? Is community autonomy respected?	Inadequate / Limited / Comprehensive
Non-discrimination	Does the study actively address potential discriminatory outcomes? Are safeguards against harmful uses implemented? Do practices challenge or reproduce inequalities?	Inadequate / Limited / Comprehensive

(See Appendix 1 for Assessment Criteria Definitions)

5. Analysis

This chapter presents a systematic application of the Data Justice framework to academic literature utilizing Call Detail Records (CDR) for disaster-induced displacement research.

Each study receives systematic evaluation across all three pillars with a detailed examination of the assessment rationale. This process identifies patterns in ethical practices, reveals gaps in current approaches, and highlights exemplary practices worthy of replication.

The analysis examines both individual pillar performance and cross-pillar relationships, assessing whether studies address the interconnected nature of Data Justice requirements. This approach enables the identification of studies that stand out in specific dimensions while revealing systemic weaknesses across the field.

5.1 Overview of Included Studies

A selected sample of six studies using CDR data for disaster-induced displacement research, spanning from 2018 to 2023, was analysed. The selection process prioritized studies that provide sufficient methodological detail to enable systematic evaluation of data privacy principles. While CDR applications in migration studies have been discussed since 2010, explicit consideration of privacy safeguards in CDR implementations has emerged mainly in recent years. This reflects both methodological growth and heightened privacy awareness, particularly following the implementation of GDPR in 2018 (European Union Agency for Fundamental Rights, 2024). The selection represents diverse geographical backgrounds and areas of application, providing extensive coverage of CDR applications in the context of disasters**.**

Table 5.1: Final Selected Studies and their Characteristics (Chronological Order)

Study	Location	Application Domain
Lwin et al. (2018)	Yangon, Myanmar	Urban planning and disaster preparedness
Zufiria et al. (2018)	Senegal	Food security and agricultural monitoring
Li et al. (2019)	Haiti, Nepal	Post-disaster recovery analysis
Arai et al. (2021)	The Gambia	COVID-19 mobility analysis
Milusheva et al. (2021)	Multiple countries	COVID-19 response and mobile data access
Giardini et al. (2023)	Italy	Post-earthquake displacement measurement

Lwin et al. (2018) makes urban commuters and transport users visible through their analysis of hourly link populations in Yangon, directly supporting public transport

optimization. However, the study acknowledges limitations in capturing pedestrians and non-motorized transport users, potentially making those invisible who cannot afford mobile phones or public transport. The authors note that "CDR has some limitation on data acquisition because of privacy protection" but recognize it as enabling identification of "mass movement of people inside a city inexpensively and time-effectively." (Lwin et al., 2018, p.1)

Zufiria et al. (2018) bring visibility to seasonal agricultural workers and rural populations in Senegal through mobility profile analysis. The study shows "seasonal mobility profiles related with economic activities, agricultural calendars and rainfalls," (Zufiria et al., 2018, p.1) directly supporting food security monitoring for vulnerable populations. However, the study notes limitations in representing populations with low mobile phone usage, particularly affecting the youngest and oldest segments of a population, as well as those in the lowest socioeconomic strata.

Li et al. (2019) focuses specifically on making internally displaced persons (IDPs) visible following natural disasters in Haiti and Nepal. The study develops methods to identify and track displacement patterns, noting that "many people who are displaced but who do not choose, or are unable to go to organised displacement sites and may be left uncounted" (Li et al., 2019, p.2) by traditional surveys. However, the analysis acknowledges CDR data "are rarely representative of an entire population, especially in low-income countries" (Li et al., 2019, p.3).

Arai et al. (2021) reveal mobility patterns during COVID-19 in The Gambia, making visible urban-rural migration flows during lockdown. The study demonstrates how CDR analysis can capture population movements and displacement, informing rapid policy responses. Yet it acknowledges that "survey and administrative data exhibit severe shortcomings" (Arai et al., 2021, p.2) while CDR data have "constraints in terms of capturing all aspects of human mobility."

Milusheva et al. (2021) examine challenges and opportunities in accessing mobile phone data for COVID-19 response across multiple developing countries, revealing institutional

and structural barriers that limit governments' capacity to utilize mobile data for pandemic response. The study highlights the differential institutional capabilities and regulatory frameworks that impact crisis response effectiveness, although it primarily focuses on institutional rather than community-level analysis.

Giardini et al. (2023) develop a methodology to measure post-earthquake population displacement using aggregated Call Detail Records following the Central Italy earthquake. The study introduces a forecasting approach to quantify displacement by comparing actual mobile phone counts with pre-earthquake predictions, combining CDR data with economic and administrative datasets to explain variations in population displacement across 663 municipalities. The research focuses on technical measurement of displacement patterns rather than examining the experiences of displaced communities themselves.

5.2 Systematic Data Justice Analysis

5.2.1 Lwin et al. (2018): Urban Transportation Planning in Yangon

Lwin et al. (2018) researched the estimation of hourly population flows in Yangon, Myanmar, representing an early application of CDR analysis for urban planning in a developing country context. The study takes place in a post-conflict setting, where urban infrastructure development holds significant importance for displaced populations who have migrated to urban areas in search of economic opportunities and safety.

Visibility Assessment: Inadequate

The study demonstrates a lack of inclusion on multiple layers, which makes affected groups invisible within urban mobility analysis. The methodology systematically excludes populations consisting of displaced persons through several interrelated mechanisms.

The reliance on CDR data from MPT, which held only 46% market share in 2015, creates immediate visibility gaps for populations using other networks or lacking mobile phone access entirely. The authors acknowledge that their dataset represents "40% of the

national population" (Lwin et al., 2018, p. 4) yet provide no analysis of who comprises the excluded 60%. In post-conflict Myanmar, displaced communities often face economic barriers to mobile phone ownership or may deliberately avoid formal telecommunications networks due to surveillance concerns (Justice For Myanmar, 2024). The study's approach to identifying home locations through calls made between 8 pm and 7 am assumes stable housing situations that displaced populations may lack. The authors note that "20% of the PIDs should be assigned a default magnification factor" (Lwin et al., 2018, p. 5) because these users made no calls during nighttime hours, suggesting irregular or unstable living arrangements that could correlate with displacement status.

The methodology's focus on formal transportation networks and "shortest-path analysis" systematically excludes informal transport modes commonly used by displaced indidivuals who cannot afford formal public transport. The validation relies on "traffic-count surveys, electronic toll collection (ETC), and gates and other roadside sensors" (Lwin et al., 2018, p. 2) which capture formal transportation infrastructure but miss pedestrian traffic and informal transport routes frequently utilized by economically marginalized groups.

Privacy protection receives minimal attention, with only a brief acknowledgment that "CDR has some limitations on data acquisition because of privacy protection" (Lwin et al., 2018, p. 1) The study provides no detailed discussion of specific privacy safeguards implemented, consent mechanisms, or consideration of particular vulnerabilities faced by exposed communities who may be at risk from mobility surveillance in Myanmar's political context.

The technical decision to move all Cell-ID locations to the closest intersections, while intended for analytical purposes, could unintentionally create location data that exposes movement patterns of exposed populations. In a context where displaced populations may face persecution or discrimination, this lack of displacement-specific privacy considerations is alarming.

The representations primarily serve transportation planning and disaster preparedness interests of government agencies rather than the immediate needs of exposed indidivuals. While the stated applications include "optimize bus routes, solve traffic congestion problems, and enhance disaster and emergency preparedness" (Lwin et al., 2018, p. 1), there is no consideration of whether these optimization goals align with the actual mobility needs of displaced communities.

The study's approach to disaster and emergency preparedness fails to examine whether current transportation planning properly considers informal settlements where displaced populations often reside, or whether evacuation and emergency response plans account for populations who rely on informal transportation networks.

Engagement Assessment: Inadequate

The study provides no evidence of consultation with displaced communities or broader urban populations affected by transportation planning decisions. The research follows a purely technocratic approach where algorithmic optimization and government agency priorities determine analytical frameworks without input from affected communities.

The methodological framework was developed without community input on research priorities, data governance concerns, or desired outcomes. Displaced communities had no voice in determining whether transportation flow optimization would address their mobility challenges or whether the research questions aligned with their needs. Additionally, CDR data collection operated through institutional arrangements between researchers and MPT without any community notification or consultation mechanisms. Communities whose mobility patterns were being extracted and analyzed had no knowledge of or input into the data collection process.

While the research aims to optimize transportation systems that could theoretically benefit public transport users, displaced populations have no voice in defining what transportation improvements would best serve their needs. The study treats communities as passive subjects of analysis whose mobility patterns are retrieved for optimization

purposes rather than as participants with rights to contribute to transportation planning processes that affect them.

The validation process relies exclusively on technical metrics ("traffic volume with link population in specific intersections and lanes" (Lwin et al., 2018, p.8)) and international agency surveys rather than incorporating community knowledge about transportation needs, service gaps, or mobility challenges faced by different populations within the city. Therfore, any potential community benefits flow through institutional middlemen (government transportation planning agencies) without mechanisms for communities to directly access research findings or influence how results are applied to transportation planning decisions.

Non-discrimination Assessment: Limited

The study lacks explicit consideration of how transportation improvements might differentially affect various urban populations. The methodology's focus on "magnitude (actual population) and flow direction" (Lwin et al., 2018, p.1) groups all mobile phone users together without analyzing whether improvement algorithms consider fair outcomes or the varying mobility needs of different demographic groups.

Without attention to digital divides or economic inequalities in mobile phone access, the research risks reproducing discriminatory outcomes by optimizing transportation systems for digitally connected populations while overlooking the needs of digitally excluded displaced persons. The "home-based magnification factor" (Lwin et al., 2018, p.1) attempts to address population representation but does not account for systematic biases in who has access to mobile phone networks.

The use of "shortest-path analysis using the well-known modified Dijstra algorithm" (Lwin et al., 2018, p.7) assumes rational route choice that may not reflect how displaced populations actually navigate urban spaces when facing informal barriers, safety concerns, or economic constraints. This algorithmic approach could reinforce transportation planning that serves already-advantaged populations only.

While improved public transportation could potentially reduce mobility inequalities by making transport more efficient and accessible, the study does not address whether optimization algorithms consider equity outcomes or whether disaster preparedness plans properly protect exposed populations in informal settlements. Furthermore, the reliance on "transport surveys conducted in 2013 by Japan International Cooperation Agency (JICA)" (Lwin et al., 2018, p.3) for validation introduces potential bias, as international agency surveys may not capture the mobility experiences of marginalized populations or displaced communities whose transportation patterns differ from formal survey methodologies. The research approach maintains existing power structures where technical experts and government agencies make decisions about public services without participation from affected communities, potentially reinforcing rather than challenging inequalities in urban service provision.

5.2.2 Zufiria et al. (2018): Food Security Monitoring in Senegal

Zufiria et al. analyzed seasonal mobility patterns in Senegal using mobile phone data to support food security monitoring and early warning systems. The research operates in a context of climate vulnerability and food insecurity, where seasonal displacement and mobility are critical survival strategies for rural populations, making Data Justice considerations particularly important for protecting exposed communities.

Visibility Assessment: Comprehensive

The study demonstrates quite good attention to representing exposed communities through an in-depth analysis of seasonal mobility patterns that directly address displacement-related exposure. The research specifically focuses on "mobility changes in vulnerable populations in response to external shocks," directly addressing populations at risk of displacement due to food insecurity, drought, and economic pressures.

The framework's temporal granularity enables the recognition of mobility patterns that point out emerging displacement before food insecurity becomes evident through traditional indicators. The authors develop an Individual Trajectories Matrix (IT-Matrix) that provides "estimates of the user preferential location with different time and

geographical resolutions" (Zufiria et al., 2019, p.6), enabling detection of seasonal displacement patterns at multiple time frames from daily to monthly resolution.

The authors utilizes data from Sonatel, which had "over 60% of the population" (Zufiria et al., 2019, p.14) market share, noting that "such a percentage of real measurements represents much more information than estimations made from some primary and secondary data sources years ago." (Zufiria et al., 2019, p.3).

The study implements sophisticated privacy protection through "aggregation schemes of mobility based on Origin-Destination (OD) matrices" (Zufiria et al., 2019, p.2) while avoiding approaches that would enable individual re-identification. The authors note that "specific privacy-preserving schemes are also required to minimize individual details by optimizing the aggregation level and avoiding potential risks such as de-identification" (Zufiria et al., 2019, p.2). The aggregation at the livelihood zone level provides appropriate privacy protection for rural contexts while maintaining analytical utility for food security monitoring. This approach acknowledges that rural populations facing food insecurity may have different privacy vulnerabilities than urban populations, especially regarding potential stigmatization or targeting based on mobility patterns.

The representations directly serve vulnerable populations' interests through clear applications to food security early warning systems. The research enables "timely identification of mobility changes in exposed groups " to "monitor food security" and "inform food security analysis and assistance targeting" (Zufiria et al., 2019, p.1-3), creating explicit pathways from data analysis to humanitarian assistance for populations at risk of displacement.

Engagement Assessment: Limited

The study demonstrates a hybrid approach to community engagement that shows both significant strengths and important limitations. The research incorporates existing community knowledge through meaningful integration with seasonal calendars developed via household surveys and community consultation processes conducted by humanitarian organizations.

The integration with livelihood zone analysis reflects recognition that technical mobility analysis should be grounded in local understanding of seasonal patterns, agricultural cycles, and economic activities. The authors state that "Available seasonal calendars are estimated for an average year by combining quantitative and qualitative data analyses, based on two types of data collection methods: primary and secondary" (Zufiria et al., 2019, p.3).

The research demonstrates meaningful engagement with local institutions, such as United Nations World Food Program Senegal, Centre de Suivi Écologique, and other established organizations working directly with affected communities. This institutional framework provides indirect pathways for community voice while acknowledging the limitations of this mediated engagement. However, CDR data collection and analysis operate without direct community participation in governance decisions about data collection priorities, analytical frameworks, or interpretation of results. Communities whose mobility patterns are being extracted and analyzed lack direct agency over essential choices about how their data is collected, processed, and applied to policy decisions.

The study operates through institutional arrangements between researchers and Sonatel "under the D4D Challenge standard nondisclosure agreement" (Zufiria et al., 2019, p.3), without evidence of community notification or alternative engagement mechanisms for populations whose mobility patterns are being analyzed.

The research creates robust pathways to community benefit through food security early warning applications, which could improve the timing and targeting of humanitarian assistance. The integration with relevant organizations provides mechanisms for translating research findings into improved aid delivery, though communities lack direct access over these benefit distribution processes.

Non-discrimination Assessment: Comprehensive

The research explicitly aims to prevent discriminatory outcomes in humanitarian assistance by enabling more accurate identification of exposed groups and emerging food security crises before they become severe. The study's focus on "mobility changes in vulnerable populations in response to external shocks" (Zufiria et al., 2019, p.1) demonstrates a clear commitment to protecting marginalized communities from discriminatory neglect in humanitarian response. The integration with existing participatory research methods helps address risks of technical analysis replicating biases present in traditional aid targeting approaches.

The authors' use of community-developed seasonal calendars and livelihood zone analysis provides safeguards against purely data-driven approaches that might miss nuanced patterns of vulnerability. This incorporation of community knowledge systems challenges some extractive research practices by building on rather than replacing traditional knowledge about seasonal patterns and livelihood strategies. However, the fundamental data collection operates through commercial telecommunications infrastructure without community ownership or control.

The framework enables analysis of differential mobility patterns across different livelihood zones, potentially revealing how various environmental and economic stressors affect diverse populations. This capability supports fair humanitarian targeting by revealing which communities face mobility-related vulnerabilities that might otherwise remain invisible to traditional monitoring systems.

The study directly challenges inequalities that affect rural populations' access to food and economic opportunities through support for proactive rather than reactive humanitarian responses. The focus on early warning applications represents a clear commitment to preventing food crises that disproportionately affect marginalized rural communities. The research addresses temporal aspects of discrimination by enabling humanitarian responses "almost in real time" rather than waiting for crises to become acute. This

approach could prevent the systematic delays in humanitarian assistance that often affect rural and marginalized populations disproportionately.

5.2.3 Li et al. (2019): Post-Disaster Resettlement Analysis

Li et al. analyzed resettlement patterns among internally displaced persons following three major disasters: the 2010 Haiti earthquake, Hurricane Matthew in Haiti in 2016, and the 2015 Nepal earthquake. This research represents a significant application of CDR analysis specifically focused on humanitarian response and disaster recovery monitoring, making its Data Justice implications quite significant for understanding how technical approaches to displacement monitoring serve or undermine displaced persons' rights and interests.

Visibility Assessment: Comprehensive

The study provides an excellent concentration on making internally displaced persons visible through attention to populations systematically excluded from conventional humanitarian data collection. The research explicitly addresses displaced persons "who do not choose, or are unable to go to organised displacement sites and may be left uncounted" (Li et al., 2019, p.1).

The study's primary focus lies in addressing the "invisible displaced" - populations who remain in host communities, informal settlements, or return to damaged areas without appearing in official displacement statistics (Polzer Ngwato & Hammond, 2008). The research provides temporal visibility into displacement and resettlement patterns, which challenge assumptions about displacement duration embedded in humanitarian programming frameworks and enable evidence-based resource allocation decisions that could improve humanitarian response timing and effectiveness. Additionally, the study's comparative analysis across three different disasters provides insights into displacement patterns that transcend individual disaster contexts. The finding that "resettling rate for all three disasters is similar" (Li et al., 2019, p.1) suggests potential universality in displacement recovery patterns that could inform predictive humanitarian planning.

The study demonstrates awareness of representation limitations that particularly affect the most vulnerable populations. The authors explicitly acknowledge that CDR data "are rarely representative of an entire population, especially in low-income countries, since only people who own and use a SIM card are included in the dataset" (Li et al., 2019, p.3).

The research identifies that mobile phone-based analysis systematically excludes "the youngest and oldest segments of a population, as well as those in the lowest socioeconomic strata" (Li et al., 2019, p.3), precisely the populations most vulnerable during disasters and most in need of humanitarian protection. This methodological consciousness represents an understanding of how technical approaches can reproduce existing inequalities in humanitarian visibility.

The study implements rigorous validation through control group comparisons, demonstrating that "there is a very obvious difference between the IDP and control groups, with the IDP group recovering much more slowly than the control group, as expected." This methodological approach provides confidence in the displacement identification methodology while acknowledging its limitations.

Privacy protection receives limited discussion despite the particular vulnerabilities of displaced populations to surveillance, persecution, and exploitation. The study uses "anonymized and aggregated mobile phone data" which provides some protection through aggregation, but lacks detailed consideration of displacement-specific privacy risks.

While the study implements technical anonymization, it lacks analysis of how displacement context affects privacy risks. Displaced groups may face different privacy vulnerabilities than general populations, including risks from family separation, property disputes, or targeting by hostile actors.

Engagement Assessment: Inadequate

Despite focusing specifically on displaced populations, the study provides no evidence of consultation with displaced communities about research priorities, methodological

approaches, or interpretation of displacement and resettlement patterns. This absence is particularly concerning given that concepts like "resettlement" and "recovery" have deeply personal and cultural dimensions that may vary significantly across individuals and communities (Disara et al., 2021).

The study's validation approaches rely exclusively on technical comparisons between mobility metrics and control groups rather than participatory confirmation with displaced communities. The authors state they "perform this validation by defining a control group that consists of a set of randomly chosen subscribers" (Li et al., 2019, p.4), without indicating any community involvement in validation processes.

The research lacks engagement with displaced communities' own understanding of recovery, resettlement, and displacement experiences. The technical definition of resettlement as return to "normal" mobility patterns may not align with how mobile populations themselves understand their recovery processes or ongoing displacement-related challenges. While the research creates pathways to institutional benefits for humanitarian response, displaced populations lack agency over how their displacement experiences are measured, analyzed, or applied to philanthropic decisions. The research maintains paternalistic frameworks where external experts define displacement and recovery metrics without affected individuals' populations' participation in research design or interpretation.

Non-discrimination Assessment: Limited

The research aims to improve humanitarian response effectiveness, potentially challenging inequalities in aid distribution by providing more accurate information about displacement patterns. The focus on populations "who do not choose, or are unable to go to organised displacement sites and may be left uncounted" (Li et al., 2019, p.2), represents an important focus on exposed displaced persons who are systematically excluded from traditional humanitarian data collection.

The study's methodology could address systematic undercounting of displaced populations that affects humanitarian resource allocation. Traditional camp-based

surveys miss displaced persons in host communities, informal settlements, or those who return to damaged areas, potentially leading to inadequate humanitarian response for these populations.

The secular analysis of displacement patterns could enable more equitable humanitarian resource allocation by providing evidence about displacement duration and recovery timelines. The finding that resettlement declines in predictable patterns could inform humanitarian programming to ensure adequate support duration.

However, the systematic exclusion of the most vulnerable displaced populations means that research-based improvements may mostly benefit more connected displaced persons. The reliance on mobile phone ownership systematically excludes a relevant portion of the population, who may face the greatest displacement-related vulnerabilities. Humanitarian programming improvements based on this analysis could unintentionally reinforce inequalities by optimizing responses for digitally connected displaced groups only. The study's filtering criteria for "frequent callers" further exclude crisis-affected individuals who may lack regular access to mobile phones due to economic constraints, network disruptions, or other challenges.

The research defines recovery through technical mobility metrics rather than individuals' own understanding of when they have achieved stability or successful resettlement. This approach risks misrepresenting displacement experiences and recovery needs from displaced populations' perspectives.

5.2.4 Arai et al. (2021): COVID-19 Mobility Analysis in The Gambia

Arai et al. investigated population mobility patterns during COVID-19 lockdowns in The Gambia, demonstrating how CDR data can inform rapid policy responses during health crises. The research operates in a context where pandemic restrictions created forms of economic displacement as urban populations returned to rural areas, making it relevant for understanding crisis-induced mobility patterns and their policy implications.

Visibility Assessment: Limited

The study demonstrates partial attention to population visibility but contains gaps in representing displaced communities within mobility analysis. While the methodology acknowledges certain exclusions, it fails to address how these gaps specifically affect displaced communities.

The reliance on CDR data from only "two major MNOs, which cover approximately 70% of the market" (Arai et al., 2021, p. 7) creates immediate visibility gaps for the remaining 30% of mobile users. The authors acknowledge this limitation but provide no analysis of who this left-out population consists of or whether this exclusion disproportionately affects displaced communities who may rely on different networks.

The methodology's approach to identifying home locations through average evening/nighttime activity assumes stable housing conditions, which displaced individuals may lack. The authors define residential location as "the modal location of the last observation on each day of the week, where the user is most frequently in the evenings or at night" (Arai et al., 2021, p. 8), which systematically excludes populations without consistent nighttime locations or those living in temporary arrangements.

The study's focus on district-level aggregation may obscure displacement-specific mobility patterns, particularly for populations moving between informal settlements or those avoiding official administrative boundaries. While the authors implement privacy protections through "three-stage approach to anonymize these identifiers" (Arai et al., 2021, p. 7), they provide limited discussion of whether these protections address the vulnerabilities of mobile populations who may face persecution or discrimination based on their mobility patterns.

The technical decision to cluster cell towers "using Ward's hierarchical clustering, with a maximum distance constraint of 1 km from the centroid" (Arai et al., 2021, p. 7), while intended to protect privacy, may unintentionally reduce spatial resolution in ways that make displaced populations' informal settlement locations invisible within the analysis.

Privacy considerations receive more attention than in other studies, with detailed protocols for data anonymization and institutional safeguards. However, the study lacks

specific consideration of how COVID-19 mobility surveillance might affect displaced populations who may already face marginalization.

Engagement Assessment: Inadequate

The study provides limited evidence of relevant consultation with affected communities. While the research involved institutional partnerships with government agencies, community engagement remained minimal.

The methodological framework was developed through a "dialogue among The World Bank, the GBoS, and the PURA" (Arai et al., 2021, p. 4), without evidence of consultation with displaced communities or populations affected by mobility restrictions. The research questions and analytical preference were defined by institutional stakeholders rather than communities whose movement patterns were being extracted and analyzed.

While the study aims to inform COVID-19 response policies that could theoretically benefit mobile populations, displaced communities had no voice in deciding what policy interventions would best serve their needs during lockdown restrictions. The research treats communities as passive subjects of analysis.

The validation process relies exclusively on comparison with "2019 WorldPop data and the 2013 Population Census" (Arai et al., 2021, p. 9) rather than integrating community knowledge about mobility constraints, informal movement patterns, or the specific challenges faced by displaced populations during lockdown measures.

Community benefits flow through institutional middlemen (government agencies and international organizations) without procedures for communities to directly access research findings or influence how results are applied to pandemic response policies that directly affect their mobility and livelihoods.

Non-discrimination Assessment: Limited

The study demonstrates some awareness of potential discriminatory impacts but lacks a thorough analysis of how mobility restrictions might differently affect various populations, especially displaced communities.

The methodology acknowledges that "multi-SIM holding" is common and that "two MNOs primarily market to different socio-economic groups" (Arai et al., 2021, p. 7), suggesting awareness of digital divides. However, the analysis does not examine how these differences in mobile phone access might lead to discriminatory policy outcomes that favor digitally connected populations.

The study's findings about "urban exodus" during lockdown, where "many migrants returned to their home villages" (Arai et al., 2021, p. 4), display displacement patterns but do not analyze whether pandemic response policies adequately protected these mobile populations or whether mobility restrictions imposed additional constraints on already vulnerable displaced communities.

The policy recommendations emphasize using findings to "inform targeted testing initiatives" and "inform where social-distancing policies should be enforced" (Arai et al., 2021, p. 15) without considering whether such targeted interventions might subject displaced communities to additional surveillance or discriminatory enforcement.

While the research could potentially inform more fair pandemic responses by identifying areas of population concentration and mobility, the study does not address whether optimization algorithms consider equity outcomes or whether policy applications account for the particular vulnerabilities of displaced populations who may lack access to healthcare, stable housing, or economic support during lockdown measures.

The study represents an improvement over purely extractive research approaches by establishing institutional partnerships for data governance, but it maintains existing power structures where technical experts and government agencies make decisions about public health policies without direct participation from affected communities, potentially reproducing inequalities in pandemic response.

5.2.5 Milusheva et al. (2021): COVID-19 Response and Mobile Data Access Challenges

Milusheva et al. examined a World Bank initiative to access and utilize CDR data across 41 developing countries for the COVID-19 response, achieving collaborations in nine countries. The study represents a large-scale institutional effort to organize mobile phone data access for crisis response during pandemic restrictions, where particularly crisis-affected populations face vulnerabilities.

Visibility Assessment: Inadequate

The study demonstrates the invisibility of displaced groups within its multi-country CDR analysis framework by failing to address how data exclusions unevenly affect exposed mobile communities across different national contexts.

The methodology acknowledges coverage limitations, stating that "mobile phone penetration is not universal" and "there is variability in ownership of phones among different demographic groups based on age, income, and gender" (Milusheva et al., 2021, p. 8). However, the study provides no analysis of how these exclusions affect displaced populations specifically.

The research recognizes that "often it is only possible to obtain data from just one MNO for that country" (Milusheva et al., 2021, p. 8), creating significant visibility gaps. The authors acknowledge that "if the MNO is correlated with specific individual characteristics (such as the income level of the users) or has limited geographic coverage, this could introduce bias" but fail to examine how such biases systematically exclude displaced communities with poor access to official telecommunications infrastructure.

The study's approach to data aggregation at "geographic administrative level" (Milusheva et al., 2021, p. 8) may obscure displacement-specific mobility patterns, particularly for populations moving between informal settlements or crossing administrative boundaries. The focus on "change over time from baseline values, which are defined as the average by day of the week across February 1 to March 15" assumes stable movement patterns that displaced populations often lack.

Privacy protections receive detailed attention through "aggregation: observations with 15 or fewer SIM cards were removed from the data and marked as missing" (Milusheva et al., 2021, p. 8). However, this technical approach may unintentionally depict small displaced communities invisible within the analysis when their population size falls below the threshold, effectively excluding them from pandemic response planning. Furthermore, the study's institutional focus on government partnerships and MNO relationships forms data access through formal channels that may exclude populations who avoid or cannot access official institutions.

Engagement Assessment: Inadequate

The study provides low evidence of meaningful consultation with displaced communities or broader affected populations whose mobility patterns were being analyzed across the 41 country cases, despite the massive range of data extraction involved.

The methodological framework was developed through institutional partnerships between "MNOs and government agencies" with "data translators (international organizations, nongovernmental organizations, academia, and private sector)" (Milusheva et al., 2021, p. 3) serving as agents. The study does not demonstrate that displaced communities or their representative organizations participated in defining research priorities, data governance frameworks, or analytical approaches across any of the 41 countries examined.

The research approach treats "Ministries of Health and their epidemic response teams" as "key beneficiaries of mobility data insights" (Milusheva et al., 2021, p. 3) without examining whether these institutions properly represent the interests of displaced populations. The study acknowledges the importance of "engagement between local and international researchers, data analysts, and stakeholder government agencies" (Milusheva et al., 2021, p. 3) but provides no evidence of engagement with displaced communities themselves.

While the authors recognize that "investing time to understand local contexts and build relationships with local research communities" is important (Milusheva et al., 2021, p. 10),

they focus on institutional capacity development rather than community engagement. The "capacity building activities" conducted "to train local researchers, PhD students, and government agency officials" (Milusheva et al., 2021, p. 12) exclude affected communities from knowledge transfer processes.

Additionally, the validation and application procedures rely on technical metrics and government policy frameworks only. The study's approach to "building demand within relevant government agencies" (Milusheva et al., 2021, p. 3) positions communities as passive subjects whose mobility patterns are extracted for institutional optimization purposes rather than as participants with rights to influence how their data is used.

Non-discrimination Assessment: Inadequate

The study acknowledges various forms of bias in CDR data but does not address how these biases translate into discriminatory outcomes for displaced populations across the selected countries.

The methodology acknowledges that "there are inherent biases in mobile phone datasets that should be considered when making population-level inferences that may feed into policy making" including "variability in ownership of phones among different demographic groups" (Milusheva et al., 2021, p. 8). However, the study does not examine how these biases might lead to discriminatory policy outcomes and could disadvantage displaced communities.

The research identifies that "adjustment factors can be derived from census or survey data to scale mobile phone data-based estimates to match with the general population" (Milusheva et al., 2021, p. 8) but does not indicate that such adjustments were put into practice to address displacement-specific exclusions across the cases. The study's reliance on formal data sources (census and survey data) may reproduce the invisibility of displaced populations, who are often underestimated or excluded from official statistics.

The aggregation approach, which removes observations with "15 or fewer SIM cards" (Milusheva et al., 2021, p. 8), while intended to protect privacy, may exclude small

displaced communities from analysis and may effectively make them unrepresented in pandemic response planning. This technical implementation could also lead to discriminatory resource allocation that favors larger, more visible populations.

The research framework maintains existing power structures where "MNOs and government agencies are key stakeholders for the supply and demand of data" (Milusheva et al., 2021, p. 3) while treating displaced communities as data subjects rather than stakeholders with rights to participate in decisions about surveillance technologies that affect their mobility and access to services during health emergencies.

5.2.6 Giardini et al. (2023): Urban Mobility During COVID-19 in Italy

Giardini et al. developed a methodology to measure post-disaster displacement using aggregated Call Detail Records following the 2016-2017 Central Italy earthquake sequence. Their work offers an important comparative perspective on how CDR applications and Data Justice considerations manifest differently in contexts with established regulatory frameworks, higher mobile phone penetration, and different institutional structures for crisis response.

Visibility Assessment: Limited

The study demonstrates partial attention to population visibility through its technical methodology, but contains gaps in representing displaced populations within post-disaster mobility analysis.

The methodology's approach to data aggregation at a municipality level may conceal displacement-specific patterns, particularly for populations seeking temporary shelter across administrative boundaries. The authors acknowledge that "our data do not fully compensate for people not having mobile phones (e.g., the presence of children and elderly)" (Giardini et al., 2023, p. 11) but provide no investigation of how this exclusion specifically affects cirsisi-affected communities.

The study's forecasting approach, which interprets predictions "as the counterfactual scenario as if the earthquake had not happened" (Giardini et al., 2023, p. 8), assumes normal mobility patterns that displaced populations commonly cannot maintain. This methodological choice may underrepresent the mobility constraints and irregular patterns characteristic of displaced communities seeking emergency accommodation.

Privacy considerations receive technical attention through aggregation and anonymization procedures, but the study lacks specific consideration of whether these protections properly address the particular vulnerabilities of displaced populations who may face additional risks from mobility surveillance during emergencies.

Engagement Assessment: Inadequate

The study provides no evidence of consultation with displaced communities or broader affected populations whose mobility patterns were being analyzed, despite the research's explicit focus on measuring population displacement following a major disaster.

The methodological framework was developed through institutional partnerships with "TIM, the largest mobile phone operator in Italy" (Giardini et al., 2023, p. 11) and academic institutions without evidence of consultation with displaced communities or their representative organizations. The research questions and analytical priorities were determined by technical and institutional stakeholders rather than communities whose displacement patterns were being extracted and analyzed.

The study treats displacement as a technical measurement problem rather than a lived experience requiring community input. The authors focus on "quantifying population displacement from fully aggregated mobile-phone data" (Giardini et al., 2023, p. 2) without examining whether their analytical approach aligns with how displaced communities understand and experience their own mobility and housing needs.

While the research aims to inform "policymakers who want to understand the determinants of population displacement" (Giardini et al., 2023, p. 1), displaced communities had no voice in determining what policy insights would best serve their

needs during displacement or recovery processes. The validation process relies exclusively on "census data" and technical correlations rather than incorporating community knowledge about displacement experiences.

The study's approach to measuring "requests for financial support to rebuild damaged buildings" (Giardini et al., 2023, p. 1) as a proxy for displacement intentions treats communities as passive subjects whose recovery decisions can be inferred from administrative data rather than as participants with rights to influence how their displacement and recovery needs are understood and addressed.

Community benefits flow through policy mediators without mechanisms for displaced communities to directly access research findings or influence how displacement analytics are applied to recovery policies that directly affect their housing, mobility, and access to services.

Non-discrimination Assessment: Limited

The study acknowledges various forms of bias in mobile phone data but fails to systematically address how these biases translate into discriminatory outcomes for displaced populations or how the technical approach might reproduce existing inequalities in post-disaster recovery.

The methodology recognizes that individuals without mobile phone access (children and elderly) are not covered, but does not examine how these exclusions might lead to discriminatory policy outcomes that systematically disadvantage displaced communities with limited access to mobile technologies. The focus on "linearly scaling numbers to consider the operators' market share" suggests awareness of coverage gaps but provides no analysis of whether such technical adjustments adequately address displacement-specific inequalities.

The study's approach to identifying economic factors affecting displacement reveals that "more modern economic sectors (secondary and tertiary), which require supply chains, logistics and interconnections...have been heavily affected by the disaster" (Giardini et al.,

2023, p. 7). However, the analysis does not consider whether policy applications of these findings might favor economic recovery over community-centered recovery approaches or whether reconstruction priorities properly consider the needs of displaced populations from different economic backgrounds. Furthermore, the research framework maintains existing power structures where technical experts and academic institutions define displacement measurement without corresponding investment in community capacity to influence how such measurements affect recovery policies.

5.3 Patterns and Gaps Identified

The systematic analysis of the six studies reveals problematic procedures or a lack thereof in how the academic community approaches Data Justice considerations when utilizing CDR data for displacement research.

A striking misalignment is visible in the technical methodological complexity compared to the attention to community representation. Studies employing the most advanced analytical techniques, such as machine learning algorithms and mobility modeling, demonstrate the weakest engagement with exposed communities. This inconsistency suggests that technical advancement has progressed without equivalent ethical development, creating increasingly powerful tools that may unintentionally harm the populations they are supposed to serve. The systematic exclusion of non-phone users appears across all studies, yet only Li et al. (2019) and Zufiria et al. (2018) acknowledge the implications for displacement contexts. The remaining investigations treat these exclusions as technical limitations rather than ethical concerns. This pattern reveals how technical analyses can obscure justice considerations, transforming ethical problems into methodological footnotes.

Besides this absence of engagement, another conventionality identified is the almost universal lack of direct community engagement across all studies examined. Even investigations explicitly focused on humanitarian interests treat affected populations as passive data subjects whose mobility patterns can be extracted, analyzed, and applied to policy decisions without their participation or consent. This data-exploitation persists

regardless of geographic context, institutional affiliation, or humanitarian objectives. The pattern becomes particularly concerning when examining studies that claim humanitarian benefits. Research aimed at improving food security monitoring (Zufiria et al., 2018) or disaster response (Li et al., 2019) maintains paternalistic frameworks where external experts define community needs, analytical priorities, and success metrics without input from affected individuals. This approach reproduces hierarchical patterns of knowledge production where communities become objects of study rather than partners in research.

Deployed privacy protection strategies demonstrate technical solutions applied universally without contextual adaptation to displacement-specific vulnerabilities. Standard anonymization and aggregation procedures are employed across studies regardless of whether populations face persecution, surveillance threats, or particular re-identification risks associated with displacement status. This pattern suggests that privacy protection remains conceptualized in individualistic terms rather than considering collective exposure or structural power dynamics that affect entire communities. The absence of displacement-specific privacy frameworks leaves crisis-affected populations potentially vulnerable to harms that extend beyond individual privacy violations to include community targeting, discrimination, and persecution.

6. Discussion & Recommendations

The analysis reveals misalliance between technical precision and community agency that characterizes current CDR displacement research. As analytical techniques become more advanced, studies surprisingly seem to become less attentive to whether these technical capabilities serve community interests or reproduce existing marginalization. This finding challenges assumptions that technical growth automatically translates into better outcomes for vulnerable communities. The pattern suggests that current research prioritizes methodological innovation over ethical reflection, creating tools that may appear scientifically precise while undermining the rights and dignity of crisis-affected

groups. This observation aligns with broader critiques of "technological solutionism" (Sætra & Selinger, 2024) in humanitarian contexts.

The absence of meaningful community engagement represents the most significant gap identified in current research practices, which is particularly troubling given the vulnerable status of populations being studied and the potential impacts of research findings on humanitarian aid and policy decisions affecting displaced communities. The examples reveal how conventional academic frameworks may be structurally incompatible with Data Justice principles. Traditional research methods emphasize expert knowledge production, institutional review processes, and publication in academic venues that are mostly inaccessible to affected communities. These structures may actively prevent the kind of participatory, community-centered approaches that Data Justice principles require.

Current engagement failures also reflect broader power imbalances between Global North institutions conducting CDR research and populations in the Global South experiencing displacement. The analysis suggests that addressing engagement gaps requires fundamental changes to research design, funding mechanisms, and institutional incentive structures rather than simply adding community consultation components to existing methodologies. Such changes would represent a significant shift from extractive to participatory research methods in displacement studies.

The consistent pattern of institutional mediation in community benefits reveals how current research practices may unintentionally strengthen existing power structures while claiming to serve exposed groups. This finding raises important questions about whether CDR research, as currently practiced, challenges or reproduces inequalities affecting displaced communities. This institutional focus reflects broader trends in humanitarian programming toward technical solutions and expert-driven interventions that may bypass community agency and self-determination. While institutions play important roles in disaster response and development programming, the complete absence of direct community engagement in benefit distribution suggests that current approaches may prioritize institutional convenience over community empowerment.

While the analysis identified some variation across geographic contexts, particularly regarding regulatory frameworks and mobile phone penetration rates, these contextual differences appear to have limited impact on ethical practices. Studies conducted in contexts with stronger data protection regulations (such as Italy) do not demonstrate significantly better community engagement or displacement-specific privacy protections than those in contexts with weaker regulatory frameworks. This finding suggests that current ethical gaps reflect academic and institutional culture rather than regulatory constraints. Even where stronger legal frameworks exist, researchers appear to apply minimum compliance standards rather than developing ethical approaches tailored to displacement contexts and community needs.

6.2 Practical Recommendations

For Researchers

Researchers utilizing CDR data for displacement analysis must fundamentally reconceptualize their methodological approaches to center community agency and Data Justice principles. This transformation requires moving beyond technical fixes toward participatory frameworks that position affected communities as partners rather than subjects in research processes. Researchers should engage displaced communities in defining research questions, analytical priorities, and success metrics before initiating data collection or analysis. This engagement has to extend beyond consultation to include shared decision-making power over research design, interpretation of findings, and application of results. Community engagement should be resourced properly and conducted in languages and cultural contexts accessible to affected populations.

Standard anonymization and aggregation procedures must be supplemented with displacement-specific privacy assessments that consider persecution risks, surveillance threats, and collective vulnerabilities affecting entire communities. Researchers should develop privacy frameworks in collaboration with affected communities that address not only individual re-identification risks but also community targeting and discrimination possibilities.

Technical validation methods should be accompanied by community validation processes that assess whether analytical findings accurately represent displacement experiences and serve community interests. Community members should have opportunities to interpret findings, identify misrepresentations, and suggest alternative analytical approaches that better capture their experiences and priorities.

Research designs must include explicit mechanisms for ensuring that communities benefit directly from research using their mobility data. This includes providing communities with accessible summaries of findings, supporting community advocacy efforts with research evidence, and creating pathways for communities to influence how findings are applied to policy and programming decisions.

For Academic Institutions

Academic institutions play crucial roles in creating enabling environments for ethical CDR research through policy frameworks, resource allocation, and institutional incentives. Current institutional practices often discourage community-centered approaches through publication pressures, funding priorities, and review processes that do not adequately assess ethical dimensions of Data Justice.

Institutions should develop specialized ethics review processes for CDR displacement research that go beyond standard privacy considerations to assess Data Justice dimensions, including community representation, engagement mechanisms, and benefit distribution. Review boards should include community representatives and displacement experts who can assess whether proposed research approaches adequately protect vulnerable populations.

Educational establishments should provide resources and infrastructure for developing long-term partnerships with displaced communities and their representative organizations. This includes funding for community engagement activities, translation services, cultural competency training for researchers, and institutional capacity for maintaining ongoing relationships with affected populations. They should create incentive structures that encourage collaboration between technical researchers and

humanitarian practitioners, displacement experts, and community advocates. Current disciplinary boundaries may prevent the kind of integrated approaches that Data Justice principles require.

Innovative publication formats that make research findings accessible to affected communities, including community-accessible summaries, multilingual materials, and formats suitable for community advocacy and organizing efforts should be supported.

For Policymakers

Policymakers at national and international levels must develop regulatory and policy frameworks that protect displaced populations from harmful data uses while enabling beneficial applications of CDR analysis for humanitarian purposes. Current regulatory frameworks often fail to address the specific vulnerabilities and needs of affected populations in data governance contexts.

Regulatory frameworks should include specific protections for displaced communities that address their particular exposure to surveillance, persecution, and discrimination based on mobility data. These protections should extend beyond individual privacy rights to include collective protections for entire communities. Given the cross-border nature of many displacement situations, international policy coordination is needed to ensure consistent protection standards and prevent forum shopping by researchers or organizations seeking weaker regulatory environments for conducting CDR analysis.

Policy concepts should establish accountability mechanisms for humanitarian organizations and government agencies that utilize CDR research in programming decisions affecting relevant groups. These mechanisms should include community complaint processes, regular impact assessments, and requirements for community participation in the evaluation of humanitarian effectiveness.

Public funding agencies should establish ethical standards for CDR displacement research that require demonstration of community engagement, Data Justice considerations, and

benefit-sharing methods as conditions for research funding. Funding priorities should encourage community-centered research approaches over purely technical innovation.

For Mobile Network Operators

Mobile network operators hold significant power in determining how CDR data is accessed and used for displacement research. Current commercial data governance frameworks may not adequately protect displaced populations or ensure that data use serves community interests.

MNOs should develop mechanisms for notifying subscribers when their mobility data may be used for displacement research and providing options for informed consent or opt-out. Special attention should be paid to ensuring that displaced populations understand potential uses of their data and risks they may face from data sharing. Data sharing agreements should include strict limitations on data use that prevent function creep from humanitarian purposes to surveillance or enforcement applications. Clear restrictions should prevent data sharing with actors who might use mobility information to target or discriminate against displaced populations.

Furthermore, MNOs should invest in capacity building for civil society organizations representing displaced populations to enable efficial participation in data governance decisions affecting their communities.

For Humanitarian Organizations

Humanitarian organizations utilizing CDR research findings in programming decisions must ensure that technical tools enhance rather than replace community-centered approaches to displacement response. Current practices may inadvertently marginalize community voices by prioritizing technical data over community knowledge and priorities.

CDR analysis should supplement, not replace, community-led assessments and participatory needs identification processes. Technical findings should be validated

against community knowledge and priorities, with community perspectives given equal importance.

Communities should be involved in interpreting CDR findings and determining how technical analysis relates to their lived experiences and priorities. This includes providing communities with accessible summaries of findings and opportunities to provide feedback on technical interpretations.

Humanitarian organizations should support community advocacy efforts by providing technical evidence that communities can use in their own advocacy and organizing activities. This includes capacity building for communities to understand and utilize technical findings in their interactions with government agencies and other stakeholders. Rather than extractive relationships focused on immediate data utility, humanitarian organizations should invest in long-term partnerships with displaced communities that extend beyond individual emergencies or programming cycles.

Regular accountability processes should assess whether CDR-informed programming serves community priorities and produces outcomes that communities value. Community feedback should inform decisions about continued use of technical tools.

6.3 Future Research Needs

The analysis reveals several critical areas where additional research is needed to support more ethical and effective applications of CDR data in displacement contexts. Significant innovation is needed in developing participatory methodologies that enable meaningful community engagement in CDR research design, implementation, and interpretation. Current academic frameworks provide limited guidance for conducting technical research in partnership with displaced communities who may face multiple constraints on participation.

Research is needed to develop community engagement methods suitable for displacement contexts, including approaches that work with transient populations, communities facing security threats, and groups with limited access to formal institutions.

This includes innovation in remote participation methods, culturally appropriate engagement strategies, and approaches that work across linguistic and cultural differences. Methodological research should also address how to integrate community knowledge systems with technical CDR analysis in ways that enhance rather than marginalize traditional knowledge about mobility patterns, survival strategies, and community needs. This requires developing frameworks for knowledge integration that avoid extractive approaches to traditional knowledge while enabling technical innovation.

Current privacy protection technologies were developed primarily for commercial contexts and may not address the specific vulnerabilities faced by displaced populations. Research is needed to develop privacy technologies adjusted to displacement contexts that address collective as well as individual privacy needs. Priority areas include developing re-identification risk assessment methods that consider displacement-specific vulnerabilities, creating aggregation techniques that preserve analytical utility while protecting communities from targeting or discrimination, and innovating consent and control techniques that work in displacement contexts where traditional consent frameworks may be inappropriate. Technical research should be conducted in partnership with displaced communities to ensure that privacy innovations address actual rather than presumed community needs and priorities. This includes understanding how different privacy approaches affect community trust, digital inclusion, and access to mobile telecommunications services.

Current research provides limited evidence about whether CDR applications actually improve outcomes for displaced populations or produce unintended negative consequences. Longitudinal research is needed to assess the impacts of CDR-informed humanitarian programming, policy decisions, and disaster response on affected communities. Impact assessment research should employ participatory methodologies that center community definitions of successful outcomes rather than institutional metrics. This includes understanding how CDR applications affect community agency, self-determination, and capacity for collective action in addressing displacement-related challenges. Research should also examine broader impacts on digital rights, community

trust in telecommunications services, and social cohesion within displaced communities. Long-term studies are needed to understand how CDR data collection and analysis affect community relationships with technology and formal institutions over time.

Additional research is needed to understand how CDR applications interact with broader power structures affecting displaced populations. This includes analysis of how technical approaches to displacement monitoring may reinforce existing inequalities or create new forms of marginalization. Research priorities include examining how CDR applications affect resource allocation decisions, policy priorities, and institutional relationships with displaced communities. Further analysis is needed of how technical framings of displacement may influence humanitarian programming approaches and whether data-driven decision-making enhances or undermines community agency.

Structural analysis should also examine how global inequalities in technological capacity, regulatory frameworks, and institutional resources affect the development and application of CDR technologies in displacement contexts. This includes understanding how dependency relationships between Global North institutions and Global South populations may be reproduced through technical assistance and capacity-building programs.

Research should also examine how communities currently understand and analyze their own mobility patterns and displacement experiences, building on these existing knowledge systems rather than imposing external frameworks. This includes documenting traditional knowledge about mobility, survival strategies, and community resilience that can inform more culturally appropriate technical approaches.

7. Conclusion

This thesis has examined how current academic research utilizing Call Detail Records for disaster-induced displacement addresses Data Justice principles, revealing significant gaps in protecting exposed populations while highlighting both the potential and limitations of technical approaches to understanding human mobility in crisis contexts.

The systematic analysis of six representative studies across diverse geographic and institutional contexts demonstrates that current CDR displacement research consistently fails to meet Data Justice standards across all three dimensions identified by Taylor's framework. The pattern of inadequate community engagement appears universally, with even studies explicitly focused on humanitarian applications treating displaced populations as passive data subjects rather than partners in research processes. This finding challenges assumptions that humanitarian motivations automatically translate into ethical practices and reveals how academic frameworks may structurally prevent meaningful community participation in research affecting relevant communities.

The visibility analysis reveals a troubling paradox where technical sophistication correlates inversely with attention to community representation. Studies employing the most advanced analytical techniques demonstrate the weakest consideration of how their methodologies systematically exclude the most vulnerable subpopulations within displaced communities.

The persistent pattern of institutional mediation in research benefits raises fundamental questions about whether current CDR research practices challenge or reproduce existing power structures affecting displaced communities. Benefits consistently flow through governmental agencies, international organizations, and humanitarian institutions without mechanisms for direct community access or influence, potentially strengthening existing inequalities while claiming to address displacement-related problems. The research demonstrates that technical solutions alone cannot address the complex challenges faced by displaced populations and that Data Justice requires fundamental changes to research paradigms, institutional practices, and power relationships between researchers and affected communities involved.

The analysis reveals that addressing current ethical gaps requires more improvements to existing practices. Meaningful progress toward Data Justice necessitates the transformation of academic frameworks from extractive to participatory approaches, the development of community-centered research methodologies, and the creation of

institutional structures that enable rather than constrain community agency in research processes affecting displaced populations.

Current privacy protection strategies, while technically advanced, fail to address the contextual exposure and collective risks faced by displaced communities. Standard anonymization and aggregation procedures developed for commercial contexts may provide insufficient protection for populations facing persecution, surveillance threats, and systematic discrimination based on their mobility patterns. This gap reveals the need for displacement-specific privacy frameworks developed in partnership with affected communities.

The geographic diversity of studies examined demonstrates that ethical gaps reflect academic and institutional culture rather than regulatory constraints or resource limitations. Studies conducted in contexts with stronger data protection regulations do not demonstrate significantly better ethical practices than those in contexts with weaker frameworks, suggesting that current problems require cultural and paradigmatic rather than merely regulatory solutions.

The research contributes to broader debates about the role of technology in humanitarian contexts and the responsibility of academic institutions to ensure that research serves rather than exploits vulnerable populations. The findings support arguments that technical innovation must be accompanied by ethical reflection and community engagement to avoid reproducing hierarchical patterns of knowledge extraction and expert-driven intervention.

However, the analysis also reveals the significant potential of CDR applications when implemented with appropriate ethical frameworks and community engagement. Studies such as Zufiria et al. (2018) demonstrate how mobile phone data can support food security early warning systems in ways that directly benefit rural populations at risk of displacement. The challenge lies in realizing this potential while ensuring that technical tools enhance rather than replace community agency and self-determination.

The implications extend beyond CDR applications to broader questions about Data Justice in contexts of vulnerability and marginalization. The framework developed for this analysis could be applied to other big data technologies affecting exposed populations, including satellite imagery analysis, social media monitoring, and digital identity systems used in humanitarian contexts. Future research must prioritize participatory methodologies that center community agency while advancing technical capabilities. This requires innovation in community engagement methods, development of privacy technologies tailored to displacement contexts, and long-term impact assessment that employs community-defined success metrics. Investment in community-led research capacity development represents a crucial priority for ensuring that technical advances serve community rather than institutional interests.

The research also reveals the need for systemic changes to academic incentive structures, funding mechanisms, and publication practices that currently discourage community-centered approaches. Addressing Data Justice requires institutional transformation that creates enabling environments for ethical innovation rather than prioritizing technical sophistication over community engagement. Ultimately, this thesis demonstrates that realizing the humanitarian potential of CDR technology requires fundamental commitment to Data Justice principles that position displaced communities as partners rather than subjects in research processes. The choice between extractive and participatory approaches to CDR research reflects broader questions about academic responsibility, institutional power, and the purposes that technical innovation should serve in addressing global challenges.

The analysis suggests that Data Justice in displacement contexts requires not only protecting communities from harmful data uses but actively supporting their capacity for self-determination, advocacy, and collective action in addressing displacement-related challenges. This vision of Data Justice extends beyond privacy protection to encompass community empowerment, institutional accountability, and transformation of power relationships that contribute to displacement and vulnerability.

Current CDR displacement research stands at a critical point. The technical capabilities exist to support more effective humanitarian response and displacement monitoring, but realizing this potential requires fundamental commitment to ethical frameworks that center community agency and Data Justice principles. The choice of whether to pursue extractive or participatory approaches will determine whether CDR technology serves as a tool for community empowerment or institutional control in contexts of displacement.

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Appendix 1

Assessment Criteria Definitions:

Inadequate Visibility: No examination of how displaced populations are represented in CDR data OR no acknowledgment of systematic exclusions (elderly, children, disabled, low-income populations etc.) OR privacy protection mentioned only in passing without specific measures OR representations serve institutional interests exclusively with no consideration of displaced populations' perspectives OR aggregation methods that obscure rather than reveal displacement patterns

Limited Visibility: Acknowledges some representation limitations but provides minimal analysis of implications for displaced populations OR implements basic privacy measures (anonymization, aggregation) but lacks displacement-specific protections OR captures some displacement patterns but misses key vulnerable subgroups OR representations provide general insights but unclear how they serve displaced populations' immediate needs OR technical validation only, without community perspective on accuracy of representations

Comprehensive Visibility: Systematically analyzes representation gaps and their implications for different vulnerable subgroups within displaced populations AND implements robust privacy protections tailored to displacement-specific risks (re-identification, persecution, surveillance) AND representations actively serve displaced populations' interests through clear applications to aid, protection, or policy AND captures temporal and spatial patterns that reveal rather than obscure displacement experiences OR demonstrates how visibility empowers rather than endangers displaced populations

Inadequate Engagement: No evidence of community consultation in research design OR data collection operates without any community notification OR benefits accrue exclusively to researchers/institutions with no pathway to affected communities OR communities treated purely as passive data subjects

Limited Engagement: Some institutional consultation (government agencies, NGOs) but no direct community involvement OR acknowledges community consent challenges but provides no alternative engagement mechanisms OR creates potential community benefits but through institutional intermediaries only OR incorporates existing community knowledge (surveys, calendars) but communities have no voice in CDR-specific data governance

Comprehensive Engagement: Direct community consultation in research design or interpretation AND explicit mechanisms for community input on data use priorities AND clear pathways for communities to access and benefit from research findings AND communities have agency over data governance decisions affecting them OR meaningful capacity building that empowers community participation in data governance

Inadequate Non-discrimination: No consideration of differential impacts on vulnerable groups OR analysis could reinforce stereotypes about displaced populations OR no safeguards against discriminatory applications of findings OR maintains extractive research relationships without addressing power imbalances

Limited Non-discrimination: Acknowledges vulnerability of displaced populations but lacks specific protections OR aims to improve services for vulnerable groups but through top-down approaches only OR addresses some structural inequalities (institutional/national level) but not community-level empowerment OR provides general privacy protections but not tailored to displacement-specific risks

Comprehensive Non-discrimination: Systematically analyzes differential impacts on vulnerable subgroups within displaced populations AND implements specific safeguards against discriminatory applications AND actively challenges power structures that contribute to displacement vulnerability AND includes anti-oppressive research practices that shift power toward affected communities OR demonstrates how findings directly counter discrimination against displaced populations