DOCTORAL THESIS

Data, Technology, and Contextual Adaptation in Urban Digital Transformation

Francesco Tonnarelli

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Declaration:
Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for doctoral or equivalent academic degree.

Francesco Tonnarelli

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Andmed, tehnoloogia ja linnade digitaalse transformatsiooni kontekstuaalne kohandamine

FRANCESCO TONNARELLI

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Contents

List of Publications

The list of author's publications, on the basis of which the thesis has been prepared:

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II **Tonnarelli, F**., & Weaver, J. (2026). Good Enough Evidence-based Urban Planning: Data and Knowledge in Southern Smart Urbanism. Information Polity, 15701255261435441. https://doi.org/10.1177/15701255261435441

III **Tonnarelli, F**., & Mora, L. (2025). Data in crisis: Mobility and fitness-for-Use in decentralized ecosystems. Environmental Science & Policy, 174, 104267. https://doi.org/10.1016/j.envsci.2025.104267

IV **Tonnarelli, F**., & Sophianos, S. (2025). Upgrading Fit-for-Purpose Land Administration Systems: Challenges and Opportunities in Bosaso, Somalia. Survey Review, 57(404), 422-437. https://doi.org/10.1080/00396265.2025.2455369

V **Tonnarelli, F**., & Mora, L. (2025). Responsible AI for Cities: A Case Study of GeoAI in African Informal Settlements. Journal of Urban Technology, 32(3), 111-137. https://doi.org/10.1080/10630732.2025.2450755

Author’s Contribution to the Publications

Contribution to the papers in this thesis are:

I In Article I, the author of the thesis contributed by conceptualizing the study and conducting the critical literature review. This included synthesizing mainstream smart city models against African institutional realities as well as writing the qualitative background overview to establish the theoretical foundation. The author also led the revision of the manuscript during the submission process.

II In Article II, the author contributed to the development of the theoretical framework and to the analysis of the empirical data. The author participated in the design and writing of the framework. The author also conducted interviews and document analysis for one of case studies (Bosaso) and led to the writing of the final draft and subsequent submissions during the journal review.

III In Article III, as the lead author, the author was primarily responsible for designing the study, defining the analytical framework, collecting the empirical data (conducting the interviews and document analysis), performing the qualitative data analysis, and writing up the paper.

IV In Article IV, the author of the thesis contributed to the initial design of the longitudinal case study, conducted the primary data collection in Bosaso, Somalia, and contributed with the analysis of the fit-for-purpose land administration systems over time. The author also led the final writing process and revised the manuscript during the submission process.

V In Article V, as the first author, the author wrote the theoretical framework (writing the sections regarding the Task-Data-User-Technology fit) and led the data collection and analysis. The author furthermore led the manuscript writing during the revision process.

Abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
FFP	Fit-for-Purpose
FFPLA	Fit-for-Purpose Land Administration
FGD	Focus Group Discussion
GeoAI	Geospatial Artificial Intelligence
GIS	Geographic Information Systems
RQ	Research Question

Explanations of abbreviations used in the thesis.

1 Focus and Aim

1.1 Research objectives and questions

The rapid urbanization of the Global South, particularly within the African continent, presents a distinct set of governance challenges that diverge profoundly from the historical trajectories of the Global North (Randolph & Storper, 2022). In response to unprecedented demographic shift and the resulting strain on urban infrastructure, smartness has been increasingly presented as a panacea-a way to bypass traditional developmental stages and swiftly solve the complex problems of Southern urbanization (Marvin et al., 2016; Watson, 2015). Yet, while digital technologies and big data have been persistently championed by global tech vendors and development agencies as transformative solutions under the banner of "smart urbanism," the application of these tools in African contexts presents considerable structural and practical challenges. (Cain, 2014; Watson, 2013). These smart city agendas rely heavily on imported, universalist models predicated on the existence of centralized, formal state capacities and robust physical infrastructures (Datta, 2015; Odendaal, 2014). Consequently, they consistently fail to account for the severe resource constraints, pervasive spatial and economic informality, and profound institutional fragmentation that characterize Southern cities (Guma & Monstadt, 2021; Odendaal, 2011). This contextual mismatch often results in exclusionary technocratic interventions that ignore the survival logics of marginalized populations and risk exacerbating existing spatial inequalities (Watson, 2013).

Accordingly, the focus of this thesis is to critically examine and reconstruct the relationship between urban governance and digital technology in the Global South. It fundamentally critiques the one-size-fits-all hegemony of mainstream smart city paradigms that treat technology as an objective, neutral fix for deeply political urban problems (Kitchin, 2014). Instead, this research advocates for a deliberate shift toward contextual adaptation-a sociotechnical process where digital interventions are rigorously tailored to local socio-political realities (Han & Kim, 2024). Contextual adaptation recognizes that successful digitalization requires moving beyond monolithic state control to embrace hybrid governance arrangements (Pieterse, 2022; Ruhlandt et al., 2020). This involves leveraging the existing human infrastructure of informal community leaders, transnational networks, and decentralized agencies to support technological initiatives, ensuring they genuinely reflect the pluralistic management structures of African cities (Simone, 2004).

Rather than constructing a prescriptive theoretical framework, the primary aim of this research is to articulate an understanding of urban digital transformation that prioritizes contextual adequacy over technical completeness. In environments where standard, data-intensive best practices are difficult to apply, waiting for comprehensive, fully standardized digital infrastructures effectively paralyzes municipal decision-making. By analysing diverse sociotechnical cases, this thesis investigates how imperfect data and technology can be mobilized effectively. It empirically demonstrates that in the Global South, good enough evidence is often a necessary and sufficient basis for urban planning (Bialski, 2024; Grindle, 2004; Kayanan et al., 2025). Furthermore, it establishes that the viability of digital tools relies on negotiated fitness-for-use (Bokulich & Parker, 2021; Parker, 2020) and multidimensional alignment rather than absolute technical standardization.

To achieve this aim, the thesis addresses the following overarching Research Questions (RQs):

RQ1: How do the specific material and institutional realities of African cities challenge universalist smart city models, and what alternative governance frameworks support effective digital transitions? (Article I, II, III, V)

RQ2: How is actionable urban knowledge produced, validated, and mobilized in data-scarce or fragmented ecosystems where standard data infrastructures are absent? (Article II, III, IV, V)

RQ3: What design principles and adaptation strategies ensure that digital technologies-from land administration to AI applications-are "fit-for-purpose" and socially responsible in the Global South? (Article IV, V)

RQ4: What are the long-term temporal dynamics of ad-hoc digital interventions, and what institutional conditions are required to prevent the decay of "fit-for-purpose" systems? (Article III, IV, V)

1.2 Structure of the thesis

This dissertation compiles and synthesizes the key results of five interconnected academic articles. To better understand the role of the different factors shaping urban digital transitions, the empirical study included different units of analysis (from municipal strategic planning practices to specific technological applications) as well as different analytical frames (from analysing overarching theoretical paradigms to evaluating the localized implementation of sociotechnical systems).

Article I provides a critical analysis of urban governance, addressing the fundamental disconnect between universalist smart city models imported from the Global North and the complex institutional realities of African cities. Drawing on Southern Urbanism and critical smart city literature, the paper argues that mainstream technocratic paradigms-which assume centralized municipal capacity and robust formal infrastructures-are deeply ill-suited for African urban environments characterized by informality, resource constraints, and hybrid governance structures. This article establishes the thesis's core inquiry into how urban governance might transition from 'one-size-fits-all' technological solutionism toward endogenous, context-aware digital strategies that genuinely reflect local socio-spatial dynamics.

Article II shifts the focus to strategic planning practices in resource-constrained secondary cities, exploring how urban planners mobilize, integrate, and apply data when comprehensive digital infrastructures are absent. Through a comparative case study of eThekwini (South Africa), Khorog (Tajikistan), and Bosaso (Somalia), the research demonstrates that waiting for "perfect" or complete datasets often paralyzes municipal decision-making. Instead, the paper introduces the concept of "good enough" evidence, advocating for adaptable planning methods that prioritize immediate urban needs over exhaustive data collection. It illustrates how local actors navigate severe data scarcity by piecing together fragmented information to create actionable and timely urban knowledge.

Article III investigates the mechanics of sociotechnical systems within highly fragmented, decentralized environments affected by crisis. Using Somalia as a primary case study, it explores the critical challenges of data mobility between diverse actors, including humanitarian agencies, development organizations, and government bodies. The research challenges the assumption that technical standardization alone guarantees data flow. Instead, it reveals that data sharing is a deeply social process reliant on human intermediaries and boundary-spanning negotiations. The article redefines data quality through the lens of "fitness-for-use," showing how information is repurposed and translated across different epistemic communities to bridge the gap between short-term relief and long-term planning.

Article IV examines foundational urban administration by focusing on the long-term trajectory of "fit-for-purpose" (FFP) land administration systems in post-conflict settings. While the initial establishment of these low-cost, flexible systems in places like Bosaso, Somalia, is widely celebrated for rapidly increasing tenure security, their sustainability is rarely scrutinized. This longitudinal case study uncovers the significant challenges associated with maintaining and upgrading these systems over time. The findings highlight a critical temporal vulnerability: without continuous institutional investment, capacity building, and political support, localized technological interventions risk rapid decay, emphasizing that technological sustainability requires enduring institutional commitment rather than mere software deployment.

Article V explores advanced technology applications, evaluating how sophisticated digital tools like geospatial Artificial Intelligence (GeoAI) can be responsibly implemented in marginalized urban areas such as African informal settlements. Grounded in a case study of an AI mapping tool deployed in eThekwini (South Africa), the research operationalizes the concept of "Responsible AI" (Gianni et al., 2022) beyond abstract ethical guidelines. It applies the Task-Data-User-Technology Fit model to demonstrate that ethical AI deployment requires a rigorous alignment between the complexity of the algorithm, the noisiness of local data, and the specific capabilities of municipal users, cautioning against the dangers of automation bias (Vered et al., 2023).

Table 1. Perspective of each article.

	Article I	Article II	Article III	Article IV	Article V
Title	Smart urbanism in Africa: when theories do not fit with contextual practices.	Good Enough Evidence-based Urban Planning: Data and Knowledge in Southern Smart Urbanism	Data in crisis: Mobility and fitness-for-Use in decentralized ecosystems	Upgrading Fit-for-Purpose Land Administration Systems: Challenges and Opportunities in Bosaso, Somalia	Responsible AI for Cities: A Case Study of geoai in African Informal Settlements
Perspective	Macro-level governance and critical urban theory.	Urban planning and municipal governance.	Sociotechnical systems and data ecosystems.	Foundational urban administration and applied systems.	Advanced technology application and responsible implementation.
Knowledge gaps	The disconnect between universalist smart city models imported from the Global North and the institutional, spatial, and material realities of African cities.	The lack of understanding regarding how urban planners in resource-constrained secondary cities mobilize data when comprehensive "smart" data infrastructures are absent.	The poorly understood mechanisms of data sharing, mobility, and reuse in highly fragmented, decentralized environments affected by crisis.	While the establishment of Fit-for-Purpose (FFP) systems is well-documented, their long-term sustainability, maintenance, and upgrading in post-conflict settings remain critically underexplored.	The lack of practical frameworks for operationalizing abstract principles of "Responsible AI" in complex, resource-constrained environments like informal settlements.
Article research question	How do mainstream smart urbanism theories fail to align with the governance realities of African cities, and what conceptual shifts are required	How do urban planners in data-scarce environments mobilize, integrate, and apply data to create actionable evidence for city planning?	How are data mobility and fitness-for-use achieved within decentralized data ecosystems in crisis contexts?	What are the challenges and opportunities associated with upgrading and sustaining fit-for-purpose land administration systems over time?	How can advanced digital tools like GeoAI be responsibly implemented and adapted to ensure they are "fit-for-purpose"?
Theoretical base	Critical Smart Urbanism, Southern Urbanism.	Knowledge use in planning, "Good Enough" Governance.	Sociotechnical Systems, Data Mobilities	Fit-for-Purpose (FFP) Land Administration.	Task-Data-User-Technology Fit model.
Empirical data	Comprehensive review of existing literature and secondary case examples.	Semi-structured interviews, FGD and document analysis from three cities: Durban Khorog, Bosaso.	Semi-structured interviews and document analysis in Somalia.	Semi-structured interviews and document analysis from Bosaso.	Participant observation, interviews, and technical documentation from the deployment of AI mapping tools in eThekwini (Durban).
Approach / methods	Critical literature review and conceptual synthesis.	Comparative case study.	Single exploratory case study	Longitudinal single case study.	Single case study.

The rest of the thesis is structured as follows. Section 2 elaborates on the analytical framework, detailing the theoretical synthesis of critical smart urbanism, pragmatic planning approaches, and sociotechnical systems that underpins this research. Section 3 outlines the methodological approach, describing the qualitative case study design, data collection methods, and analytical strategies employed across the constituent articles. Section 4 presents a synthesis of the main findings, categorized thematically to address the overarching research questions regarding hybrid governance, data fitness, contextual technological alignment, and long-term sustainability. Section 5 discusses the theoretical and practical implications of the findings. Section 6 concludes the thesis suggesting directions for future research.

2 Analytical Framework

This thesis draws upon a multi-dimensional theoretical perspective that synthesizes distinct but interconnected bodies of literature. This approach allows for an examination of urban digital transitions that is theoretically robust, strategically contextualized, and technically grounded. By moving beyond the technological determinism that characterizes much of the mainstream smart city discourse, these perspectives situate digital interventions strictly within the complex social, political, and institutional realities of the Global South.

2.1 Critical Smart Urbanism and Southern Urbanism

Smart urbanism represents a developing paradigm for improving urban sustainability, utilizing innovative processes where the widespread deployment of digital technologies serves as a solution to the challenges confronting cities (Marvin et al., 2016). Mainstream smart urbanism-often promoted by global technology vendors and international consultancies-tends to conceptualize the city as a programmable system where inefficiencies can be optimized through ubiquitous sensing, big data analytics, and algorithmic governance (Kitchin, 2014). This paradigm assumes a universal model of urbanization, typically based on the infrastructural and institutional standards of the Global North (Europe, North America, and parts of East Asia) (Boyle et al., 2023; Calzada et al., 2023). In this idealized view, the city is a legible, formal entity with strong municipal capacity, reliable energy grids, and a citizenry that interacts with the state through formalized digital channels. Increasingly, empirical evidence suggests that such heavily techno-centric approaches to smart urbanism are ineffective in most urban environments. (Mattern, 2016).

However, when these models are exported to the Global South, they encounter a profound contextual mismatch (Alizadeh & Prasad, 2024). To fully grasp this mismatch, it is necessary to first understand the theoretical paradigm of Southern Urbanism and the broader push to globalize urban studies. Historically, mainstream urban theory has been overwhelmingly derived from the experiences of Euro-American cities, treating them as universal benchmarks. However, scholars have increasingly called for a decentring of this Northern-centric epistemology. The concept of "provincializing" global urbanism argues that Western models represent just one specific historical trajectory rather than a universal standard, emphasizing that novel theories must emerge from the everyday realities of cities in the Global South (Sheppard et al., 2013). Similarly, there is an emphasized need for "new geographies of theory" that embrace the profound difference and complexity of global urbanisms, suggesting that actionable urban theory can and must be generated from any city, rather than merely exporting Northern concepts to Southern case studies (Robinson & Roy, 2016, p. 182). In enacting this more pluralistic urban studies, scholars navigate the tension between Southern urbanism - which highlights the distinct socio-material and historical conditions of the South, such as profound informality and post-colonial legacies-and a "world of cities" approach that seeks to integrate these diverse experiences into a comprehensive global framework (Lawhon & Le Roux, 2019).

It is within this critical theoretical landscape that the deployment of smart cities in the Global South must be scrutinized. Drawing on these Southern Urbanism foundations, the literature challenges the uncritical application of Northern digital planning theories to African contexts. Notably, critiques of "African Urban Fantasies" illustrate how top-down smart city master plans-often imported directly from international tech vendors - function not as a contextualised developmental tools, but as exclusionary visions (Watson, 2013). These glossy technological imaginaries routinely ignore the lived, material realities of the urban majority (Boyle et al., 2023). These aspirations frequently necessitate the erasure of informality, the displacement of the poor, and the imposition of aesthetic orders that have little connection to the way Southern cities function (Cirolia et al., 2023; Guma & Monstadt, 2021).

Within this literature, the smart city cannot be understood merely as a technological project; it intersects with post-colonial aspirations of modernization (Boyle et al., 2023; Datta, 2018). The analytical lens of Southern Urbanism forces a recognition of the "conflicting rationalities" (Watson, 2009, p. 2268) between the technocratic logic of city management and the proactive adaptation of urban residents and practitioners (Guma et al., 2023). In this context, governance is rarely the monopoly of a centralized state but is instead characterized by institutional hybridity, where state power is negotiated alongside traditional authorities, informal service providers, and international aid agencies.

Furthermore, the literature highlights how the uneven rollout of digital infrastructures onto already fragmented cities risks exacerbating existing inequalities (Alizadeh & Prasad, 2024; Graham & Marvin, 2001; Odendaal, 2022) The digital divide is not merely about access to the internet; it is about the data divide - who is counted, who is visible, and whose knowledge is legitimized in planning processes (Odendaal, 2021). This reality underscores the necessity of rejecting imported "best practices" (Andrews, 2012) establishing the need for endogenous strategies that value low-tech solutions and acknowledge the resilience of informal systems (Veloso et al., 2024).

A critical approach to smart urbanism in the Global South must de-centre the technology itself and focus on the institutional and spatial context of its deployment. This involves asking not "how can this technology optimize the city?" but "whose city is being optimized, and at what cost?" This perspective draws on the critique that mainstream smart urbanism is solutionist, proposing technical fixes for deeply political problems. In the context of African urbanization, where challenges include massive infrastructure deficits, unplanned sprawl, and precarious livelihoods, the deployment of high-tech sensors or digital twins can represent a diversion of scarce resources away from basic needs.

2.2 'Good enough' planning systems, data and outcomes

The drive to digitize urban planning and land administration is increasingly central to governance, theoretically promising enhanced efficiency, transparency, and data-driven decision-making. Mainstream narratives heavily promote evidence-based urban planning and decision making (Faludi & Waterhout, 2006; Krizek et al., 2009), asserting that rigorous, comprehensive data collection - often reliant on advanced digital infrastructures - is a prerequisite for rational policymaking. In this view, digitalization is framed as the ultimate solution to systemic inefficiencies. However, recognizing that the ideal conditions for comprehensive evidence-based planning are rarely present in the Global South, various theories and frameworks have emerged to conceptualize how planners can act effectively in imperfect environments. The concept of "Good Enough Governance", challenges the overwhelming agenda of institutional reform imposed on developing countries (Grindle, 2004). Expecting developing states to achieve perfect governance across all sectors simultaneously is a recipe for paralysis. Instead, the focus should shift towards targeting a minimum threshold of governance capacity that is sufficient to achieve specific development goals (Grindle, 2007).

In the context of the "urban data deluge," (Kourtit et al., 2020) urban planners are often told that they need big data, real-time analytics, and comprehensive baselines to manage cities effectively (Kitchin, 2014; Mattern, 2016). When imported to data-scarce and institutionally fragmented Southern cities, these requirements often fail to map onto local realities, creating a profound disconnect between the mandated ideal of data-driven policy and the actual, messy process of municipal decision-making. However, the concept of good enough has been theoretically reinterpreted to tackle the mobilization of data and technologies in these resource-constrained contexts (Gabrys et al., 2016; Kayanan et al., 2025). This emerging literature argues that planning must not be paralyzed by structural data gaps. Validating the use of good enough evidence shifts the metric of success from absolute scientific rigor to practical utility for immediate decision-making (Bialski, 2024). This is particularly critical in Southern secondary cities, where the quest for "perfect data" can trap municipalities in a cycle of delayed action, waiting for comprehensive censuses or fully operational, interoperable GIS systems that rarely materialize. Valuing actionable, timely, and relevant data - even when fragmented, qualitative, or derived through everyday observational practices - provides a crucial epistemological shift for planners navigating these constraints. Operating through the assembly of available information and informal knowledge generation allows local actors to bypass structural data deficits and address immediate civic needs without waiting for standardized, top-down digital data infrastructure to be fully established (McFarlane, 2011).

2.2.1 Fit-for-Purpose Land Administration

Despite the widespread recognition of a good enough approach, what constitutes good enough planning, including the evidence and practices that support it, has yet to be fully determined.

The logic of pragmatic adequacy is systematically operationalized in basic urban systems through Fit-for-Purpose Land Administration (FFPLA) (Enemark et al., 2014). Effective land administration serves as the basis of urban digitalization; without knowing who occupies what space, subsequent digital planning interventions often falter. Yet, traditional cadastral systems - which demand rigorous field surveys, highly trained professionals, and complex legal verification - have proven too slow, rigid, and expensive to keep pace with rapid urbanization or to function effectively in fragile, resource-scarce, and post-conflict settings (Zevenbergen et al., 2013). In these complex environments, adherence to Western-style cadastral models often leaves the vast majority of the urban poor legally invisible to the state. FFPLA emerged as a direct response to this systemic failure, establishing a flexible approach that bypasses these structural bottlenecks. It explicitly prioritizes rapid spatial coverage and broad tenure security for vulnerable populations over strict legal precision, representing a vital paradigm shift from abstract accuracy to contextual adequacy (Enemark, 2015).

To achieve this, the FFP approach is anchored in key principles that emphasize flexibility, inclusivity, and attainability. Attainability ensures that a municipality can rapidly implement a functional spatial registry using only its immediately available human, financial, and technical resources, deliberately avoiding reliance on imported, high-end technologies. The approach champions flexibility by substituting costly, time-consuming ground surveys with alternative spatial identification methods-such as the use of high-resolution satellite imagery and community-led participatory mapping to capture visual boundaries rather than mathematically exact fixed boundaries (Lemmen et al., 2015). Rather than imposing western-like, individualized land titles, FFPLA legally recognizes a diverse spectrum of customary, informal, and anti-eviction tenure arrangements, allowing marginalized populations to be formally recorded within the city's digital infrastructure without facing insurmountable bureaucratic barriers (Augustinus & Tempra, 2021).

However, the acceptability of these immediate, imperfect solutions rests on the principle of upgradability (Enemark et al., 2016; Zevenbergen et al., 2016). Upgradability is the central temporal mechanism of FFPLA: it dictates that systems are built adequately for today's urgent post-conflict or developmental needs, but are explicitly designed for continuous, incremental improvement over time. This implies a phased trajectory across three distinct frameworks: spatial upgrading (gradually improving boundary accuracy from satellite imagery to ground surveys as land values rise), legal upgrading (transitioning from basic occupancy certificates to formalized freehold titles when legally necessary), and institutional upgrading (evolving from decentralized, paper-based or basic digital records into integrated, national municipal cadastres) (Bennett et al., 2021). Upgradability theoretically ensures that these methods act as a stepping stone rather than a permanent state of sub-standard administration.

Despite its theoretical appeal, the practical implementation of FFPLA often celebrates the initial, low-cost setup of these systems while neglecting their longitudinal trajectory. This exposes a significant temporal vulnerability: while ad-hoc spatial tools are highly effective at delivering immediate, project-based tenure security, they are highly susceptible to rapid institutional decay post-implementation. Research demonstrates that the critical dimension of upgradability frequently fails to materialize in practice (Barry, 2018; Bennett et al., 2021). Because these systems are frequently initiated through short-term international donor cycles, they often lack the long-term political mandates, dedicated municipal budget lines, and continuous staff capacity building required for ongoing maintenance (Augustinus & Tempra, 2021). Without the sustained institutional endurance to manage software updates, hardware repair, and continuous data validation, the envisioned upgrade is indefinitely postponed. Consequently, localized technological interventions risk degrading into obsolete, unusable systems. Unless the initial deployment is actively matched by an enduring, locally financed institutional commitment to incrementally maintain and upgrade the system, the temporal costs will ultimately undermine the very tenure security it sought to establish.

2.2.2 Functional Alignment and Multi-dimensional fit of technology

Building on the necessity of contextual adequacy observed in spatial registries, the evaluation of digital interventions requires structured methods to assess how specific tools align with local operational realities. The transition away from idealized, universal smart city models - as critiqued in the overarching analytical framework - suggests that the concept of good enough evidence can be theoretically inscribed into broader attempts to evaluate technology adoption. This evaluation focuses on both task performance efficacy and appropriateness for the target user groups within a specific application context. To conceptualize this alignment, theoretical frameworks draw on the concept of Task-Technology Fit (TTF) (Goodhue & Thompson, 1995). Originally developed to understand information systems adoption, TTF posits that digital interventions are effective when there is a strong functional alignment between the capabilities of a technology and the specific demands of a given task. Rather than defaulting to the most complex system available on the global market, TTF requires evaluating whether a technology provides the relevant features needed to execute specific urban management activities efficiently.

In the context of urban planning, this means matching the analytical capabilities of digital tools - such as geospatial mapping or predictive modelling - to practical planning tasks, like resource allocation, infrastructure maintenance, or settlement upgrading (Jiang et al., 2020). Furthermore, it necessitates that these tools are suitable for the institutional capacities of the users operating them. When tools introduce technical sophistication that does not correspond to local institutional conditions or the specific characteristics of the task, they often remain underutilized. This indicates that structural complexity does not automatically equate to operational success, reinforcing the need for contextualized technology adoption strategies.

However, as urban digitalization moves toward algorithmic governance and GeoAI, traditional two-dimensional TTF models have proven insufficient (Rzepka & Berger, 2018; Sturm & Peters, 2020). These advanced tools introduce sociotechnical complexities that require expanding the framework to explicitly encompass the User. Traditional models often assume a standardized baseline of technical proficiency. In contrast, municipal users in resource-constrained environments frequently face significant institutional limitations and steep learning curves when confronted with sophisticated software. When highly advanced digital tools outpace the technical literacy of local government staff, a disconnect occurs. Users may either abandon the technology or, conversely, fall into "automation bias" (Vered et al., 2023). This cognitive hazard happens when planners uncritically accept the outputs of opaque algorithms without having the capacity to interrogate or validate the underlying computational logic (Arun, 2020). Therefore, a robust User-Technology fit is required to ensure tools are scaled to the interpretive capacities of the civil servants deploying them (Jiang et al., 2020; Russo et al., 2018).

Furthermore, evaluating advanced digital tools in the Global South requires integrating Data as a distinct and active variable, creating a comprehensive Task-Data-User-Technology model (Ghasemaghaei et al., 2017; Sturm & Peters, 2020). In predictive modelling and machine learning, the input material is just as critical as the software itself. Urban data extracted from African informal settlements is frequently unstructured, fragmented, and noisy (Milan & Treré, 2020). Standard algorithms, often trained on highly structured data from Northern cities, struggle to process this informality, leading to a breakdown in Data-Technology fit. Additionally, assessing Data-Task fit ensures that the available, imperfect information is actually suitable for the specific planning problem at hand (Gabrys et al., 2016), while User-Data fit ensures that local planners possess the contextual knowledge necessary to interpret datasets accurately.

2.2.3 Relational Data Quality: Fitness-for-Use and the Politics of Data Movement

By integrating data into this multi-dimensional alignment, the focus of the thesis extends directly into how data quality is understood and negotiated across fragmented ecosystems. In traditional information systems theory, data quality is largely defined by intrinsic attributes such as accuracy, completeness, and consistency (Bishop & Hank, 2018; Bishop et al., 2019). However, in the crisis-affected and resource-scarce contexts of the Global South, relying on these strict metrics is rarely attainable or practical. Consequently, drawing on the philosophy of data science, contemporary literature argues that data should be judged relationally through its fitness-for-use - evaluating how well information serves its intended users within specific contextual circumstances to achieve goals to varying degrees (Bokulich & Parker, 2021; Parker, 2020).

This relational understanding requires acknowledging the political and negotiated nature of data movement (Sheehan & Leonelli, 2025). In decentralized urban environments, data is not a neutral resource that flows smoothly between organizations. Instead, its movement is a highly negotiated sociotechnical process characterized by data friction (Kitchin et al., 2025). The concept of data friction highlights the structural, institutional, and social resistance information encounters when it travels across differing systems (Bates, 2018; Bates et al., 2016). For instance, when data moves from a humanitarian agency managing an immediate crisis to a municipal department handling long-term urban planning, it does not transfer seamlessly. Overcoming these frictions requires active human labour to format, clean, and interpret the information so it can be recognized by different institutions. Information infrastructures in these contexts are characterized by a multiplicity of actors with overlapping or disjointed mandates, making the smooth integration of databases highly complex (Kitchin et al., 2024).

The complexities of this movement are closely tied to the divergent epistemic cultures operating within the city. Building on theories of knowledge production (McKenzie et al., 2014), it becomes evident that different actors possess distinct ways of knowing the urban space and varying criteria for what constitutes valid evidence. A rapid spatial assessment generated by an international non-governmental organization might be highly fit-for-use for directing emergency relief, yet the same dataset might be viewed with scepticism by local land administrators who require different spatial formats or legal verifications. Because these actors operate with distinct mandates, professional norms, and technical schemas, data cannot simply be transferred without translation; it must be carefully adapted to fit the receiving context.

Navigating these divergent cultures necessitates the creation of collaborative spaces where the meaning and utility of data can be negotiated across organizational divides. Rather than striving for universal standardization - which frequently exacerbates data friction by imposing rigid, top-down constraints - effective digital transitions rely heavily on human intermediaries (Neang et al., 2021). These intermediaries adapt existing information to meet localized planning needs, performing the vital, often invisible labour of bridging institutional silos (Leonelli, 2025). This continuous process of translation demonstrates that the value of information is not an inherent technical property, but a socially constructed outcome shaped by organizational priorities and resource availability. Evaluating digital interventions through this lens of relational fitness and data mobility establishes that technological viability relies on multi-dimensional contextual adaptation, ensuring that the datasets deployed respond to the specific, negotiated realities of the organizations using them.

2.3 Sociotechnical Systems of Data and Technology

To fully comprehend how functional alignment and data integration actually occur in practice, a third conceptual pillar delves into the mechanics of the digital transition by adopting a Sociotechnical Systems perspective (Lykouras & Mora, 2025; Meijer & Thaens, 2018). This approach rejects the view of technology as a neutral instrument or an independent driver of urban change. Instead, it conceptualizes digital transformation as an intertwined process where hardware, software, and data are continuously shaped by

- and actively reshape - social relations, organizational cultures, and historical power dynamics.

Applying this lens to urban governance reveals that digitalization is rarely a straightforward technical upgrade (Fadmastuti et al., 2024). Rather, it represents a complex socio-material reconfiguration (Manny, 2023; Manny et al., 2022). Digital systems arrive loaded with the assumptions, values, and priorities of their designers. When these systems are deployed in the resource-scarce and highly decentralized environments of the Global South, they frequently collide with established bureaucratic routines, informal civic practices, and preexisting infrastructural deficits. The sociotechnical approach highlights that this collision is not merely an operational hurdle; it is a generative process that determines how municipal authority is exercised and how urban space is governed.

A critical dimension introduced by this perspective is the emphasis on temporality and the hidden labour of maintenance. While mainstream smart city narratives frequently celebrate the disruptive moment of technological deployment, sociotechnical theories draw attention to the everyday, continuous work required to keep digital infrastructures operational. In contexts characterized by fragile institutional support, the survival of a spatial registry or an algorithmic planning tool relies on localized repair practices, sustained capacity building, and ongoing financial commitment. This perspective shifts the theoretical focus away from the initial sophistication of the technological artifact and toward the enduring human support structures that prevent rapid institutional decay.

Furthermore, this sociotechnical framing provides a critical lens for analysing how advanced digital interventions reconfigure the politics of urban knowledge. As municipalities adopt increasingly complex algorithms, decision-making processes can subtly shift from transparent public discourse to opaque computational models. A sociotechnical analysis interrogates these shifts, examining how algorithmic categorizations make certain informal urban realities legible to the state while systematically obscuring others. By viewing urban digitalization as an ongoing, negotiated, and deeply political endeavour, this framework reinforces the understanding that technological efficacy is achieved by adapting tools to the lived, socio-material realities of the city.

3 Methodology

3.1 Methodological Approach

As this thesis aims to explore and understand the sociotechnical and institutional factors shaping urban digital transitions in the Global South, it has adopted an exploratory qualitative approach centred on in-depth case studies (Yin, 2018). This research strategy was selected to address the inherent complexity of the subject matter. Given the multifaceted nature of contextualizing digital technologies in resource-constrained environments, the variables influencing digitalization processes and their outcomes are highly diverse, rendering case study methodology a suitable framework for detailed empirical investigation.

The thesis incorporates cases of secondary cities characterized by varying degrees of institutional fragility, informality, and decentralized governance. The constituent papers employed diverse analytical approaches to examine these cases, applying distinct perspectives for studying urban data ecosystems and the sociotechnical dynamics of digital technology adoption. While the majority of the articles utilized single case study designs to investigate specific technological deployments in detail (Articles III, IV, and V), one paper (Article II) offers a comparative case study of strategic planning practices and evidence mobilization across three resource-constrained secondary cities: eThekwini (South Africa), Khorog (Tajikistan), and Bosaso (Somalia). Furthermore, the articles adopted varying temporal perspectives to analyse the evolution of digital tools, data practices, and planning processes. These range from examining the setup and initiation phases of information systems during crises (Article III) and assessing established data practices (Articles II and V), to employing a longitudinal perspective to track the trajectory of spatial registries over time (Article IV). An overview of the methodological approaches employed across the constituent articles is provided in Table 1.

3.2 Data Collection and analysis

The data collection methods applied across the individual articles include:

- Semi-Structured Interviews: The primary source of primary data, conducted with a diverse range of stakeholders including municipal officials, urban planners, international organizations, and technical developers.
- Focus Group Discussions (FGDs): Employed specifically in the comparative analysis of strategic planning practices (Article II), facilitating group dynamics to explore collective perspectives and negotiated consensus among urban practitioners regarding data scarcity.
- Document Analysis: Systematic review of policy documents, technical specifications, project reports, and municipal development plans to understand the "official" discourse versus the practical reality.

For data analysis, the articles forming the core of the thesis adopted exploratory qualitative approaches, primarily utilizing thematic analysis (Gioia et al., 2012). These methods were selected to facilitate a deep understanding of the specific conditions relevant to each phenomenon, as well as to determine the influence of institutional and sociotechnical factors in producing specific outcomes.

The exploratory papers primarily aimed to conduct an in-depth analysis of the role of institutional environments and human intermediaries in shaping digital transitions. This perspective was covered in Articles II, III, and V, which provided an overview of the factors relevant for mobilizing data and adapting technology to local capacities. The articles adopted different analytical perspectives, ranging from examining macro-level urban governance paradigms (Article I) to evaluating specific sociotechnical alignments and longitudinal institutional dynamics (Articles III, IV, and V). These varied perspectives provide structured approaches to better understand the relevance of human infrastructure, epistemic cultures, and cross-organizational networks for initiating and sustaining digital initiatives.

3.3 Limitations

While the publications forming the core of this thesis utilized qualitative case study methodologies designed to provide in-depth analyses of sociotechnical transitions, certain limitations inherent to this approach are present. These constraints pertain primarily to the scope of the empirical data and the boundaries of the selected case studies.

First, the reliance on qualitative data collection methods, such as semi-structured interviews and participant observation, introduces challenges related to subjectivity (Magnusson & Marecek, 2015). The findings are dependent on the individual perceptions, professional biases, and memories of the stakeholders involved (Bergen & Labonté, 2020). Furthermore, when interviewees were asked to recall the initial phases of long-term technological initiatives (such as in Article IV), the retrospective nature of the accounts may affect the precision of the historical narrative. Additionally, the individual articles analyse technology deployments and data processes at varying temporal phases. While Article V examines initial setup and deployment, Articles II and III focus on ongoing use and maintenance, and Article IV provides a longitudinal perspective. Although this variation offers a broad view of the technology lifecycle, the lack of a standardized, multi-year longitudinal framework applied systematically across all cases limits the ability to uniformly track system evolution over time (Evangelinou-Yiannakis, 2017).

Secondly, the empirical research is geographically and institutionally focused on environments characterized by significant resource constraints, widespread informality, or post-conflict recovery dynamics. Consequently, the empirical findings can be deemed deeply context dependent. The identified mechanisms of contextual adaptation, such as the specific roles of human intermediaries or the dynamics of informal data generation, reflect the realities of these specific geographies (Guma & Monstadt, 2021; Sadowski & Maalsen, 2020). While these insights provide analytical frameworks for examining similar environments in the Global South, caution is required when attempting to generalize these findings to urban contexts possessing robust formal state capacities, stable institutional funding, or substantially different historical trajectories of urbanization (Randolph & Storper, 2022). The research design deliberately prioritizes depth of contextual understanding over broad statistical generalizability. This focus aligns with the epistemological principles of Southern Urbanism, responding to the academic call for generating "new geographies of theory" directly from the everyday practices of Southern cities, rather than treating Northern institutional models as a default baseline (Robinson & Roy, 2016; Sheppard et al., 2013). Therefore, while the conclusions may not be directly transposable to formalized urban systems, they offer analytical generalizability for understanding digital transitions in environments characterized by institutional hybridity and conflicting planning rationalities (Lawhon & Le Roux, 2019; Watson, 2009).

Finally, as a former staff member and consultant for UN-Habitat in the Regional Office for Africa, the author was intimately familiar with the topic and the cases that constitute this study. This insider positionality (Bandauko, 2024), facilitated substantive discussions and built credibility with participants (Berkovic et al., 2020; Chavez, 2008). It also provided preferential access to key stakeholders, as well as to project documentation (Chavez, 2008). However, this presented the risk of several methodological biases, including selection bias through network-based recruitment (Collier et al., 2004; Geddes, 1990) and social desirability bias, where participants might provide responses aligned with perceived institutional priorities (Schulz, 2020). These challenges appear to be common in high-risk, low-information contexts (Bell-Martin & Marston Jr, 2021). At the same time, this positionality may have foregrounded themes that aligned with international development agendas and the professional background of the author, potentially obscuring dissenting local perspectives or alternative socio-spatial realities. To mitigate such biases, interviews and FGDs where triangulated with an extensive review of policy documents and datasets (Bell-Martin & Marston Jr, 2021). Additionally, a second author consistently collaborated in each of the articles, assisting in defining the research aim, developing the coding schemes, and conducting peer debriefing sessions (Eppich et al., 2019). This provided an outsider perspective to challenge potential biases and ensure a more balanced interpretation. The analysis involved multiple iterative coding cycles to systematically refine categories, ensuring that emerging themes were consistent and strictly grounded in the empirical data rather than institutional assumptions.

4 Main Findings

The research yields four primary thematic findings corresponding to the Research Questions.

4.1 Contextual Adjustments and Hybrid Governance as Responses to Institutional Fragmentation (Addressing RQ1)

Contemporary smart city paradigms have increasingly evolved beyond the assumption of a single, centralized governing body. Modern approaches to urban digitalization often advocate for multiple partnership models - such as the triple or quadruple helix, which emphasize collaborative ecosystems involving the state, academia, industry, and civil society. These models theoretically recognize that urban transitions require diverse inputs and distributed action. However, when examining these concepts through the analytical lens of Southern Urbanism established in the analytical framework, a persistent tension emerges. While multiple partnership models acknowledge multi-actor participation, they frequently still presume a baseline of institutional stability, cohesive regulatory environments, and relatively seamless coordination mechanisms that can actively steer these diverse stakeholders. In the context of many African cities, these underlying preconditions for structured, formal collaboration are often absent or highly fragmented (article I).

When advanced, multi-actor governance models are applied to the Global South without sufficient consideration for the local context, they can sometimes encounter structural friction rather than acting as immediate catalysts for urban innovation (Article I, III). Attempting to organize formalized, helix-style collaborations in urban environments characterized by widespread informality, shifting political mandates, and systemic resource constraints can contribute to the stalling of digital projects (Article V). This challenges the efficacy of standardized collaborative frameworks by highlighting their difficulty in accounting for the *conflicting rationalities* of African cities-environments where official policy objectives may frequently clash with the everyday survival strategies of urban residents and the realities of fragmented, decentralized power.

The tension between imported theoretical models and local realities suggests that navigating digital transitions may require specific contextual adjustments that go beyond the formal partnerships typically described in smart city literature. The empirical observations of this study indicate that functional digital initiatives are not always driven by structured, formalized blueprints or neatly organized partnerships. Rather, they can emerge from more fluid, ad-hoc ecosystems where power and responsibility are negotiated continuously among various traditional, informal, and international actors (Article III). Navigating the complexities of resource-constrained environments implies that urban technology initiatives may need to align with governance structures that reflect the pluralistic and often unstructured nature of the cities themselves.

An emerging perspective from this research is the potential utility of contextual adjustments, particularly through hybrid governance arrangements, in addressing institutional fragmentation (Article II). Drawing on the concept of Good Enough Governance, effective urban management in these contexts can be understood as inherently pluralistic, but not necessarily formal. Hybrid governance frameworks acknowledge that the state is one of several actors, but they also recognize that coordination may occur outside of official channels, facilitating the exchange of resources and information across different institutional levels.

The integration of data within these hybrid ecosystems highlights the necessity of boundary-spanning negotiation. Because data mobility across fragmented environments involves interacting with divergent epistemic cultures, establishing formal data-sharing agreements is often impractical. Instead, data integration relies on informal interactions and the establishment of functional trading zones, where the utility of information is negotiated contextually rather than standardized universally (Article III).

The findings suggest that functional technological initiatives often involve a complex, sometimes improvised combination of formal municipal authorities, informal community leaders, transnational networks, non-governmental organizations, and decentralized local agencies. For instance, in situations where a central state may face challenges in establishing a comprehensive digital cadastre or an urban data observatory, informal actors and international development partners may participate in creating localized, pragmatic data ecosystems that function despite the lack of formal, overarching coordination (Article IV).

Recognizing these decentralized practices points toward a localized form of urban resilience. Rather than focusing primarily on formalizing all urban processes to fit a recognizable collaborative model, Contextual Adaptation involves leveraging existing informal and hybrid networks as functional components of a city's digital infrastructure (Article III). This approach suggests that technological viability is linked to the flexibility of the governing actors and their ability to adapt to fluid conditions. When urban planning processes accommodate imperfect institutional settings and instead negotiate technology deployment and data sharing across diverse, multi-actor coalitions, digital tools may be more likely to be utilized and sustained. The findings indicate that navigating urban digital transitions in the Global South may rely less on establishing formal multi-helix frameworks and more on continuous contextual adjustments and the negotiated, hybrid collaboration characteristic of local urban governance.

4.2 Data: Fitness-for-Use over Standardization (Addressing RQ2)

In the absence of comprehensive datasets, "good enough" evidence is not merely a fallback option, but a necessary and sufficient foundation for effective decision-making in the Global South. A pervasive myth within mainstream smart city discourse is that urban management requires exhaustive, real-time, and perfectly standardized data. However, the paralysis of waiting for such ideal conditions is profoundly more detrimental to urban development than proceeding with imperfect, yet actionable, information.

This reality is acutely visible in the strategic planning practices of resource-constrained secondary cities. Rather than adhering to rigid, data-intensive models that inevitably stall in data-scarce environments like Durban, Khorog, and Bosaso, urban practitioners successfully mobilize fragmented and partial datasets (Article II). By piecing together this informal knowledge, they generate insights tailored to immediate urban needs, demonstrating that the true metric of data quality is its practical utility for urgent decision-making rather than absolute scientific completeness (Article II).

Because this practical data is often decentralized and heterogeneous, sharing it across fragmented environments requires a shift away from rigid standardization. The prevailing assumption that data mobility is a purely technical challenge—resolved simply by implementing universal interoperability standards—fails in complex settings like the crisis-affected ecosystems of Somalia (Article III). In reality, data mobility is fundamentally a social process. Information travels across divergent humanitarian, development, and municipal mandates only when actively translated by human intermediaries. Consequently, data quality becomes a fluid, negotiated status of *fitness-for-use*. Information deemed inadequate for a long-term national census may be perfectly viable for an immediate disaster response, proving that forced standardization often creates data friction rather than resolving it (Article III).

The imperative of prioritizing this contextual *fitness-for-use* over universal standards extends into the implementation of foundational urban infrastructure. Traditional cadastral systems, for example, demand high-accuracy professional surveys that are too slow and costly for rapidly expanding African cities. Yet, by embracing *good enough* spatial data—such as satellite imagery or participatory community mapping—municipalities can bypass these bottlenecks to rapidly secure land tenure for vulnerable populations, as observed in post-conflict Bosaso (Article IV). This *fit-for-purpose* approach illustrates that accepting imperfect data is a strategic necessity for broad, inclusive governance, even if it introduces subsequent challenges for long-term system upgrading (Article IV).

The reliance on contextualized data persists even at the frontier of technological innovation. When applying advanced tools like GeoAI to the informal settlements of eThekwini, the principles of good enough evidence must be deeply integrated into algorithmic governance (Article V). Because informal urban environments inherently generate messy, noisy, and incomplete data, responsible AI deployment depends heavily on a *Task-Data-User-Technology fit* model. Users must possess the capacity to critically interpret *good enough* algorithmic outputs to prevent dangerous automation bias (Article V). Ultimately, whether conducting basic urban planning, building foundational land registries, or deploying advanced machine learning, effective digital intervention in the Global South relies not on the pursuit of universal standardization, but on contextual fitness and social translation.

4.3 Technology: The Imperative of Contextual Fit (Addressing RQ3)

The successful deployment and long-term sustainability of digital interventions in the Global South rely heavily on a multidimensional alignment between the technological tool, the specific urban task, the available data, and the end-user. Moving away from the technological determinism that assumes the inherent sophistication of a tool guarantees its success, empirical evidence underscores that fitness-for-purpose must serve as the primary design principle. When digital initiatives fail to accurately assess existing structural and human capabilities, they often introduce complex solutions that overlook local resource constraints or proficiency gaps. This misalignment frequently generates long-term dependencies on external actors and results in significant but underutilized investments.

This imperative of contextual fit is highly evident within foundational urban systems, such as land administration technologies (Article IV). Traditional, high-accuracy cadastral mapping techniques are often entirely unsuited for rapidly urbanizing, resource-constrained cities. Instead, *fit-for-purpose* systems offer a pragmatic alternative, enabling municipalities to achieve rapid spatial coverage and deliver crucial tenure security to vulnerable populations through low-cost, adaptable solutions. However, establishing technological fit at the initiation of a project is insufficient for its long-term survival. These foundational tools are acutely vulnerable to institutional decay if a municipality's maintenance capacities are not upgraded alongside the technology itself. A system might adequately serve immediate post-conflict recovery, but without enduring financial commitments, continuous staff training, and robust technical support, it quickly becomes obsolete. When external support eventually diminishes, local authorities often find themselves unable to maintain the infrastructure, demonstrating that the contextual fit of basic systems is not a static achievement but a dynamic, temporal process requiring continuous recalibration between the tool and evolving institutional capabilities (Article IV).

The necessity of this contextual adaptation becomes even more pronounced when implementing highly sophisticated digital solutions (Article V). While global smart city discourses increasingly champion artificial intelligence as a panacea for urban planning, the ethical and practical viability of AI in the Global South hinges on a rigorous alignment operationalized through a Task-Data-User-Technology fit model. Specifically, algorithms must be calibrated to the complex reality of the specific urban task and trained on data that accurately reflects the dynamic, often undocumented nature of informal settlements, rather than relying on sanitized proxies. Most crucially, the technology must align with the technical proficiencies of municipal users. When algorithmic interventions require specialized data science expertise absent within local planning departments, a systemic imbalance occurs. This creates a significant risk of automation bias—a scenario where high-tech tools operate as opaque black boxes, outpacing the user's ability to critically interpret, interrogate, or validate the algorithmic outputs. Consequently, tools that are overly sophisticated for their organizational context inadvertently waste municipal resources and perpetuate reliance on the external technology vendors who initially supplied the models (Article V).

Across the entire spectrum of urban digital infrastructure—from basic civic registries to advanced algorithmic models—technological sophistication remains secondary to contextual appropriateness. Digital solutions achieve sustainable success only when they are explicitly designed and continuously adapted to accommodate the actual material, institutional, and human capacities present within the specific urban environment.

4.4 Sustainability: The Temporal Cost of Pragmatism (Addressing RQ4)

The analysis of digital transitions through a sociotechnical lens underscores a persistent vulnerability inherent in *good enough* approaches and adaptive implementation strategies. While these methods are often successful at lowering the initial barriers to entry for digital innovation, they remain highly susceptible to rapid institutional decay. This temporal cost of adaptation reveals that ensuring the sustainability of digital interventions in the Global South is rarely a problem confined to hardware durability or software architecture. Instead, it constitutes a significant institutional challenge focused on the continuous maintenance, repair, and long-term "upgrading" of systems over time. Without embedding these adaptive tools into resilient administrative structures, initial technological gains are quickly eroded by organizational friction.

The mobilization of fragmented or alternative evidence allows urban planners to circumvent the paralysis caused by severe data scarcity. However, these adaptive practices are frequently informal, relying on the personal networks, tacit knowledge, and individual capacities of specific planners actively piecing together data (Article III). Because this form of knowledge generation often lacks formal institutionalization, it is highly sensitive to shifts in personnel or changes in immediate political priorities. When these shifts occur, informal data practices risk dissipating. The failure to translate individual spatial knowledge into standardized municipal protocols illustrates the profound difficulty of converting ad-hoc planning habits into permanent institutional memory within resource-constrained secondary cities. Consequently, municipalities may find themselves repeatedly starting from scratch each time a key practitioner departs (Article III, IV).

The broader challenge of temporality is further conceptualized by the structural distinction between the "project time" associated with international donors and the "institutional time" of the city itself (Article III). Project time is generally short-term, output-oriented, and supported by dedicated funding, whereas institutional time is long-term, focused on routine maintenance, and subject to chronic resource constraints.

When the short-term project cycle concludes and the associated external support structures—such as donor funding pipelines, technical training, and external personnel—are withdrawn, these ecosystems deteriorate quickly (Article III).. Without specific strategies designed to bridge the gap between project-oriented funding and long-term institutional capacity, initial interventions leave behind obsolete systems rather than sustainable urban infrastructures (Article IV, V).

While flexible, low-cost spatial tools can be highly effective for establishing initial systems and attend immediate needs, their survival post-implementation is remarkably precarious. These systems frequently lack the necessary long-term political mandates, statutory recognition, and dedicated municipal budget lines required for continuous operational maintenance (Article IV). Consequently, the initial technological success often masks an underlying fragility. The ultimate test of contextual adaptation is therefore the subsequent challenge of upgrading—the complex process of legally, financially, and technically transforming an isolated project intervention into a permanent, integrated municipal function before the underlying technology or data becomes obsolete.

This temporal vulnerability persists even when deploying advanced analytical tools for specific tasks (Article V). The implementation of geospatial AI may achieve an initial alignment between the task, data, user, and technology. However, sustaining this alignment is a continuous, resource-intensive endeavour. Because the spatial morphologies of Southern Cities are highly dynamic, AI models are particularly susceptible to "concept drift"—where algorithms trained on historical data rapidly lose their predictive accuracy as the physical environment changes. Therefore, these models require ongoing data updates, iterative algorithmic retraining, and continued capacity building for users. If local governments perceive the deployment of advanced models as a static, one-off software installation rather than a continuous process necessitating dedicated maintenance regimes, the tool will inevitably degrade into algorithmic irrelevance. Ultimately, by synthesizing these findings across planning, crisis management, and land administration, this thesis asserts that the long-term viability of urban digital transitions depends fundamentally on shifting the focus away from initial technological deployment and toward the ongoing practices of systemic maintenance and institutional upgrading.

5 Discussion

The overarching argument synthesized from the empirical and conceptual findings of this thesis posits that Contextual Adaptation is a requisite mechanism for urban digital transitions in the Global South. This research advances a theoretical and practical shift. It asserts that technological efficacy is inextricably linked to the human infrastructure, informal negotiations, and institutional capacity required to support and maintain it.

In articulating this position, the thesis acknowledges that contemporary urban scholarship increasingly recognizes the importance of local context (Colding & Barthel, 2017; Sadowski & Maalsen, 2020), moving toward more nuanced theoretical frameworks (Burns et al., 2021). However, a significant tension persists within the literature and practice, as various international development agencies and technology vendors continue to promote generalized frameworks and universal guidelines-such as global handbooks for urban digital transformation or regional blueprints for digital governance (Beckers et al., 2022, 2023). These top-down approaches often presume a uniformity of institutional capacity that rarely maps onto the realities of Southern cities.

Consequently, a core intellectual challenge involves maintaining a balance between localized contextualization and comparative global urban analysis. Rather than flattening differences, theories that seek broader applicability can sharpen the identification of key variations in urbanization and digitalization processes across different geographies (Miller et al., 2021). Analysing how the underlying dynamics of technology adoption and urban governance interact in diverse settings offers insight into policy challenges that cut across cities, both within and between the Global South and North (Randolph & Storper, 2022). It also illuminates context-specific policy issues that arise through the intersection of global digitalization forces and local socio-spatial specificities.

To articulate this shift and navigate the tension between universal models and local adaptation, the thesis makes specific contributions across theoretical scholarship and practical urban management, anchoring these insights within the distinct realities of African and Southern urbanization.

5.1 Theoretical Contribution: From Best Practice to Best Fit

This thesis outlines a theoretical shift in how urban digitalization is conceptualized in the Global South, offering a vocabulary for scholars studying digitalization in resource-constrained environments. Mainstream smart city literature frequently relies on Northern-centric assumptions of centralized state capacity, structured physical infrastructure, and seamless digital interoperability (Datta, 2015; Kitchin, 2015). By integrating perspectives of critical smart urbanism with Southern Urbanism, this research questions these technological determinist narratives. It demonstrates that standardized models encounter structural limitations because they do not account for the institutional hybridity and "conflicting rationalities" common in African cities (Watson, 2009, p. 2268). Instead of treating the lack of structured infrastructure solely as a deficit to be corrected by imported technology, the thesis theoretically positions contextual realities-such as resource scarcity and decentralized governance-as the primary baselines for assessing viable digital transitions.

This thesis identifies a theoretical shift in how urban digitalization is conceptualized in the Global South, offering a vocabulary for analysing digitalization in resource-constrained environments. As indicated by the findings, analysing urban technology adoption through universalist frameworks often obscures the specific mechanisms that enable or hinder digital transitions in practice. The research questions technological determinist narratives, demonstrating that standardized models frequently encounter structural limitations because they struggle to account for the institutional hybridity and differing rationalities prevalent in African cities (Guma, 2019; Guma & Monstadt, 2021). Instead of treating the lack of highly structured technical infrastructure solely as a deficit to be corrected by imported systems, the thesis theoretically positions contextual realities-such as resource scarcity, informal organizational practices, and decentralized governance-as the necessary baselines for assessing viable digital integration (Datta & Hoefsloot, 2025; Guma, 2020).

By foregrounding these contextual realities, the research seeks to integrate the concept of adequate data within a broader theoretical effort to evaluate technology adoption. This evaluation focuses not only on task performance efficacy but also on the appropriateness of the technology for the target user groups and the specific application context (Jiang et al., 2020). The research builds on the understanding that for a digital intervention to be effective, its functional capabilities must correspond clearly with both the demands of the urban task and the existing capacities of the users operating within a given institutional framework. This aligns the theoretical evaluation of "smartness" with established technology adoption models, suggesting that structural complexity in technological design does not automatically guarantee operational success in the absence of institutional compatibility.

5.1.1 Reevaluating Planning Knowledge and Adequacy

Building upon the necessity of contextual adaptation, the thesis provides a theoretical reconceptualization of how planning knowledge is validated and mobilized. The concept of "fitness" serves as a unifying thread across this multi-dimensional framework developed in Section 2, shifting the evaluation of urban digital transitions from fixed technical benchmarks to task-based achievements. The research integrates criteria to assess whether a state of good enough is present, drawing from governance and planning literature (Grindle, 2004; Kayanan et al., 2025). These criteria include: credibility (the degree to which the generated outputs are plausible and align with contextual expectations); integrity (the extent to which outputs meet acceptable thresholds of reliability and trustworthiness, prioritizing sufficiency over technical flawlessness); legitimacy (the adherence of the underlying processes to accepted local norms and practices); relevance (the capacity of the outputs to directly address and fulfil specific planning requirements); authority (the institutional or social standing of the actors producing the outputs, which grounds the information in local validation); and attainability (the feasibility of securing, implementing, and maintaining the necessary data or technological systems using available local resources) (Zevenbergen et al., 2016). A good enough approach involves satisfying a minimum operational threshold across these criteria (Kayanan et al., 2025). It acknowledges that sociotechnical systems can function effectively in resource-constrained environments without needing to meet idealized, universal benchmarks of performance.

This perspective suggests that imperfect or fragmented data can provide a legitimate epistemological basis for urban knowledge production. This shift alters the metric of success in planning from a strict expectation of scientific exhaustiveness to a requirement for contextual actionability (Sheehan & Leonelli, 2025), while noting that continuous maintainability remains necessary to ensure long-term viability (Bialski, 2024).

5.1.2 Relational Data Quality and Sociotechnical Translation

Furthermore, the thesis advances sociotechnical systems theory by examining the nature of data quality within highly fragmented, crisis-affected ecosystems. Traditional information systems literature frequently evaluates data based on strict, intrinsic metrics such as accuracy and standardization. This research theorizes data mobility not strictly as a technical achievement of software interoperability, but as a negotiated process of translation across varying epistemic cultures (Knorr-Cetina, 1999; Leonelli, 2023). By conceptualizing data quality through the lens of fitness-for-use (Bokulich & Parker, 2021; Parker, 2020), the thesis provides a relational framework. Within this framework, the value of information is evaluated by its practical utility for specific communities of practice, accommodating the structural constraints that characterize data generation in the Global South.

5.1.3 Extending Technology Fit for Algorithmic Governance

Finally, this theoretical approach is applied to the deployment of advanced algorithmic governance. The research introduces the Task-Data-User-Technology fit model, offering a theoretical lens designed for evaluating Artificial Intelligence in undocumented urban spaces. Building upon traditional technology adoption models (Goodhue & Thompson, 1995), this approach explicitly incorporates the dimensions of "Data" and "User" into the evaluation of digital tools. This expanded model provides a mechanism for analysing the practical boundaries of algorithmic deployment. It cautions against the theoretical blind spots such as "automation bias" (Vered et al., 2023), asserting that the effectiveness of an intervention relies not on its algorithmic complexity alone, but on its multi-dimensional alignment with the material realities of the local data and the specific institutional capabilities of the actors utilizing it (Jiang et al., 2020).

5.2 Practical contribution: Good enough and smart enough

This thesis translates its theoretical insights into actionable strategies for urban practitioners, municipal governments, and international development agencies navigating the resource scarcity, institutional fragmentation, and rapid urbanization typical of the Global South (Randolph & Storper, 2022). The core practical mandate derived from this research indicates a potential shift in operational focus: moving away from short-term, project-based software deployment toward continuous capacity building and contextual maintenance, recognizing that technological sustainability requires long-term institutional investment.

One of the practical contributions of this research, demonstrated in Article II, involves identifying strategies for municipal planners in secondary cities to navigate data scarcity (Milan & Treré, 2020). By framing the use of alternative or fragmented evidence as theoretically acceptable under the conditions of good enough urban planning (Kayanan et al., 2025), the research highlights how practitioners can leverage qualitative and informal datasets-such as community mapping, incomplete utility records, and observational knowledge-to support immediate strategic planning decisions (Bialski, 2024; Collins et al., 1994; Gabrys et al., 2016). This approach may provide municipalities an alternative to the often costly and protracted pursuit of comprehensive data baselines, allowing them to formulate urban strategies that respond to pressing civic needs in a timely manner. The notion of good enough aligns with emerging discussions on "smart enough cities" (Green, 2020; Sadowski & Maalsen, 2020), which advocate for technological solutions that are low-cost, decentralized, and directly responsive to the immediate problems of urban residents. The "smart enough" perspective prioritizes social and political infrastructure over technical optimization for its own sake, suggesting that cities should adopt digital technologies to address specific, situated urban challenges effectively rather than pursuing technological novelty (Calzada et al., 2023).

The research also underscores the practical importance of human intermediaries in the digital transition process. In decentralized and crisis-affected ecosystems, such as those analysed in Article III, establishing strict technical standardization across multiple organizations is frequently difficult to achieve. Therefore, the thesis points toward the value of investing in the human actors - planners, aid workers, and local municipal technicians-who actively facilitate communication between differing technological and organizational systems. These intermediaries function as translators, mobilizing data across organizational silos and epistemic boundaries (Leonelli, 2025). This suggests that supporting human negotiation, relationship building, and localized data translation mechanisms may be a functional complement to, or in some cases a more viable alternative than, the implementation of complex interoperable database management software (Odendaal, 2021).

Furthermore, the thesis identifies longitudinal pathways that may contribute to the survival of basic digital infrastructure. While Fit-for-Purpose land administration systems are often recognized for their initial low-cost and rapid deployment capabilities, this research details their vulnerability to institutional decay over time. A practical contribution of this analysis is the conceptualization of upgrading as an active requirement (Bennett et al., 2021). This research indicates that the implementation of a flexible systems may require subsequent, structured support, including the establishment of long-term political mandates, dedicated municipal budget lines, and continuous staff training programs. The findings caution that without intentional upgrading mechanisms and sustained local commitment, agile interventions may face difficulties functioning once initial project cycles conclude (Barry, 2018).

Finally, as cities across the Global South explore the use of advanced algorithms, the thesis provides a framework for considering the deployment of Artificial Intelligence. Derived from the analysis of GeoAI in informal settlements in Article V, this framework suggests that practitioners evaluate the alignment between technological tools, the characteristics of locally available data, and the existing technical literacy and technological resources of municipal staff prior to implementation. By utilizing the extended Task-Data-User-Technology model, local governments may be better equipped to assess whether sophisticated analytical tools align with the capabilities of their users, potentially reducing the risks associated with automation bias and ensuring that digital deployments respond appropriately to the specific realities of marginalized urban communities.

6 Conclusions and Future Research Directions

The findings of this thesis indicate that advancing urban digital transitions in the Global South requires a deliberate departure from universalist, technocentric models. Instead, successful digitalization is predicated on Contextual Adaptation—a sociotechnical process wherein technologies, datasets, and governance frameworks are continuously negotiated to align with local institutional capacities and spatial realities. By demonstrating the efficacy of hybrid governance networks, the functional necessity of adequate evidence, and the requirement for a multi-dimensional Task-Data-User-Technology alignment, this research asserts that technological viability relies on institutional compatibility rather than mere computational complexity. This approach resonates with the concept of “smart enough city" (Green, 2020), which suggests that municipalities should deploy digital tools deliberately to support specific social and civic objectives, rather than pursuing technical optimization as an independent goal. Ensuring that technology remains subordinate to urban policy objectives requires continuous human intervention and ongoing institutional maintenance.

While this thesis provides a structured understanding of these localized adaptations, the empirical and conceptual findings reveal significant gaps in current scholarship, opening several critical avenues for future research:

Longitudinal Institutionalization of Adaptive Systems: The temporal vulnerability of localized interventions, particularly Fit-for-Purpose land administration systems, highlights a distinct need for extended, longitudinal studies. Future research should track these systems over multi-decade horizons to analyse their complete operational lifecycles. Examining the specific institutional, financial, and political variables that determine whether adaptive digital tools successfully transition into formalized municipal infrastructure or experience rapid institutional decay will provide essential insights into the mechanics of long-term "upgradability" (Enemark et al., 2014; Zevenbergen et al., 2013).

Private Sector Influence on Urban Data Infrastructures: This research has primarily focused on public-sector and international donor-driven digitalization efforts. These actors have undoubtedly a central role in prioritizing, executing, and pacing digitisation initiatives across spaces, scales and institutions (Datta & Hoefsloot, 2024). However, the increasing involvement of global and regional technology corporations and private vendors in providing foundational urban infrastructure in the Global South is starting to attract critical academic examination (Cirolia et al., 2026). Future studies must investigate how the proprietary platforms and standardized solutions offered by these private entities interact with the established need for contextual adaptation (Cirolia et al., 2023) but also how they spill over into the build environment (Goodfellow et al., 2024). Analysing the influence of these actors on local data governance, municipal resource dependencies, and the shaping of regulatory frameworks remains a highly relevant area of inquiry.

Scalability of Contextual Adequacy across scales and geographies: The efficacy of mobilizing alternative evidence and leveraging hybrid governance has been observed in this thesis primarily within the context of resource-constrained secondary cities. A critical question for future research involves the scalability of these adaptive approaches. Studies are needed to determine whether the reliance on human intermediaries, informal data generation, and functional trading zones can be effectively scaled to manage the immense organizational and spatial complexity of rapidly expanding global megacities (Parnell & Pieterse, 2014) but also emerging territorial concepts addressing the digital divide between urban and rural areas (Navío-Marco et al., 2020). The focus on data, in particular, can open new avenue to analyse urbanization and urban life in a digital age, capturing the complexities of geographic and informational territories in the Global South (Datta & Hoefsloot, 2025). Furthermore, it is crucial to test these findings beyond the Global South (Burns et al., 2021). These adaptive mechanisms are equally applicable to the Global North, where cities increasingly rely on hybrid governance and human intermediaries to navigate austerity, bureaucratic silos, and gaps in formal datasets. Ultimately, investigating how data friction and inter-organizational translation operate across diverse scales and global geographies will test the broader applicability of good enough planning frameworks.

Systemic Impacts of Algorithmic Governance: The development of ever larger AI models, trained on vast datasets, promises to deliver both highly sophisticated and highly generalizable outputs (Mai et al., 2022). For GeoAI and planning applications, these models may be able to reason, plan, and execute multi-step geographic analysis and urban design workflows (Li & Hsu, 2022; Tiwari, 2025) However, these models require major resource-intensive enterprise, making them increasingly unattainable (Ball et al., 2017). This accessibility gap is mostly addressed by focusing on the characteristics of AI, for example reducing the need for specialized computational resources and cloud-based services (Lins et al., 2021; Rolf et al., 2021). Future scholarship should analyse the long-term systemic impacts of automated decision-making on vulnerable populations and institutions characterized by unstructured data ecosystems. Extending the Task-Data-User-Technology model to assess municipal reliance on machine learning will be necessary to understand how algorithmic governance reconfigures urban authority, the potential for sustained automation bias, and the structural mechanisms required to ensure responsible technological deployment. Accessibility also entails fostering AI skills and readiness (Jöhnk et al., 2021), and further research could specifically explore ways to improve capabilities in data preparation, data processing, and quality assurance in local governments (Engin et al., 2020).

These research directions emphasize that the study of urban digitalization must continuously evolve to reflect the material realities of the cities it seeks to understand. By maintaining a focus on contextual alignment, critical scholarship can better support digital transitions that are equitable, sustainable, and genuinely responsive to the diverse needs of the urban majority in the Global South.

List of Tables

References

Alizadeh, T., & Prasad, D. (2024). The right to the smart city in the Global South: A research agenda. Urban Studies, 61(3), 426-444. https://doi.org/10.1177/00420980231183167

Andrews, M. (2012). The logical limits of best practice administrative solutions in developing countries. Public Administration and Development, 32(2), 137-153. https://doi.org/10.1002/pad.622

Arun, C. (2020). AI and the Global South: Designing for Other Worlds. In M. D. Dubber, F. Pasquale, & S. Das (Eds.), The Oxford Handbook of Ethics of AI (pp. 588–606). Oxford University Press. https://doi.org/https://doi.org/10.1093/oxfordhb/9780190067397.013.38

Augustinus, C., & Tempra, O. (2021). Fit-for-Purpose Land Administration in Violent Conflict Settings. Land, 10(2). https://mdpi-res.com/d_attachment/land/land-10-00139/article_deploy/land-10-00139.pdf?version=1612171750

Ball, J. E., Anderson, D. T., & Chan, C. S. (2017). A Comprehensive Survey of Deep Learning in Remote Sensing: Theories, Tools and Challenges for the Community. Journal of Applied Remote Sensing, 11(4), 042609. https://doi.org/10.1117/1.jrs.11.042609

Bandauko, E. (2024). Negotiating the insider–outsider dilemma in urban research: Experiences of a graduate student returning home for fieldwork. Area, 56(2), e12931. https://doi.org/https://doi.org/10.1111/area.12931

Barry, M. (2018). Fit-for-purpose land administration – administration that suits local circumstances or management bumper sticker? Survey Review, 50(362), 383-385. https://doi.org/10.1080/00396265.2018.1501130

Bates, J. (2018). The politics of data friction. Journal of Documentation, 74(2), 412-429. https://doi.org/10.1108/JD-05-2017-0080

Bates, J., Lin, Y.-W., & Goodale, P. (2016). Data journeys: Capturing the socio-material constitution of data objects and flows. Big Data & Society, 3(2), 2053951716654502. https://doi.org/10.1177/2053951716654502

Beckers, D., Gerli, P., Mora, L., Thabit, S., & Tonnarelli, F. (2022). Global Review of Smart City Governance Practices.

Beckers, D., Gerli, P., Mora, L., Thabit, S., & Tonnarelli, F. (2023). Managing smart city governance: A playbook for local and regional governments. 10.13140/RG.2.2.16598.22085

Bell-Martin, R. V., & Marston Jr, J. F. (2021). Confronting Selection Bias: The Normative and Empirical Risks of Data Collection in Violent Contexts. Geopolitics, 26(1), 159-192. https://doi.org/10.1080/14650045.2019.1659780

Bennett, R. M., Unger, E.-M., Lemmen, C., & Dijkstra, P. (2021). Land Administration Maintenance: A Review of the Persistent Problem and Emerging Fit-for-Purpose Solutions. Land, 10(5), 509. https://doi.org/10.3390/land10050509

Bergen, N., & Labonté, R. (2020). "Everything Is Perfect, and We Have No Problems": Detecting and Limiting Social Desirability Bias in Qualitative Research. Qualitative Health Research, 30(5), 783-792. https://doi.org/10.1177/1049732319889354

Berkovic, D., Ayton, D., Briggs, A. M., & Ackerman, I. N. (2020). The View From the Inside: Positionality and Insider Research. International Journal of Qualitative Methods, 19, 1609406919900828. https://doi.org/10.1177/1609406919900828

Bialski, P. (2024). Middle Tech: Software Work and the Culture of Good Enough (Vol. 36). Princeton University Press.
Bishop, B. W., & Hank, C. (2018). Measuring FAIR principles to inform fitness for use. International Journal of Digital Curation, 13(1), 35-46.
Bishop, B. W., Hank, C., Webster, J., & Howard, R. (2019). Scientists' data discovery and reuse behavior: (Meta)data fitness for use and the FAIR data principles. Proceedings of the Association for Information Science and Technology, 56(1), 21-31. https://doi.org/https://doi.org/10.1002/pra2.4
Bokulich, A., & Parker, W. (2021). Data models, representation and adequacy-for-purpose. European Journal for Philosophy of Science, 11(1), 31. https://doi.org/10.1007/s13194-020-00345-2
Boyle, L., Harlow, J., & Keeler, L. W. (2023). (D)evolving smartness: exploring the changing modalities of smart city making in Africa. Urban Geography, 1-25. https://doi.org/10.1080/02723638.2023.2213035
Burns, R., Fast, V., Levenda, A., & Miller, B. (2021). Smart cities: Between worlding and provincialising. Urban Studies, 58(3), 461-470. https://doi.org/10.1177/0042098020975982
Cain, A. (2014). African urban fantasies: past lessons and emerging realities. Environment and Urbanization, 26(2), 561-567. https://doi.org/10.1177/0956247814526544
Calzada, I., Pérez-Batlle, M., & Batlle-Montserrat, J. (2023). People-Centered Smart Cities: An exploratory action research on the Cities' Coalition for Digital Rights. Journal of Urban Affairs, 45(9), 1537-1562. https://doi.org/10.1080/07352166.2021.1994861
Chavez, C. (2008). Conceptualizing from the inside: Advantages, complications, and demands on insider positionality. The qualitative report, 13(3), 474-494.
Cirolia, L. R., Sitas, R., Pollio, A., Sebarenzi, A. G., & Guma, P. K. (2023). Silicon Savannahs and motorcycle taxis: A Southern perspective on the frontiers of platform urbanism. Environment and Planning A: Economy and Space, 0(0), 0308518X231170193. https://doi.org/10.1177/0308518x231170193
Cirolia, L. R., Tahir, A., Goodfellow, T., & Hassan, A. A. (2026). Worlding Mogadishu: 'New cities' and material modes of urban speculation. Urban Studies, 00420980261420075. https://doi.org/10.1177/00420980261420075
Colding, J., & Barthel, S. (2017). An urban ecology critique on the "Smart City" model. Journal of Cleaner Production, 164, 95-101. https://doi.org/https://doi.org/10.1016/j.jclepro.2017.06.191
Collier, D., Mahoney, J., & Seawright, J. (2004). Claiming too much: Warnings about selection bias. In Rethinking social inquiry: Diverse tools, shared standards (pp. 85-102). Rowman and Littlefield.
Collins, W. R., Miller, K. W., Spielman, B. J., & Wherry, P. (1994). How good is good enough? An ethical analysis of software construction and use. Communications of the ACM, 37(1), 81-91.
Datta, A. (2015). New urban utopias of postcolonial India: 'Entrepreneurial urbanization' in Dholera smart city, Gujarat. Dialogues in Human Geography, 5(1), 3-22. https://doi.org/10.1177/2043820614565748
Datta, A. (2018). The digital turn in postcolonial urbanism: Smart citizenship in the making of India's 100 smart cities. Transactions of the Institute of British Geographers, 43(3), 405-419. https://doi.org/10.1111/tran.12225

Datta, A., & Hoefsloot, F. I. (2024). The state as auteur: Timing digitisation in Africa's Silicon Savannah. Dialogues on Digital Society, 1(1), 51-68. https://doi.org/10.1177/29768640241295479

Datta, A., & Hoefsloot, F. I. (2025). An introduction to informational peripheries. In A. Datta & F. I. Hoefsloot (Eds.), Informational Peripheries: Rethinking the urban in a digital age. UCL Press. https://doi.org/https://doi.org/10.14324/111.9781800088894

Enemark, S. (2015). A well-tailored cadastral system is in fact acting as a backbone in society [Journal article]. Coordinates, XI(04), 12-13.

Enemark, S., Bell, K., Lemmen, C., & McLaren, R. (2014). Building fit-for-purpose land administration systems. XXV FIG Congress 2014: Engaging the Challenges, Enhancing the Relevance,

Enemark, S., Mclaren, R., Lemmen, C., Antonio, D., & Gitau, J. (2016). Scaling up responsible land governance: a guide for building fit-for-purpose land administration systems in less developed countries. Scaling up Responsible Land Governance: Annual World Bank Conference on land and Poverty, Washington DC,

Engin, Z., van Dijk, J., Lan, T., Longley, P. A., Treleaven, P., Batty, M., & Penn, A. (2020). Data-driven urban management: Mapping the landscape. Journal of Urban Management, 9(2), 140-150. https://doi.org/https://doi.org/10.1016/j.jum.2019.12.001

Eppich, W. J., Olmos-Vega, F. M., & Watling, C. J. (2019). Grounded Theory Methodology: Key Principles. In D. Nestel, J. Hui, K. Kunkler, M. W. Scerbo, & A. W. Calhoun (Eds.), Healthcare Simulation Research: A Practical Guide (pp. 127-133). Springer International Publishing. https://doi.org/10.1007/978-3-030-26837-4_18

Evangelinou-Yiannakis, A. (2017). A reflection on the methodology used for a qualitative longitudinal study [Journal Article]. Issues in Educational Research, 27(2), 269-284. https://search.informit.org/doi/10.3316/informit.789328372199804

https://search.informit.org/doi/full/10.3316/informit.789328372199804

https://search.informit.org/doi/pdf/10.3316/informit.789328372199804

Fadmastuti, M., Nowak, D., & Crompvoets, J. (2024). Flood data platform governance: Identifying the technological and socio-technical approach(es) differences. Environmental Science & Policy, 162, 103938. https://doi.org/https://doi.org/10.1016/j.envsci.2024.103938

Faludi, A., & Waterhout, B. (2006). Introducing Evidence-Based Planning. disP - The Planning Review, 42(165), 4-13. https://doi.org/10.1080/02513625.2006.10556950

Gabrys, J., Pritchard, H., & Barratt, B. (2016). Just good enough data: Figuring data citizenships through air pollution sensing and data stories. Big Data & Society, 3(2), 2053951716679677. https://doi.org/10.1177/2053951716679677

Geddes, B. (1990). How the Cases You Choose Affect the Answers You Get: Selection Bias in Comparative Politics. Political Analysis, 2, 131-150. https://doi.org/10.1093/pan/2.1.131

Ghasemaghaei, M., Hassanein, K., & Turel, O. (2017). Increasing firm agility through the use of data analytics: The role of fit. Decision Support Systems, 101, 95-105. https://doi.org/https://doi.org/10.1016/j.dss.2017.06.004

Gianni, R., Lehtinen, S., & Nieminen, M. (2022). Governance of Responsible AI: From Ethical Guidelines to Cooperative Policies [Original Research]. Frontiers of Computer Science, 4, 873437. https://doi.org/10.3389/fcomp.2022.873437

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2012). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. Organizational Research Methods, 16(1), 15-31. https://doi.org/10.1177/1094428112452151

Goodfellow, T., Tahir, A., Cirolia, L. R., & Acheampong, R. (2024, 2024-05-08). Land and Connectivity in African Cities: A Six-City Comparative Study. African Cities Research Consortium. https://policycommons.net/artifacts/12383753/working-paper-12-land-and-connectivity/

Goodhue, D. L., & Thompson, R. L. (1995). Task-Technology Fit and Individual Performance. MIS Quarterly, 19(2), 213-236. https://doi.org/10.2307/249689

Graham, S., & Marvin, S. (2001). Splintering Urbanism. https://doi.org/10.4324/9780203452202

Green, B. (2020). The smart enough city: lessons from the past and a framework for the future. MIT Press.

Grindle, M. S. (2004). Good Enough Governance: Poverty Reduction and Reform in Developing Countries. Governance, 17(4), 525-548. https://doi.org/10.1111/j.0952-1895.2004.00256.x

Grindle, M. S. (2007). Good Enough Governance Revisited. Development Policy Review, 25(5), 533-574. https://doi.org/10.1111/j.1467-7679.2007.00385.x

Guma, P. K. (2019). Smart urbanism? ICTs for water and electricity supply in Nairobi. Urban Studies, 56(11), 2333-2352. https://doi.org/10.1177/0042098018813041

Guma, P. K. (2020). Incompleteness of urban infrastructures in transition: Scenarios from the mobile age in Nairobi. Social Studies of Science, 50(5), 728-750. https://doi.org/10.1177/0306312720927088

Guma, P. K., & Monstadt, J. (2021). Smart city making? The spread of ICT-driven plans and infrastructures in Nairobi. Urban Geography, 42(3), 360-381. https://doi.org/10.1080/02723638.2020.1715050

Guma, P. K., Mwaura, M., Njagi, E. W., & Akallah, J. A. (2023). Urban way of life as survival: navigating everyday life in a pluriversal global south. City, 27(3-4), 275-293. https://doi.org/10.1080/13604813.2023.2214961

Han, M. J. N., & Kim, M. J. (2024). A systematic review of smart city research from an urban context perspective. Cities, 150, 105027. https://doi.org/https://doi.org/10.1016/j.cities.2024.105027

Jiang, H., Geertman, S., & Witte, P. (2020). Ignorance is bliss? An empirical analysis of the determinants of PSS usefulness in practice. Computers, Environment and Urban Systems, 83, 101505. https://doi.org/https://doi.org/10.1016/j.compenvurbsys.2020.101505

Jöhnk, J., Weißert, M., & Wyrtki, K. (2021). Ready or Not, AI Comes— An Interview Study of Organizational AI Readiness Factors. Business & Information Systems Engineering, 63(1), 5-20. https://doi.org/10.1007/s12599-020-00676-7

Kayanan, C. M., Mutter, S., Davret, J., & Kitchin, R. (2025). The digital turn in planning and the production of 'good enough' planning systems. European Planning Studies, 1-22. https://doi.org/10.1080/09654313.2025.2599869

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. GeoJournal, 79(1), 1-14. https://doi.org/10.1007/s10708-013-9516-8

Kitchin, R. (2015). Making sense of smart cities: addressing present shortcomings. Cambridge Journal of Regions, Economy and Society, 8(1), 131-136. https://doi.org/10.1093/cjres/rsu027

Kitchin, R., Davret, J., Kayanan, C. M., & Mutter, S. (2024). Assemblage theory, data systems and data ecosystems: The data assemblages of the Irish planning system. https://mural.maynoothuniversity.ie/id/eprint/19238/

Kitchin, R., Davret, J., Kayanan, C. M., & Mutter, S. (2025). Data mobilities: rethinking the movement and circulation of digital data. Mobilities, 1-19. https://doi.org/10.1080/17450101.2025.2481309

Knorr-Cetina, K. (1999). Epistemic Cultures: How the Sciences Make Knowledge, . Harvard University Press.

Kourtit, K., Elmlund, P., & Nijkamp, P. (2020). The urban data deluge: challenges for smart urban planning in the third data revolution. International Journal of Urban Sciences, 24(4), 445-461. https://doi.org/10.1080/12265934.2020.1755353

Krizek, K., Forysth, A., & Slotterback, C. S. (2009). Is There a Role for Evidence-Based Practice in Urban Planning and Policy? Planning Theory & Practice, 10(4), 459-478. https://doi.org/10.1080/14649350903417241

Lawhon, M., & Le Roux, L. (2019). Southern urbanism or a world of cities? Modes of enacting a more global urban geography in textbooks, teaching and research. Urban Geography, 40(9), 1251-1269. https://doi.org/10.1080/02723638.2019.1575153

Lemmen, C., van Oosterom, P., & Bennett, R. (2015). The Land Administration Domain Model. Land Use Policy, 49, 535-545. https://doi.org/https://doi.org/10.1016/j.landusepol.2015.01.014

Leonelli, S. (2023). Opacity and reproducibility in data processing. KI-Kritik/AI Critique Volume 6, 313.

Leonelli, S. (2025). What to Do About Data Distance? Responsible Alternatives to Data Sharing. Harvard Data Science Review(7.2). https://doi.org/10.1162/99608f92.e95b5c26

Li, W., & Hsu, C.-Y. (2022). GeoAI for Large-Scale Image Analysis and Machine Vision: Recent Progress of Artificial Intelligence in Geography. ISPRS International Journal of Geo-Information, 11(7), 1-44. https://doi.org/10.3390/ijgi11070385

Lins, S., Pandl, K. D., Teigeler, H., Thiebes, S., Bayer, C., & Sunyaev, A. (2021). Artificial Intelligence as a Service. Business & Information Systems Engineering, 63(4), 441-456. https://doi.org/10.1007/s12599-021-00708-w

Lykouras, I., & Mora, L. (2025). Material matters: Recommendations for the analysis of relational spaces in sociotechnical transition studies. Technology in Society, 80, 102764. https://doi.org/https://doi.org/10.1016/j.techsoc.2024.102764

Magnusson, E., & Marecek, J. (2015). Doing Interview-based Qualitative Research: A Learner's Guide. Cambridge University Press. https://doi.org/DOI: 10.1017/CBO9781107449893

Mai, G., Cundy, C., Choi, K., Hu, Y., Lao, N., & Ermon, S. (2022, November 1-4, 2022). Towards a foundation model for geospatial artificial intelligence (vision paper) ACM SIGSPATIAL 2022, Seattle, Washington. https://doi.org/10.1145/3557915.3561043

https://dl.acm.org/doi/pdf/10.1145/3557915.3561043

Manny, L. (2023). Socio-technical challenges towards data-driven and integrated urban water management: A socio-technical network approach. Sustainable Cities and Society, 90, 104360. https://doi.org/https://doi.org/10.1016/j.scs.2022.104360

Manny, L., Angst, M., Rieckermann, J., & Fischer, M. (2022). Socio-technical networks of infrastructure management: Network concepts and motifs for studying digitalization, decentralization, and integrated management. Journal of Environmental Management, 318, 115596. https://doi.org/https://doi.org/10.1016/j.jenvman.2022.115596

Marvin, S., Luque-Ayala, Andrés, & McFarlane, C. (Eds.). (2016). Smart Urbanism - Utopian vision or false dawn? Routledge.

Mattern, S. (2016). Instrumental city: The view from Hudson Yards, circa 2019. Places Journal. https://placesjournal.org/article/instrumental-city-new-york-hudson-yards/

McKenzie, E., Posner, S., Tillmann, P., Bernhardt, J. R., Howard, K., & Rosenthal, A. (2014). Understanding the Use of Ecosystem Service Knowledge in Decision Making: Lessons from International Experiences of Spatial Planning. Environment and Planning C: Government and Policy, 32(2), 320-340. https://doi.org/10.1068/c12292j

Meijer, A., & Thaens, M. (2018). Urban Technological Innovation: Developing and Testing a Sociotechnical Framework for Studying Smart City Projects. Urban Affairs Review, 54(2), 363-387. https://doi.org/10.1177/1078087416670274

Milan, S., & Treré, E. (2020). The Rise of the Data Poor: The COVID-19 Pandemic Seen From the Margins. Social Media + Society, 6(3), 2056305120948233. https://doi.org/10.1177/2056305120948233

Miller, B., Ward, K., Burns, R., Fast, V., & Levenda, A. (2021). Worlding and provincialising smart cities: From individual case studies to a global comparative research agenda. Urban Studies, 58(3), 655-673. https://doi.org/10.1177/0042098020976086

Navío-Marco, J., Rodrigo-Moya, B., & Gerli, P. (2020). The rising importance of the "Smart territory" concept: definition and implications. Land Use Policy, 99, 105003. https://doi.org/https://doi.org/10.1016/j.landusepol.2020.105003

Neang, A. B., Sutherland, W., Beach, M. W., & Lee, C. P. (2021). Data Integration as Coordination [Article]. Proceedings of the ACM on Human-Computer Interaction, 4(CSCW3), Article 256. https://doi.org/10.1145/3432955

Odendaal, N. (2011). Splintering Urbanism or Split Agendas? Examining the Spatial Distribution of Technology Access in Relation to ICT Policy in Durban, South Africa. Urban Studies, 48(11), 2375-2397. https://doi.org/10.1177/0042098010388951

Odendaal, N. (2014). Space matters: the relational power of mobile technologies. URBE - Revista Brasileira de Gestão Urbana, 6, 31. https://doi.org/10.7213/urbe.06.001.SE02

Odendaal, N. (2021). Everyday urbanisms and the importance of place: Exploring the elements of the emancipatory smart city. Urban Studies, 58(3), 639-654. https://doi.org/10.1177/0042098020970970

Odendaal, N. (2022). Splintering by Proxy: A Reflection on the Spatial Impacts and Distributed Agency of Platform Urbanism. Journal of Urban Technology, 29(1), 21-27. https://doi.org/10.1080/10630732.2021.2007204

Parker, W. S. (2020). Model Evaluation: An Adequacy-for-Purpose View. Philosophy of Science, 87(3), 457-477. https://doi.org/10.1086/708691

Parnell, S., & Pieterse, E. (2014). Africa´s Urban Revolution (1 ed.). Zed Books. https://doi.org/10.5040/9781350218246

Pieterse, M. (2022). Corporate power, urban governance and urban law. Cities, 131, 103893. https://doi.org/https://doi.org/10.1016/j.cities.2022.103893

Randolph, G. F., & Storper, M. (2022). Is urbanisation in the Global South fundamentally different? Comparative global urban analysis for the 21st century. Urban Studies, 004209802110679. https://doi.org/10.1177/00420980211067926

Robinson, J., & Roy, A. (2016). Debate on Global Urbanisms and the Nature of Urban Theory. International Journal of Urban and Regional Research, 40(1), 181-186. https://doi.org/10.1111/1468-2427.12272

Rolf, E., Proctor, J., Carleton, T., Bolliger, I., Shankar, V., Ishihara, M., Recht, B., & Hsiang, S. (2021). A generalizable and accessible approach to machine learning with global satellite imagery. Nature Communications, 12(1), 4392. https://doi.org/10.1038/s41467-021-24638-z

Ruhlandt, R. W. S., Levitt, R., Jain, R., & Hall, D. (2020). Drivers of Data and Analytics Utilization within (Smart) Cities: A Multimethod Approach. Journal of Management in Engineering, 36(2), 04019050. https://doi.org/doi:10.1061/(ASCE)ME.1943-5479.0000762

Russo, P., Lanzilotti, R., Costabile, M. F., & Pettit, C. J. (2018). Towards satisfying practitioners in using Planning Support Systems. Computers, Environment and Urban Systems, 67, 9-20. https://doi.org/https://doi.org/10.1016/j.compenvurbsys.2017.08.009

Rzepka, C., & Berger, B. (2018, December 13-16, 2018). User Interaction with AI-enabled Systems: A Systematic Review of IS Research. ICIS, San Francisco, USA.

Sadowski, J., & Maalsen, S. (2020). Modes of making smart cities: Or, practices of variegated smart urbanism. Telematics and Informatics, 55, 101449. https://doi.org/https://doi.org/10.1016/j.tele.2020.101449

Schulz, P. (2020). Recognizing research participants' fluid positionalities in (post-)conflict zones. Qualitative Research, 21(4), 550-567. https://doi.org/10.1177/1468794120904882

Sheehan, N., & Leonelli, S. (2025). Reconciling data actionability and accountability in global health research: The case of SARS-CoV-2. Global Public Health, 20(1), 2436422. https://doi.org/10.1080/17441692.2024.2436422

Sheppard, E., Leitner, H., & Maringanti, A. (2013). Provincializing Global Urbanism: A Manifesto. Urban Geography, 34(7), 893-900. https://doi.org/10.1080/02723638.2013.807977

Simone, A. (2004). People as Infrastructure: Intersecting Fragments in Johannesburg. Public Culture, 16(3), 407-429. https://doi.org/10.1215/08992363-16-3-407

Sturm, T., & Peters, F. (2020, June 15-17, 2020). The impact of artificial intelligence on individual performance: Exploring the fit between task, data, and technology ECIS, Marrakech, Morocco.

Tiwari, A. (2025). Conceptualising the emergence of Agentic Urban AI: from automation to agency. Urban Informatics, 4(1), 13. https://doi.org/10.1007/s44212-025-00079-7

Veloso, Á., Fonseca, F., & Ramos, R. (2024). Insights from Smart City Initiatives for Urban Sustainability and Contemporary Urbanism. Smart Cities, 7(6), 3188-3209.

Vered, M., Livni, T., Howe, P. D. L., Miller, T., & Sonenberg, L. (2023). The effects of explanations on automation bias. Artificial Intelligence, 322, 103952. https://doi.org/https://doi.org/10.1016/j.artint.2023.103952
Watson, V. (2009). Seeing from the South: Refocusing Urban Planning on the Globe's Central Urban Issues. Urban Studies, 46(11), 2259-2275. https://doi.org/10.1177/0042098009342598
Watson, V. (2013). African urban fantasies: dreams or nightmares? Environment and Urbanization, 26(1), 215-231. https://doi.org/10.1177/0956247813513705
Watson, V. (2015). The allure of 'smart city' rhetoric: India and Africa. Dialogues in Human Geography, 5(1), 36-39. https://doi.org/10.1177/2043820614565868
Yin, R. K. (2018). Case study research and applications (Vol. 6). Sage Thousand Oaks, CA.
Zevenbergen, J., Augustinus, C., Antonio, D., & Bennett, R. (2013). Pro-poor land administration: Principles for recording the land rights of the underrepresented. Land Use Policy, 31, 595-604. https://doi.org/https://doi.org/10.1016/j.landusepol.2012.09.005
Zevenbergen, J., de Vries, W., & Bennett, R. M. (Eds.). (2016). Advances in Responsible Land Administration. CRC Press. https://doi.org/10.1201/b18988.

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Abstract

Data, Technology, and Contextual Adaptation in Urban Digital Transformation

The rapid urbanization of the Global South, particularly within the African continent, presents a set of governance challenges that diverge profoundly from the historical trajectories of the Global North. In response to unprecedented demographic shifts and the resulting strain on urban infrastructure, digital technologies and big data have been persistently championed under the banner of "smart urbanism" as a panacea to swiftly solve the complex problems of Southern urbanization. Yet, the application of these tools in African contexts is deeply problematic. Mainstream smart city agendas rely heavily on imported, universalist models predicated on the existence of formal capacities and robust physical infrastructures. Consequently, these models consistently fail to account for the severe resource constraints, pervasive spatial and economic informality, and profound institutional fragmentation that characterize Southern cities, often resulting in exclusionary technocratic interventions.

To address this disconnect, this thesis critically examines and reconstructs the relationship between urban governance and digital technology in the Global South. It critiques the one-size-fits-all hegemony of mainstream smart city paradigms that treat technology as an objective, neutral fix for deeply political urban problems. Instead, this research advocates for a deliberate shift toward "contextual adaptation"—a sociotechnical process where digital interventions are rigorously tailored to local socio-political realities. The primary aim is to articulate an understanding of urban digital transformation that prioritizes contextual adequacy over technical completeness. By investigating how imperfect data and technology can be mobilized effectively, the thesis demonstrates that "good enough" evidence is often a necessary and sufficient basis for urban planning, establishing that the viability of digital tools relies on negotiated "fitness-for-use" and multidimensional alignment rather than absolute technical standardization.

The study employs an exploratory qualitative methodology centered on in-depth case studies across resource-constrained secondary cities, including eThekwini (South Africa), Khorog (Tajikistan), and Bosaso (Somalia). Primary data collection methods comprised semi-structured interviews, focus group discussions, and systematic document analysis. The constituent articles utilized thematic analysis across single exploratory, comparative, and longitudinal analytical frames to investigate strategic planning practices, data ecosystems, and the sociotechnical dynamics of specific digital deployments.

The empirical findings reveal four primary mechanisms for successful digital transitions. First, navigating systemic institutional fragmentation requires hybrid governance arrangements and continuous, informal contextual adjustments rather than standardized multi-helix collaborative frameworks. Second, in data-scarce environments, planning is not paralyzed if actors prioritize the relational "fitness-for-use" of imperfect data; data mobility acts as a deeply social process relying on human intermediaries for translation across epistemic boundaries rather than pure technical standardization. Third, the deployment of foundational infrastructure, such as Fit-for-Purpose (FFP) land administration, alongside advanced tools like geospatial Artificial Intelligence (GeoAI), necessitates a rigorous Task-Data-User-Technology alignment to prevent systemic failures and cognitive hazards like automation bias. Finally, the research uncovers a severe temporal vulnerability: "fit-for-purpose" and pragmatic interventions

are highly susceptible to rapid institutional decay unless supported by continuous maintenance, sustained local financing, and deliberate upgrading strategies beyond the initial project cycle.

Ultimately, the thesis concludes that technological viability in the Global South relies primarily on institutional compatibility and ongoing sociotechnical negotiation rather than computational complexity. Achieving equitable and sustainable urban digital transitions demands a departure from universalist models in favor of continuous contextual adaptation, ensuring that digital infrastructures genuinely reflect and serve the pluralistic socio-material realities of Southern urbanization.

Lühikokkuvõte
Andmed, tehnoloogia ja linnade digitaalse transformatsiooni kontekstuaalne kohandamine

Globaalse Lõuna, eriti Aafrika mandri kiire linnastumine seab rea valitsemise väljakutseid, mis lahknevad sügavalt Globaalse Põhja ajaloolistest trajektooridest. Vastusena enneolematutele demograafilistele muutustele ja sellest tulenevale survele linnataristule on digitehnoloogiaid ja suurandmeid pidevalt propageeritud "targa urbanismi" (smart urbanism) sildi all kui imerohtu, mis lahendaks kiiresti Lõuna linnastumise keerulised probleemid. Ometi on nende vahendite rakendamine Aafrika kontekstis sügavalt problemaatiline. Tavalise targa linna (smart city) tegevuskavad toetuvad tugevalt imporditud, üldistavatele mudelitele, mis eeldavad tugeva füüsilise infrastruktuuri ning formaalse võimekuse olemasolu . Järelikult ei arvesta need mudelid järjekindlalt Lõuna linnadele iseloomulike tõsiste ressursipiirangute, laialdase ruumilise ja majandusliku informaalsuse ning sügava institutsionaalse killustatusega, mis sageli viib kõrvale tõrjuvate tehnokraatlike sekkumisteni.

Selle ebakõla lahendamiseks uuritakse ja rekonstrueeritakse käesolevas doktoritöös kriitiliselt linnajuhtimise ja digitehnoloogia vahelist seost Globaalses Lõunas. Selles kritiseeritakse tavalise targa linna paradigmade "üks suurus sobib kõigile" hegemooniat, mis käsitlevad tehnoloogiat kui objektiivset ja neutraalset lahendust sügavalt poliitilistele linnaprobleemidele. Selle asemel toetab käesolev uurimus sihikindlat üleminekut "kontekstuaalsele kohandamisele" – sotsiotehnilisele protsessile, kus digitaalsed sekkumised on rangelt kohandatud kohaliku sotsiaalpoliitilise reaalsusega. Peamine eesmärk on sõnastada selline arusaam linna digitaalsest transformatsioonist, mis seab kontekstuaalse vastavuse tähtsamaks tehnilisest täiuslikkusest. Uurides, kuidas puudulikke andmeid ja tehnoloogiat saab tõhusalt mobiliseerida, näitab doktoritöö, et "piisavalt heast" (good enough) tõendusmaterjalist piisab sageli linnaplaneerimise aluseks, tuvastades, et digitaalsete tööriistade elujõulisus tugineb pigem läbiräägitud "kasutuskõlblikkusele" (fitness-for-use) ja mitmemõõtmelisele kooskõlale kui absoluutsele tehnilisele standardiseerimisele.

Uuringus kasutatakse uurivat kvalitatiivset metoodikat, mis keskendub põhjalikele juhtumiuuringutele piiratud ressurssidega teisejärgulistes linnades, sealhulgas eThekwinis (Lõuna-Aafrika Vabariik), Khorogis (Tadžikistan) ja Bosasos (Somaalia). Peamised andmekogumismeetodid hõlmasid poolstruktureeritud intervjuusid, fookusgrupi arutelusid ja süstemaatilist dokumentide analüüsi. Kasutuses olevates artiklites kasutati temaatilist analüüsi üksikute uurivate, võrdlevate ja pikaajaliste analüütiliste raamistike lõikes, et uurida strateegilise planeerimise praktikaid, andmeökosüsteeme ja spetsiifiliste digitaalsete lahenduste sotsiotehnilist dünaamikat.

Empiirilised tulemused toovad esile neli peamist mehhanismi edukateks digipööreteks. Esiteks, süsteemses institutsionaalses killustatuses navigeerimine nõuab hübriidseid valitsemiskorraldusi ning pidevaid ja mitteformaalseid kontekstuaalseid kohandamisi, mitte standardiseeritud mitmeheelikseliseid koostööraamistikke. Teiseks, andmenappusega keskkondades ei peata see planeerimist, kui osalejad seavad esikohale puudulike andmete suhtelise "kasutuskõlblikkuse"; andmete liikuvus toimib kui sügavalt sotsiaalne protsess, mis toetub pigem inimestest vahendajatele, et tõlkida teavet üle episteemiliste piiride, mitte aga puhtale tehnilisele standardiseerimisele. Kolmandaks, baasinfrastruktuuri, näiteks otstarbekohase (Fit-for-Purpose, FFP) maahaldussüsteemi, ja kõrgtehnoloogiliste vahendite, nagu georuumiline tehisintellekt (GeoAI), rakendamine

nõuab ranget ülesande-andmete-kasutaja-tehnoloogia (Task-Data-User-Technology) kooskõla, et vältida süsteemseid tõrkeid ja kognitiivseid ohte, nagu automatiseerimise erapoolikus. Lõpuks paljastab uurimus tõsise ajalise haavatavuse: "otstarbekohased" ja pragmaatilised sekkumised on äärmiselt vastuvõtlikud kiirele institutsionaalsele lagunemisele, kui neid ei toetata pideva hoolduse, jätkusuutliku kohaliku rahastamise ja sihipäraste ajakohastamisstrateegiatega väljaspool esialgset projektitsüklit.

Lõppkokkuvõttes järeldatakse doktoritöös, et tehnoloogiline elujõulisus Globaalses Lõunas tugineb eelkõige institutsionaalsele sobivusele ja pidevatele sotsiotehnilistele läbirääkimistele, mitte arvutuslikule keerukusele. Õiglase ja jätkusuutliku linnalise digipöörde saavutamine nõuab üldistavatest mudelitest loobumist pideva kontekstuaalse kohandamise kasuks, tagades, et digitaalsed infrastruktuurid peegeldavad ja teenivad Lõuna linnastumise pluralistlikku sotsiaal-materiaalset reaalsust.

Appendix 1

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Smart urbanism in Africa: when theories do not fit with contextual practices

Francesco Tonnarelli[a,b] and Luca Mora[b,c]

ABSTRACT
Theories of smart urbanism have overlooked the influence of contextual factors on the conception, planning and implementation of digital transformation practices across regions. To articulate this critique, we focus on African cities and draw on a diverse range of urban and regional scholarship. We present the core assumptions advanced in the mainstream literature on smart urbanism and prove their inability to fit the organisation of African urban contexts. Three main research questions emerge from this critical examination and offer new perspectives for expanding knowledge on how smart urbanism challenges recombine with place-based governance approaches, not only in Africa, but globally.

KEYWORDS
smart urbanism; urban innovation; governance; digital transformation; Africa

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1. INTRODUCTION

Smart urbanism is an emerging approach to urban sustainability enhancement that involves an innovation process in which the extensive application of digital technologies becomes a remedy for the sustainability challenges facing urban communities (Marvin et al., 2016). This approach to sustainable urban development has gained growing attention in urban and regional studies and plays a central role in international urban policies (Mouton & Burns, 2021; Su & Fan, 2023), including those formulated in Africa. African countries have expressed strong faith in technological innovation, which is perceived as the key to unleashing the power of urbanisation (Slavova et al., 2016). From the African Union's agenda (African Union Commission, 2015, 2020) to national strategies and local plans (Bandauko & Nutifafa Arku, 2023), smart urbanism has been repeatedly described as a potential solution to African urbanisation challenges. Such enthusiasm is fuelled by unprecedented growth in digital capabilities and the widespread adoption of digital devices that have allowed African countries to leapfrog traditional development paths while helping the continent enter the digital era (Denis, 2021).

Smart urbanism offers opportunities 'in many foundational areas of the digital economy to leverage [African] global and regional initiatives' (Broadband Commission, 2019, p. 10). However, for this opportunity to be realised, smart urbanism practices in Africa and the Global South need to be cautious in uncritically adopting the governance frameworks and policy recommendations brought forward in the extant academic literature. Research on smart urbanism has been widely criticised (Datta, 2015; Odendaal, 2014; Watson, 2015) for developing a body of knowledge that is largely dependent on the experiences of cities located in Western, industrialised and wealthy countries. It does not account for the specific characteristics of African and Southern urbanisation processes in terms of scale and pace (Parnell & Pieterse, 2014; Parnell & Walawege, 2011), history, and governance (Cohen, 2006; Fox, 2014). As a result, when mobilising existing theories, African cities face challenges in ensuring that the integration of digital technologies into urban life aligns with their specific contextual needs (Aurigi & Odendaal, 2021; Odendaal, 2021).

In response to this policy mobility challenge, several studies have attempted to 'provincialise' (Burns et al., 2021) smart urbanism. These studies have highlighted

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the distance between unrealistic smart urbanism ideals and practical local conditions (Cinnamon, 2023; Guma & Monstadt, 2021) while portraying cities and communities as innovation producers rather than consumers of external ideas and resources (Baptista, 2015; Odendaal, 2022). A call for action emerges from this literature that recognises the need for a governance theory of smart urbanism tailored to the distinctive attributes of African urban environments. However, the available research falls short of achieving a twofold objective. First, it remains unclear which core assumptions of smart urbanism governance frameworks should be challenged to fit urban governance dynamics in African regions (Watson, 2021). Second, current studies do not clarify which lines of enquiry should be pursued to support Africa-related theoretical developments that address existing policy issues and implementation challenges (Ernstson et al., 2014; Peck, 2015).

This study helps to overcome this gap by exposing key inconsistencies that affect the theoretical propositions underpinning the three main governance dimensions of smart urbanism: institutional settings for urban innovation, urban innovation ecosystems and technological infrastructure (Mora et al., 2023). Our arguments draw on a combination of multiple data collection methods. First, we sourced relevant data from the literature on smart urbanism projects. Second, we conducted 10 expert interviews (see Appendix A in the supplemental data online[1]) online using a semi-structured protocol organised around the abovementioned governance dimensions. All interviews lasted approximately one hour and were conducted with public sector officials with experience in managing smart urbanism on the African continent. Third, we complemented these two data sources with lessons acquired from participant observations of smart urbanism projects promoted by the United Nations in various African countries, in which one of the authors has been actively involved as a strategic advisor. These countries included Djibouti, Eritrea, Ethiopia, Kenya, Nigeria, Somalia and South Africa. The data collected from these multiple sources were organised and analysed using thematic coding assisted by qualitative data analysis software. Through our examination, we uncover a set of questions and link them with areas of enquiry in urban and regional studies that have already recognised the limits of the existing theory in understanding and explaining the southern urban experience. To move beyond present conceptual borders and practical limitations, we argue that smart urbanism must dwell on this wider framing context.

The remainder of the paper is structured as follows. The next three sections introduce the theoretical inconsistencies identified in smart urbanism literature and present them within the framework of African urban development processes and governance approaches. In the discussion section, each inconsistency is linked to a set of critical yet unanswered research questions and to varying institutional, territorial and technological concepts from urban and regional studies, which can help expand smart urbanism research. Finally, the last section concludes the article by enhancing the call for smart urbanism research to be more attentive to contextualisation requirements and locally shaped development trajectories.

2. INSTITUTIONAL SETTING FOR URBAN INNOVATION

Political and institutional arrangements are determining factors in smart urbanism, shaping the ability of urban actors to promote urban sustainability enhancements (Ciasullo et al., 2020; Ehnert et al., 2018). According to the extant literature on smart urbanism, the key to success is the combination of three factors: the multilevel coordination of government actions, which is required to facilitate the sharing of data, technology, expertise and financial resources; coherent and integrated bodies of policies and regulations, which can simplify implementation processes and ensure a more effective governance structure; and public authorities able to formulate smart urbanism strategies and lead urban change in complex cross-sector collaborative environments (Mancebo, 2020). In particular, municipal governments are often assigned a leadership role in decision-making and orchestration (Clement et al., 2022), following the general assumption in urban and regional studies that substate entities are best positioned to deliver public services (Ahmad et al., 2005; Stren, 2012). This notion acknowledges the mutual interdependence between political and administrative levels (Bulkeley & Betsill, 2005; Hodson & Marvin, 2010), and the importance of a coherent distribution of political representation, fiscal responsibilities, and administrative functions between central and subnational governments (Ehnert et al., 2018; Keating, 2017). However, the smart urbanism theory overlooks the complexity of intergovernmental relations in African urban politics (Pieterse, 2018; Smit, 2018). Vertical and horizontal coordination between public authorities is often fragmented. Vertically, roles and responsibilities are not clearly defined; horizontally, transformation dynamics and urbanisation processes transcend administrative boundaries governed by single public authorities (Croese et al., 2021; Resnick, 2021).

Concerning fiscal and financial autonomy, most African countries centralise mandates and resources; municipal governments do not define and implement investment decisions and have limited control over sources of revenue, such as taxes, tariffs and fees (UCLG & Cities Alliance, 2018). Moreover, most municipal governments do not have access to debt financing (OECD et al., 2022). Without locally owned resources and financial instruments for investment, local governments cannot afford to undertake many urban development projects that can generate large economic and social returns, including smart urbanism projects (Devas, 2003). Further, without controlling revenue generation for public service delivery, municipal governments may lose interest in investing in digital innovation initiatives that may improve the quality and efficiency of their offerings (Mello & Ter-Minassian, 2020). For instance, multiple case study analyses demonstrate that municipal governments are more inclined to digitalise cadastral records when they are responsible for managing tax-related revenue because property taxation is one of the favoured systems for income generation (Rochell et al., 2022). This, in turn, can trigger additional innovation. Digitalisation processes are instrumental in creating geospatial databases that form urban areas' spatial intelligence (Tao, 2013) while enabling new smart urbanism initiatives, with projects introducing data analytics for visualisation and decision-making to location-based services (INT.03).

The devolution of administrative functions and responsibilities has caused high fragmentation levels (Resnick, 2021) and weakened the reach of local urban politics in African urban settlements (Devas, 2001; Myers, 2011), creating a coordination void in infrastructure and service delivery at the urban scale. Infrastructure development, planning processes and policy formulation, for example, tend to be controlled nationally, with very little decision-making power left for the subnational levels of government (Cupers & Meier, 2020; Wiig & Silver, 2019). Simultaneously, the spatially splintered and informal nature of African urbanisation prevents local public authorities from focusing on city-scale service delivery and coordination, as many electricity, water, sanitation, waste removal and housing provision services are under the control of multiple private sector organisations that often operate outside formal regulatory systems defined by the public sector (Baptista, 2015; Guma, 2019; Lawhon, 2012; van Welie et al., 2018).

Despite being unable to perform their usual administrative functions and responsibilities, a growing number of local governments have begun to engage in international relations, a mandate previously held by national governments (Acuto, 2013). Local governments have directly developed their foreign relations, international commitments and development initiatives, generating the mushrooming of African associations, local public sector organisations, urban forums and mayor covenants. Resnick (2021) notes how this trend has raised 'the stakes of subnational competition' as mayors are gaining 'a global stage on which to hone their reputation and image' (p. 148) through transnational initiatives, while central governments, in turn, protect their power position with measures to constrain local-level autonomy. Some exceptions may exist because of variations in urban governance structures throughout the continent. However, even in highly decentralised states, such as South Africa, which is recognised as a good practice for devolution, national politics, policies and funding strongly influences smart urbanism initiatives (INT.09). Smart urbanism is shaped and filtered through a complex weave of national and municipal governance arrangements (Boyle et al., 2023), making it multi-scalar and intrinsically connected to wider policy scales (Cinnamon, 2023).

Smart urbanism practices are also inhibited by the nesting of public authorities within wider metropolitan regions, where urbanisation dynamics outpace any attempt at institutional restructuring. To control the spatial expansion of urban agglomerations, national governments have reshaped municipal boundaries and created metropolitan authorities. However, these new administrative entities are provided with weak coordinating authority, which is frequently bypassed by their constitutive municipalities or the national government itself (Bannister & Sutcliffe, 2019). For example, in Nigeria, the megacity of Lagos was split into 20 local government authorities (LGAs) spanning two federal states. This division has posed critical coordination challenges: citywide policy and strategy formulation would require dialogue between LGAs subject to different state-defined policies and regulatory frameworks (UN-HABITAT, 2018). Conversely, in Kenya, constitutional reforms have introduced highly decentralised and spatially extensive counties. Municipal governments were eliminated, hampering the effective management of city-level operations (Bassett, 2016).

Within metropolitan and municipal entities, understanding decision-making related to smart urbanism requires examining dialogue and cooperation among elected leaders as well as the interactions between politicians and bureaucrats. In particular, effective urban service delivery can be largely shaped by the degree of separation between the political and bureaucratic spheres and the degree of autonomy bureaucrats face in implementing their responsibilities (Dasandi & Esteve, 2017). For example, Boyle et al. (2023) detailed how the digital strategy of Cape Town was shaped by the strong political interference of the mayor's office over administrative branches, which undermined the competence and autonomy of public officials, causing frustration, resignations and fragmentation among departments.

Institutional arrangements in the African territorial system are further complicated by the unclear functional interrelations between urban and rural areas. Research has demonstrated that the flows of people, goods, labour and capital moving across urban areas and rural environments have blurred their boundaries (Agergaard & Ortenbjerg, 2017). This difficulty in dividing urban settings from their hinterlands is also exacerbated by the wider socioeconomic changes that new global connectivity has brought about – money transfers, the proliferation of smartphones and mobile Internet, to name a few (Muto, 2012). This reading of urban–rural fluidity within digital transitions calls for a deeper reflection on the geographic scope of current theories on the governance of smart urbanism.

3. URBAN INNOVATION ECOSYSTEM

Theorising smart urbanism suggests that the governance of urban innovation processes requires organising cross-sector collaborations that connect public organisations to businesses, research institutions, civil society organisations and citizens (Mora & Deakin, 2019; Vallance et al., 2020). Research on these collaborations, which enact 'complex interactions between multiple stakeholders operating at different levels of governance' (Knox & Arshed, 2022, p. 1161) has positioned regional-level ecosystem theories into smart urbanism studies, leading to concepts like *stakeholder constellations* (Mello Rose, 2022) and *urban* *innovation ecosystems* (Camboim et al., 2019). However, extant theories on collaboration in smart urbanism do not consider that the fragmentation of African public action requires focusing on additional actors and distinct forms of intervention (Devas, 2001; Smit, 2018). However, the influence of these factors on urban digital transformation remains unexplored.

First, compared with other regions of the world, traditional and informal authorities play a significant role in local African communities, especially in urban fringes, transition spaces and rural environments. They have recognised responsibilities for key governance matters and significant decision-making power and operate as hybrid organisations positioned at the intersection between civil society and the public sector (Meth et al., 2021). For example, while examining the governance of urbanisation processes in South Africa and Tanzania, Beall et al. (2015) and Schlimmer (2022) described how municipal and central governments need to constantly negotiate and mediate power over land management and basic service provision with village councils and chiefs. Similarly, Ameyaw and De Vries (2021) showed that the implementation of a blockchain-based digital land registry in Ghana has become a matter of authority negotiation between traditional rural elites and formal political bodies.

Second, African regions are characterised by a dynamic migratory profile, with many groups maintaining a high degree of mobility (Cottyn et al., 2013). With a strong emphasis on the local dimension and proximity conditions shaping urban innovation ecosystems, current smart urbanism theories fail to account for transnational communities and their effects on entrepreneurial activities. Technological advancements related to cheaper transportation and real-time communication have enabled the move from a static diaspora, settling in a new country while maintaining ties to their homeland, to cohesive transnational communities that are active in multiple countries. This change has triggered transnational entrepreneurship: cross-border business ventures that rely on multiple 'cultural, institutional and economic features' (Zapata-Barrero & Rezaei, 2020, p. 1960). Telecommunications and digital technologies are often at the core of such businesses and are essential for enabling and promoting them in a feedback loop (Houngbonon et al., 2022). Transnational entrepreneurs operate in local innovation ecosystems, but they work as external actors with internal insight and agency, entrenching a strong competitive position in environments characterised by weak institutions and difficult business environments (Ojo et al., 2013). In the Horn of Africa, for instance, transnational businesses are indicated as a stabilising force and provide public services in sectors where a legitimate government is lacking (Meester et al., 2019). Additionally, transnational entrepreneurship facilitates the cross-national diffusion of technological competencies, skills and social–cultural capital acquired by migrants (Hübler, 2016; Oiarzabal & Reips, 2012), while influencing home country policies (Kshetri, 2013).

Third, the influence of donors such as philanthropies, international agencies, and governmental and non-governmental organisations in developing regions means that African smart urbanism is often shaped by a combination of coercive, normative and mimetic forces (DiMaggio & Powell, 1983). Donors push African countries towards innovation-driven development (Denis, 2021), but resource dependency creates coercive pressure to implement administrative reforms, procurement practices and service provision modalities that align with the preferences of funding agents (Andrews, 2012). When designing smart urbanism projects, many African cities ask themselves, 'Which donor will be involved? Which kind of agenda? What is its interest? It is not about local and national strategy; it is about hype, money, and opportunities' (INT.07). Simultaneously, funding agencies tend to impose norms and standards for smart urbanism set by global market forces and internationally claimed best practices (Joss et al., 2019). When faced with this imposition, local communities tend to replicate predominant practices and behaviours without local-level assimilation and place-based adaptation (Manda & Backhouse, 2019). This pressure aggravates the consequences of what can be considered a mimicking effect. African cities tend to imitate successful examples drawn from global imaginaries of urban modernity to solve existing urban planning issues and fulfil their aspirations to be recognised as innovative and cosmopolitan places. Watson (2014) describes these 'African urban fantasies' and their alluring rhetoric as one of the most dangerous phenomena in African urbanisation.

Finally, a relevant proportion of citizens are excluded from the opportunities brought about by smart urbanism due to factors such as poverty, illiteracy, marginalisation and limited access to digital technology (OECD et al., 2022). Questions on power dynamics, inequality and injustice across levels of society have only been marginally examined, despite being of utmost importance in Africa (Fuchs & Horak, 2008; Odendaal, 2023). More clarity is needed on how to level these benefits with a broader audience and engage these marginalised populations in co-design processes (INT.06). In addition, the digital divide in African countries has a territorial component (Furuholt & Kristiansen, 2007; Pick & Sarkar, 2015). This distinctive attribute derives from a high level of urban primacy. Most of the urban population and central political powers are concentrated in a few main cities that receive the largest and disproportionate shares of resources and infrastructure provision (Cities Alliance & AfDB, 2022). African secondary cities and their inhabitants suffer from huge infrastructural, technological and governance gaps, the correlation of which with smart urbanism practices has been neglected in research and policy development (Ranchod, 2020).

4. URBAN TECHNOLOGICAL INFRASTRUCTURE

The backbone of smart urbanism is urban technological infrastructure that combines digital services and applications with data, software and hardware components

(Mora et al., 2021). For many scholars, the very notion of smart urbanism is a constantly expanding network of ubiquitous sensors and other digital devices built into the urban fabric (Greenfield, 2006; Kitchin, 2014). However, this idea of the gradual, linear and widespread growth of the technological layer and its deployment contrasts with the social fragmentation and splintered spatiality of African cities and regions (Guma & Monstadt, 2021). There is a vast and overlooked divide between how technological infrastructure is planned, promoted, and perceived, and how it is implemented, owned and accessed.

Government authorities in Africa tend to promote smart urbanism plans and strategies anchored to hypermodernist visions that are translated into new towns by processes of 'utopian speculative urbanism' (Cairns et al., 2022). The best-known examples of smart urbanism projects on the continent, from Konza in Kenya to Hope City in Ghana, promise to solve Africa's urbanisation challenges through satellite city developments infused with cutting-edge digital technology. Not only are these projects generally incapable of meeting their claims (Arku et al., 2022), but they also show no connection with the ordinary realities of African communities (Guma & Monstadt, 2021; Watson, 2014). The technological infrastructure that builds the foundations of these developments and the human capital needed to appropriate them represent a reality only in a limited number of geographical locations within the continent (Watson, 2015). These experiences have become exemplary cases of African smart urbanism thanks to international debates. However, they offer only a partial understanding of current practices. What remains invisible in the extant literature is an 'actually existing' (Shelton et al., 2015, p. 13) landscape of more dispersed and multifaced urban digital developments that have proved to respond to local development needs better than projects inspired by utopian thinking. Overlooking these practices leads to a misleading understanding of smart urbanism in Africa.

Most of these practices did not emerge from speculative, top-down city plans. Rather, they are the products of social entrepreneurship activities mediated through ground-level negotiations within collaborative ecosystems, the objective of which is to deliver basic public services (Guma & Monstadt, 2021). These approaches to smart urbanism also reflect the uneven development and splintering spatiality of African cities and regions. Technology-based systems of service delivery are scarcely integrated among themselves, and they often target specific urban niches or clusters instead of being available citywide (Guma, 2019). These bespoke digitally rendered services appear to mirror and intensify socio-spatial inequalities (Odendaal, 2011) while allowing decentralised systems to coexist and serve specific user segments that would otherwise be neglected (van Welie et al., 2018).

This approach to smart urbanism demonstrates a rethinking of the general assumptions related to what urban technological infrastructure should be envisaged; there is more than advanced and emerging technology. Urban technological infrastructure does not always require advanced, expensive, or highly experimental technological devices. Smart urbanism can also be generated through readily available and relatively unsophisticated applications (United Nations Conference on Trade and Development (UNCTAD), 2022). Mobile money applications, such as the Kenyan *mPesa*, which rely on low technology such as mobile phones and their short message services, and unstructured supplementary service data are examples of frugal innovations with deep transformative effects (Tiwari & Kalogerakis, 2016). They provide critical financial services to individuals who lack access to formal financial services and modern technologies (David-West et al., 2019). Mobile money is now a standard in resource-poor settings worldwide and wider population segments choose (or are forced to use) these systems. In fragile contexts such as Somalia, this technology has bypassed the challenges of currency depreciation crises and transitioned to an almost cashless economy. Typically, by recognising the benefits offered by these services, aid agencies attempt to increase their diffusion by distributing mobile phones and SIM cards loaded with mobile money to displaced communities. Due to this process, a larger number of displaced individuals can maintain economic ties with their global diaspora through remittances, which have long been vital to the wider economy of the region (Chonka & Bakonyi, 2021).

These overlooked digital developments reflect the ability of African cities to adapt, contextualise, and expand foreign technologies while launching less advanced but disruptive innovations that mobilise dynamic and complex sociotechnical development processes (Odendaal, 2022). Exemplary cases include digital metres for energy and water provision in Mozambique and Kenya (Baptista, 2015; Guma, 2019). They have been used by utility companies to expand their markets while improving accessibility and affordability, especially in informal neighbourhoods. Similarly, already available mobility apps have been adapted to serve informal public transport systems composed of a wide range of vehicles, such as taxis, minibuses, motorcycles and auto rickshaws. These apps have proven to promote safety for both drivers and customers, regularise payment transactions and support job creation (Odendaal, 2022).

Several examples of smart urbanism projects also show how the aspirational desire of project partners swings from ambitions of modernity and profit-oriented interests to pro-poor intentions. With the help of local communities, geospatial information technologies and digital land management systems have been introduced in the urban fringes of countries such as Rwanda, Uganda, Benin, Kenya and Nigeria. These technologies help map informal settlements and make them visible (Kamalipour & Dovey, 2019) while ensuring that a variety of informal and customary land rights are acknowledged (Arko-Adjei & Akrof, 2019). In Gambia, the government partnered with Google to introduce *+codes* and to provide a digital address system throughout the Greater Banjul region. The broader ambition is to equip the country with a mapping and positionality infrastructure that is foundational for the uses and services of a globalising digital economy (INT.02).

5. PROBLEMATISING SMART URBANISM IN AFRICA

Regional studies have long been aware of the limited capability of the existing theory to explain the southern urban experience and have already underlined the need to strengthen theory-building efforts (Ernstson et al., 2014; Robinson, 2002; Roy, 2009). The discussion of smart urbanism needs to account for this wider framing context. Our critical analysis reveals that several constructs that frame the smart urbanism theory do not apply properly to African cities. These incompatibilities can be synthesised into three main research questions (RQs) connected to established areas of enquiry in urban and regional studies. Their investigation can help expand our knowledge of smart urbanism.

RQ: How can we complement the city-level orientation of smart urbanism research with a stronger focus on territorial governance?

Some research efforts have been put into finding 'the right scale of governance' (Herrschel, 2013) and operationalising city-region approaches (Kitchin & Moore-Cherry, 2021), but further research is needed to understand how administrative and geographical arrangements impede or facilitate smart urbanism practices at different scales. This is especially important in African cities, where traditional administrative hierarchies and multiscale governance fail to respond to urbanisation dynamics (Watson, 2021). Smart urbanism in Africa needs to be understood in terms of the complexity of vertical and horizontal institutional relations: in the conflicts, overlaps and grey areas of devolved administrative functions; in the misalignment between devolved functions and the financial means to achieve them; and in the interplay between cities, territories, and their local and national governments. In this context, urban and regional studies have sought new concepts for these distinct modes of space production, and the resulting disparate state structures and non-linear government arrangements (Caldeira, 2017; Meth et al., 2021; Schmid et al., 2018). Emerging territorial concepts seem more suitable for analysing and theorising African smart urbanism, but they have little to no recognition in the smart urbanism literature addressing African cities. Examples of these concepts include smart territory, a term which addresses the digital divide between urban and rural areas while promoting local opportunities (Navío-Marco et al., 2020), and digital nations, which involves a comprehensive approach to nationwide digital transformation (Kar et al., 2019).

RQ: Who is involved and excluded in agenda setting and prioritisation, and how?

Given the heterogeneous ecosystem of non-state actors involved in the governance of African cities, detailed insights into their single agency are needed concerning how they interact with the political and contested nature of contemporary urban and regional spaces (Lindell, 2008). Place leadership and a collaborative governance lens (Beer et al., 2019; Sotarauta et al., 2017) could help recognise the level of leadership dispersion (Hambleton, 2015) and map how resources – knowledge, human and organisational – are distributed across different actors in Africa's societal sectors and segments of space (Grillitsch & Sotarauta, 2020). This is an essential step in understanding the roles of individual actors in driving change and determining the extent to which they can form coalitions of interest to sustain smart urbanism practices (Nicholds et al., 2017). In particular, the micropolitical dynamics of local arrangements, governance practices and power relations (Sotarauta, 2017) could reveal the mechanisms by which largely invisible individuals and groups participate in path creation and development (Hutchinson & Eversole, 2022) and day-to-day administration and politics (Drivdal, 2016). Moreover, crucial to understanding the socioeconomic coordination issues arising between actors is the need to embrace dimensions of proximity beside the geographical one (Boschma, 2005; Torre & Rallet, 2005). As African cities become increasingly wired to their regions and a globalised world, the resulting networks of mobility and migration on one side and donor assistance on the other make the place-based development strategies of cities and regions a complex process spanning across geographical boundaries (Cortinovis & van Oort, 2022).

RQ: How is technology infrastructure embedded in uneven urban environments?

Africa's digital infrastructure is integrated into multiple aspects of urban and regional dynamics. However, the ownership of this infrastructure, the nature of the technologies themselves, and their unequal distribution and utilisation reflect a dynamic and contested spatiality and an uneven landscape of innovations and smart users. The extant literature on urban and regional studies has problematised urban infrastructure and its deployment (Glass et al., 2019; Wiig & Silver, 2019) by examining how the provision of technology often fragments urban spaces (Graham & Marvin, 2001) and by highlighting how people reformulate urban geographies through informal, incremental appropriation (Rao, 2014; Simone, 2004). The challenges and potential of smart urbanism in Africa cannot be addressed without similar changes in thinking. Research needs to reconcile different conceptions of smartness, multiple ways of engaging with and understanding the technology, and balance locally defined uses of smartness and the specific socio-spatial relations in which usage takes place.

6. CONCLUSIONS

We recognise the need for radical change in the approach to provincialising the smart urbanism theory. Urban and regional studies are unclear as to which core assumptions of governance frameworks for smart urbanism projects should be adjusted to align with the multifaceted complexity of regional conditions. What is overlooked is that urban transformations are 'stubbornly local affairs' (Grandin & Haarstad, 2021, p. 296) that depend on local factors such as local agency, political negotiation and material change (Peck & Theodore, 2015) and extant theories require adaptation to changing conditions before being mobilised (McCann et al., 2013; Peck, 2015). Clarity is also missing around the lines of enquiry we should pursue to support these region-focused theory developments.

This article articulates this critique by focusing on the distinctive attributes of African urban environments. Core assumptions in mainstream smart urbanism theory are presented, and their validity is examined on the African continent by drawing on a diverse range of scholarship on urban and regional studies. Based on this analysis, we formulated three main research questions that future academic contributions should consider. However, it is important to highlight that these questions are not exclusive to Africa; they can also help trigger research offering theoretical adjustments in other geographical contexts.

In line with the remarks made in recent studies, we acknowledge that relationality and comparability are key components of a smart urbanism research agenda that calls for decentring and decolonialising the dominant interpretations of smartness and digital transition that only build upon the experiences of cities located in Western, industrialised and wealthy countries (Miller et al., 2021). Moving beyond overly generalised theories of smart urbanism requires an understanding of how transformations are negotiated within and across multiple geographically dispersed settings and sensitivity to the need for mutual adaptation that links policy mobility practices to regional context conditions (McCann & Ward, 2011). This means employing comparative approaches that 'seek to understand the systemic and political processes at play' and open 'new spaces for thinking about what smartness means, how it operates, and its attendant implications' (Burns et al., 2021, p. 467) across regions.

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NOTE

1. Direct quotations extracted from interviews are referenced with a code directly connected to Appendix A online. Oral consent to reuse these data for publication purposes was obtained from all participants and recorded while conducting the interviews.

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REFERENCES

Acuto, M. (2013). City leadership in global governance. *Global Governance: A Review of Multilateralism and International Organizations*, *19*(3), 481–498. https://doi.org/10.1163/19426720-01903008

African Union Commission. (2015). *Agenda 2063: The Africa we want*. African Union.

African Union Commission. (2020). *The digital transformation strategy for Africa (2020–2030)*. African Union.

Agergaard, J., & Ortenbjerg, S. B. (2017). Urban transformations and rural–city connections in Africa. *Geografisk Tidsskrift – Danish Journal of Geography*, *117*(2), 63–67. https://doi.org/10.1080/00167223.2017.1367698

Ahmad, J., Devarajan, S., Khemani, S., & Shah, S. (2005). *Decentralization and service delivery* (Policy Research Working Paper No. 3603). World Bank. https://openknowledge.worldbank.org/handle/10986/8933

Ameyaw, P. D., & De Vries, W. T. (2021). Toward smart land management: Land acquisition and the associated challenges in Ghana. A look into a blockchain digital land registry for prospects. *Land*, *10*(3), 239. https://doi.org/10.3390/land10030239

Andrews, M. (2012). The logical limits of best practice administrative solutions in developing countries. *Public Administration and Development*, *32*(2), 137–153. https://doi.org/10.1002/pad.622

Arko-Adjei, A., & Akrof, E. O. (2019). *Customary land tenure security: Tools and approaches in Sub-Saharan Africa (a synthesis report)*. UN-HABITAT.

Arku, R. N., Buttazzoni, A., Agyapon-Ntra, K., & Bandauko, E. (2022). Highlighting smart city mirages in public perceptions: A twitter sentiment analysis of four African smart city projects. *Cities*, *130*, 103857. https://doi.org/10.1016/j.cities.2022.103857

Aurigi, A., & Odendaal, N. (2021). From 'smart in the box' to 'smart in the city': Rethinking the socially sustainable smart city in context. *Journal of Urban Technology*, *28*(1–2), 55–70. https://doi.org/10.1080/10630732.2019.1704203

Bandauko, E., & Nutifafa Arku, R. (2023). A critical analysis of 'smart cities' as an urban development strategy in Africa. *International Planning Studies*, *28*, 69–86. https://doi.org/10.1080/13563475.2022.2137112

Bannister, S., & Sutcliffe, M. (2019). *African metropolitan report*. Metropolis. https://www.metropolis.org/sites/default/files/resources/african-metropolitan-reoprt.pdf

Baptista, I. (2015). 'We live on estimates': Everyday practices of prepaid electricity and the urban condition in Maputo, Mozambique. *International Journal of Urban and Regional Research*, *39*(5), 1004–1019. https://doi.org/10.1111/1468-2427.12314

Bassett, E. (2016). Urban governance in a devolved Kenya. In C. N. Silva (Ed.), *Governing urban Africa* (pp. 73–98). Palgrave Macmillan. https://doi.org/10.1057/978-1-349-95109-3_3

Beall, J., Parnell, S., & Albertyn, C. (2015). Elite compacts in Africa: The role of area-based management in the new governmentality of the Durban city-region. *International Journal of Urban and Regional Research*, *39*(2), 390–406. https://doi.org/10.1111/1468-2427.12178

Beer, A., Ayres, S., Clower, T., Faller, F., Sancino, A., & Sotarauta, M. (2019). Place leadership and regional economic development: A framework for cross-regional analysis. *Regional Studies*, *53*(2), 171–182. https://doi.org/10.1080/00343404.2018.1447662

Boschma, R. (2005). Proximity and innovation: A critical assessment. *Regional Studies*, *39*(1), 61–74. https://doi.org/10.1080/0034340052000320887

Boyle, L., Harlow, J., & Keeler, L. W. (2023). (D)evolving smartness: Exploring the changing modalities of smart city making in Africa. *Urban Geography*, 1–25. https://doi.org/10.1080/02723638.2023.2213035

Broadband Commission. (2019). *Connecting Africa through broadband*. https://broadbandcommission.org/working-groups/digital-infrastructure-moonshot-for-africa/

Bulkeley, H., & Betsill, M. (2005). Rethinking sustainable cities: Multilevel governance and the 'urban' politics of climate change. *Environmental Politics*, *14*(1), 42–63. https://doi.org/10.1080/0964401042000310178

Burns, R., Fast, V., Levenda, A., & Miller, B. (2021). Smart cities: Between worlding and provincialising. *Urban Studies*, *58*(3), 461–470. https://doi.org/10.1177/0042098020975982

Cairns, R., Onyango, J., Stirling, A., & Johnstone, P. (2022). Imagining urban transformation in Kenya. *Environmental Science & Policy*, *135*, 86–95. https://doi.org/10.1016/j.envsci.2022.04.016

Caldeira, T. P. (2017). Peripheral urbanization: Autoconstruction, transversal logics, and politics in cities of the global south. *Environment and Planning D: Society and Space*, *35*(1), 3–20. https://doi.org/10.1177/0263775816658479

Camboim, G. F., Zawislak, P. A., & Pufal, N. A. (2019). Driving elements to make cities smarter: Evidences from European projects. *Technological Forecasting and Social Change*, *142*, 154–167. https://doi.org/10.1016/j.techfore.2018.09.014

Chonka, P., & Bakonyi, J. (2021). Precarious technoscapes: Forced mobility and mobile connections at the urban margins. *Journal of the British Academy*, *9*(s11), 67–91. https://doi.org/10.5871/jba/009s11.067

Ciasullo, M. V., Troisi, O., Grimaldi, M., & Leone, D. (2020). Multi-level governance for sustainable innovation in smart communities: An ecosystems approach. *International Entrepreneurship and Management Journal*, *16*(4), 1167–1195. https://doi.org/10.1007/s11365-020-00641-6

Cinnamon, J. (2023). On data cultures and the prehistories of smart urbanism in 'Africa's digital city'. *Urban Geography*, *44*(5), 850–870. https://doi.org/10.1080/02723638.2022.2049096

Cities Alliance & African Development Bank (AfDB). (2022). *Dynamics of systems of secondary cities in Africa*. AfDB. https://www.afdb.org/sites/default/files/2022/05/16/the_dynamics_of_systems_of_secondary_cities_in_africa_urbanisation_migration_and_development_-_2022.pdf

Clement, J., Manjon, M., & Crutzen, N. (2022). Factors for collaboration amongst smart city stakeholders: A local government perspective. *Government Information Quarterly*, *39*(4), 101746. https://doi.org/10.1016/j.giq.2022.101746

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society*, *28*(1), 63–80. https://doi.org/10.1016/j.techsoc.2005.10.005

Cortinovis, N., & van Oort, F. (2022). Economic networks, innovation and proximity. In A. Torre & D. Gallaud (Eds.), *Handbook of proximity relations* (pp. 292–306). Edward Elgar.

Cottyn, I., Schapendonk, J., & van Lindert, P. (2013). *Mobility in SubSaharan Africa: Patterns, processes and policies* (RurbanAfrica State of the Art Number 2). University of Copenhagen.

Croese, S., Oloko, M., Simon, D., & Valencia, S. C. (2021). Bringing the global to the local: The challenges of multi-level governance for global policy implementation in Africa. *International Journal of Urban Sustainable Development*, *13*(3), 435–447. https://doi.org/10.1080/19463138.2021.1958335

Cupers, K., & Meier, P. (2020). Infrastructure between statehood and selfhood: The trans-African highway. *Journal of the Society of Architectural Historians*, *79*(1), 61–81. https://doi.org/10.1525/jsah.2020.79.1.61

Dasandi, N., & Esteve, M. (2017). The politics–bureaucracy interface in developing countries. *Public Administration and Development*, *37*(4), 231–245. https://doi.org/10.1002/pad.1793

Datta, A. (2015). New urban utopias of postcolonial India: 'Entrepreneurial urbanization' in Dholera smart city. *Gujarat. Dialogues in Human Geography*, *5*(1), 3–22. https://doi.org/10.1177/2043820614565748

David-West, O., Iheanachor, N., & Umukoro, I. O. (2019). Mobile money as a frugal innovation for the bottom of the pyramid – Cases of selected African countries. *Africa Journal of Management*, *5*(3), 274–302. https://doi.org/10.1080/23322373.2019.1652023

Denis, B. (2021). *The rise of Africa's digital economy*. European Investment Bank.

Devas, N. (2001). Does city governance matter for the urban poor? *International Planning Studies*, *6*(4), 393–408. https://doi.org/10.1080/13563470120092395

Devas, N. (2003). Can city governments in the south deliver for the poor: A municipal finance perspective. *International Development Planning Review*, *25*(1), 1–29. https://doi.org/10.3828/idpr.25.1.1

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, *48*(2), 147–160. https://doi.org/10.2307/2095101

Drivdal, L. (2016). Community leadership in urban informal neighbourhoods: Micro-politics and micro-administration in informal settlements in Cape Town. *Urban Forum*, *27*(3), 275–295. https://doi.org/10.1007/s12132-016-9289-5

Ehnert, F., Kern, F., Borgström, S., Gorissen, L., Maschmeyer, S., & Egermann, M. (2018). Urban sustainability transitions in a context of multi-level governance: A comparison of four European states. *Environmental Innovation and Societal Transitions*, *26*, 101–116. https://doi.org/10.1016/j.eist.2017.05.002

Ernstson, H., Lawhon, M., & Duminy, J. (2014). Conceptual vectors of African urbanism: 'engaged theory-making' and 'platforms of engagement'. *Regional Studies*, *48*(9), 1563–1577. https://doi.org/10.1080/00343404.2014.892573

Fox, S. (2014). The political economy of slums: Theory and evidence from Sub-Saharan Africa. *World Development*, *54*, 191–203. https://doi.org/10.1016/j.worlddev.2013.08.005

Fuchs, C., & Horak, E. (2008). Africa and the digital divide. *Telematics and Informatics*, *25*(2), 99–116. https://doi.org/10.1016/j.tele.2006.06.004

Furuholt, B., & Kristiansen, S. (2007). A rural–urban digital divide? *The Electronic Journal of Information Systems in Developing Countries*, *31*(1), 1–15. https://doi.org/10.1002/j.1681-4835.2007.tb00215.x

Glass, M. R., Addie, J.-P. D., & Nelles, J. (2019). Regional infrastructures, infrastructural regionalism. *Regional Studies*, *53*(12), 1651–1656. https://doi.org/10.1080/00343404.2019.1667968

Graham, S., & Marvin, S. (2001). *Splintering urbanism*. Routledge. https://doi.org/10.4324/9780203452202

Grandin, J., & Haarstad, H. (2021). Transformation as relational mobilisation: The networked geography of Addis Ababa's sustainable transport interventions. *Environment and Planning D: Society and Space*, *39*(2), 289–308. https://doi.org/10.1177/0263775820963281

Greenfield, A. (2006). *Everyware: The dawning age of ubiquitous computing*. New Riders.

Grillitsch, M., & Sotarauta, M. (2020). Trinity of change agency, regional development paths and opportunity spaces. *Progress in Human Geography*, *44*(4), 704–723. https://doi.org/10.1177/0309132519853870

Guma, P. K. (2019). Smart urbanism? ICTs for water and electricity supply in Nairobi. *Urban Studies*, *56*(11), 2333–2352. https://doi.org/10.1177/0042098018813041

Guma, P. K., & Monstadt, J. (2021). Smart city making? The spread of ICT-driven plans and infrastructures in Nairobi. *Urban Geography*, *42*(3), 360–381. https://doi.org/10.1080/02723638.2020.1715050

Hambleton, R. (2015). Place-based collaboration: Leadership for a changing world. *Administration*, *63*(3), 5–25. https://doi.org/10.1515/admin-2015-0018

Herrschel, T. (2013). Competitiveness and sustainability: Can 'smart city regionalism' square the circle? *Urban Studies*, *50*(11), 2332–2348. https://doi.org/10.1177/0042098013478240

Hodson, M., & Marvin, S. (2010). Can cities shape socio-technical transitions and how would we know if they were? *Research Policy*, *39*(4), 477–485. https://doi.org/10.1016/j.respol.2010.01.020

Houngbonon, G. V., Mensah, J. T., & Traore, N. (2022). *The impact of internet access on innovation and entrepreneurship in Africa*. World Bank. http://hdl.handle.net/10986/37059

Hutchinson, D., & Eversole, R. (2022). Local agency and development trajectories in a rural region. *Regional Studies*, 1–12. https://doi.org/10.1080/00343404.2022.2108543

Hübler, M. (2016). Does migration support technology diffusion in developing countries? *World Development*, *83*, 148–162. https://doi.org/10.1016/j.worlddev.2016.01.024

Joss, S., Sengers, F., Schraven, D., Caprotti, F., & Dayot, Y. (2019). The smart city as global discourse: Storylines and critical junctures across 27 cities. *Journal of Urban Technology*, *26*(1), 3–34. https://doi.org/10.1080/10630732.2018.1558387

Kamalipour, H., & Dovey, K. (2019). Mapping the visibility of informal settlements. *Habitat International*, *85*, 63–75. https://doi.org/10.1016/j.habitatint.2019.01.002

Kar, A. K., Ilavarasan, V., Gupta, M. P., Janssen, M., & Kothari, R. (2019). Moving beyond smart cities: Digital nations for social innovation & sustainability. *Information Systems Frontiers*, *21*(3), 495–501. https://doi.org/10.1007/s10796-019-09930-0

Keating, M. (2017). Contesting European regions. *Regional Studies*, *51*(1), 9–18. https://doi.org/10.1080/00343404.2016.1227777

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal*, *79*(1), 1–14. https://doi.org/10.1007/s10708-013-9516-8

Kitchin, R., & Moore-Cherry, N. (2021). Fragmented governance, the urban data ecosystem and smart city-regions: The case of metropolitan Boston. *Regional Studies*, *55*(12), 1913–1923. https://doi.org/10.1080/00343404.2020.1735627

Knox, S., & Arshed, N. (2022). Network governance and coordination of a regional entrepreneurial ecosystem. *Regional Studies*, *56*(7), 1161–1175. https://doi.org/10.1080/00343404.2021.1988067

Kshetri, N. (2013). The diaspora as a change agent in entrepreneurship-related institutions in sub-Saharan Africa. *Journal of Developmental Entrepreneurship*, *18*(3), 1350021. https://doi.org/10.1142/S1084946713500210

Lawhon, M. (2012). Contesting power, trust and legitimacy in the South African e-waste transition. *Policy Sciences*, *45*(1), 69–86. https://doi.org/10.1007/s11077-012-9146-x

Lindell, I. (2008). The multiple sites of urban governance: Insights from an African city. *Urban Studies*, *45*(9), 1879–1901. https://doi.org/10.1177/0042098008093382

Mancebo, F. (2020). Smart city strategies: Time to involve people. Comparing Amsterdam, Barcelona and Paris. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, *13*(2), 133–152. https://doi.org/10.1080/17549175.2019.1649711

Manda, M. I., & Backhouse, J. (2019). Smart governance for inclusive socio-economic transformation in South Africa: Are we there yet? In M. P. Rodríguez Bolívar & L. Alcaide Muñoz (Eds.), *e-Participation in smart cities: Technologies and models of governance for citizen engagement* (pp. 179–201). Springer . https://doi.org/10.1007/978-3-319-89474-4_9

Marvin, S., Luque-Ayala, A., & McFarlane, C. (Eds.). (2016). *Smart urbanism – Utopian vision or false dawn?* Routledge.

McCann, E., Roy, A., & Ward, K. (2013). Assembling/worlding cities. *Urban Geography*, *34*(5), 581–589. https://doi.org/10.1080/02723638.2013.793905

McCann, E., & Ward, K. (2011). Urban assemblages: Territories, relations, practices, and power. In E. McCann, & K. Ward (Eds.), *Mobile urbanism – Cities and policymaking in the global Age* (pp. xiii–xxxiii). Minnesota University Press.

Meester, J., Uzelac, A., & Elder, C. (2019). *Transnational capital in Somalia*. Clingendael Institute. https://www.clingendael.org/publication/transnational-capital-somalia

Mello, L. d., & Ter-Minassian, T. (2020). *Digitalisation challenges and opportunities for subnational governments* (OECD Working Papers on Fiscal Federalism Number 31). Organisation for Economic Co-operation and Development (OECD).

Mello Rose, F. (2022). Activity types, thematic domains, and stakeholder constellations: Explaining civil society involvement in Amsterdam's smart city. *European Planning Studies*, *30*(6), 975–993. https://doi.org/10.1080/09654313.2021.1914556

Meth, P., Goodfellow, T., Todes, A., & Charlton, S. (2021). Conceptualizing African urban peripheries. *International Journal of Urban and Regional Research*, *45*(6), 985–1007. https://doi.org/10.1111/1468-2427.13044

Miller, B., Ward, K., Burns, R., Fast, V., & Levenda, A. (2021). Worlding and provincialising smart cities: From individual case studies to a global comparative research agenda. *Urban Studies*, *58*(3), 655–673. https://doi.org/10.1177/0042098020976086

Mora, L., & Deakin, M. (2019). *Untangling smart cities*. Elsevier. https://doi.org/10.1016/C2017-0-02666-6

Mora, L., Deakin, M., Zhang, X., Batty, M., De Jong, M., Santi, P., & Appio, F. P. (2021). Assembling sustainable smart city transitions: An interdisciplinary theoretical perspective. *Journal of Urban Technology*, *28*(1–2), 1–27. https://doi.org/10.1080/10630732.2020.1834831

Mora, L., Gerli, P., Ardito, L., & Messeni Petruzzelli, A. (2023). Smart city governance from an innovation management perspective: Theoretical framing, review of current practices, and future research agenda. *Technovation*, *123*, 102717. https://doi.org/10.1016/j.technovation.2023.102717

Mouton, M., & Burns, R. (2021). (Digital) neo-colonialism in the smart city. *Regional Studies*, *55*(12), 1890–1901. https://doi.org/10.1080/00343404.2021.1915974

Muto, M. (2012). The impacts of mobile phones and personal networks on rural-to-urban migration: Evidence from Uganda. *Journal of African Economies*, *21*(5), 787–807. https://doi.org/10.1093/jae/ejs009

Myers, G. (2011). *African cities: Alternative visions of urban theory and practice* (1 ed.). Bloomsbury Academic. https://doi.org/10.5040/9781350218123

Navío-Marco, J., Rodrigo-Moya, B., & Gerli, P. (2020). The rising importance of the 'smart territory' concept: Definition and implications. *Land Use Policy*, *99*, 105003. https://doi.org/10.1016/j.landusepol.2020.105003

Nicholds, A., Gibney, J., Mabey, C., & Hart, D. (2017). Making sense of variety in place leadership: The case of England's smart cities. *Regional Studies*, *51*(2), 249–259. https://doi.org/10.1080/00343404.2016.1232482

Odendaal, N. (2011). Splintering urbanism or split agendas? Examining the spatial distribution of technology access in relation to ICT policy in Durban, South Africa. *Urban Studies*, *48*(11), 2375–2397. https://doi.org/10.1177/0042098010388951

Odendaal, N. (2014). Space matters: The relational power of mobile technologies. *URBE – Revista Brasileira de Gestão Urbana*, *6*(1), 31–45. https://doi.org/10.7213/urbe.06.001.SE02

Odendaal, N. (2021). Everyday urbanisms and the importance of place: Exploring the elements of the emancipatory smart city. *Urban Studies*, *58*(3), 639–654. https://doi.org/10.1177/0042098020970970

Odendaal, N. (2022). Splintering by proxy: A reflection on the spatial impacts and distributed agency of platform urbanism. *Journal of Urban Technology*, *29*(1), 21–27. https://doi.org/10.1080/10630732.2021.2007204

Odendaal, N. (2023). *Disrupted urbanism: Situated smart initiatives in African cities*. Bristol University Press. https://doi.org/10.51952/9781529218596

OECD, UNECA & AfDB. (2022). *Africa's urbanisation dynamics 2022: The economic power of Africa's cities*. Organisation for Economic Co-operation and Development (OECD). https://doi.org/10.1787/3834ed5b-en

Oiarzabal, P. J., & Reips, U.-D. (2012). Migration and diaspora in the age of information and communication technologies. *Journal of Ethnic and Migration Studies*, *38*(9), 1333–1338. https://doi.org/10.1080/1369183X.2012.698202

Ojo, S., Nwankwo, S., & Gbadamosi, A. (2013). African diaspora entrepreneurs: Navigating entrepreneurial spaces in 'home' and 'host' countries. *The International Journal of Entrepreneurship and Innovation*, *14*(4), 289–299. https://doi.org/10.5367/ijei.2013.0126

Parnell, S., & Pieterse, E. (2014). *Africa's urban revolution*. Bloomsbury Academic. https://doi.org/10.5040/9781350218246

Parnell, S., & Walawege, R. (2011). Sub-Saharan African urbanisation and global environmental change. *Global Environmental Change*, *21*, S12–S20. https://doi.org/10.1016/j.gloenvcha.2011.09.014

Peck, J. (2015). Cities beyond compare? *Regional Studies*, *49*(1), 160–182. https://doi.org/10.1080/00343404.2014.980801

Peck, J., & Theodore, N. (2015). *Fast policy: Experimental statecraft at the thresholds of neoliberalism*. University of Minnesota Press.

Pick, J. B., & Sarkar, A. (2015). Digital divide in Africa. In *Progress in IS* (pp. 275–310). Springer. https://doi.org/10.1007/978-3-662-46602-5_9

Pieterse, E. (2018). The politics of governing African urban spaces. *International Development Policy – Revue Internationale de Politique de Développement*, *10*, 26–52. https://doi.org/10.4000/poldev.2626

Ranchod, R. (2020). The data-technology nexus in South African secondary cities: The challenges to smart governance. *Urban Studies*, *57*(16), 3281–3298. https://doi.org/10.1177/0042098019896974

Rao, V. (2014). Infra-city: Speculations on flux and history in infrastructure-making. In S. Graham, & C. McFarlane (Eds.), *Infrastructural lives* (pp. 39–58). Routledge.

Resnick, D. (2021). The politics of urban governance in sub-Saharan Africa. *Regional & Federal Studies*, *31*(1), 139–161. https://doi.org/10.1080/13597566.2020.1774371

Robinson, J. (2002). Global and world cities: A view from off the map. *International Journal of Urban and Regional Research*, *26*(3), 531–554. https://doi.org/10.1111/1468-2427.00397

Rochell, K., Delbridge, V., Harman, O., Zhang, X.-Q., & Fleck, L. (2022). *Financing sustainable urban development*. UN-HABITAT.

Roy, A. (2009). The 21st-century metropolis: New geographies of theory. *Regional Studies*, *43*(6), 819–830. https://doi.org/10.1080/00343400701809665

Schlimmer, S. (2022). Governing cities in Africa: Panorama of challenges and perspectives. *Études de l'Ifri*.

Schmid, C., Karaman, O., Hanakata, N. C., Kallenberger, P., Kockelkorn, A., Sawyer, L., Streule, M., & Wong, K. P. (2018). Towards a new vocabulary of urbanisation processes: A comparative approach. *Urban Studies*, *55*(1), 19–52. https://doi.org/10.1177/0042098017739750

Shelton, T., Zook, M., & Wiig, A. (2015). The 'actually existing smart city'. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 13–25. https://doi.org/10.1093/cjres/rsu026

Simone, A. (2004). People as infrastructure: Intersecting fragments in Johannesburg. *Public Culture*, *16*(3), 407–429. https://doi.org/10.1215/08992363-16-3-407

Slavova, M. & Okwechime, E. (2016). African smart cities strategies for agenda 2063. *Africa Journal of Management*, *2*(2), 210–229. https://doi.org/10.1080/23322373.2016.1175266

Smit, W. (2018). Urban governance in Africa: An overview. *International Development Policy | Revue Internationale de Politique de Développement*, *10*, 55–77. https://doi.org/10.4000/poldev.2637

Sotarauta, M. (2017). An actor-centric bottom-up view of institutions: Combinatorial knowledge dynamics through the eyes of institutional entrepreneurs and institutional navigators. *Environment and Planning C: Politics and Space*, *35*(4), 584–599. https://doi.org/10.1177/0263774X16664906

Sotarauta, M., Beer, A., & Gibney, J. (2017). Making sense of leadership in urban and regional development. *Regional Studies*, *51*(2), 187–193. https://doi.org/10.1080/00343404.2016.1267340

Stren, R. (2012). Cities and politics in the developing world: Why decentralization matters. In P. John, K. Mossberger, & S. E. Clarke (Eds.), *Oxford handbook of urban politics* (pp. 567–589). Oxford University Press.

Su, Y., & Fan, D. (2023). Smart cities and sustainable development. *Regional Studies*, 57(4), 722–738. https://doi.org/10.1080/00343404.2022.2106360

Tao, W. (2013). Interdisciplinary urban GIS for smart cities: Advancements and opportunities. *Geo-spatial Information Science*, *16*(1), 25–34. https://doi.org/10.1080/10095020.2013.774108

Tiwari, R. & Kalogerakis, K. (2016). *A bibliometric analysis of academic papers on frugal innovation* (Working Paper). https://doi.org/10.15480/882.1311

Torre, A., & Rallet, A. (2005). Proximity and localization. *Regional Studies*, *39*(1), 47–59. https://doi.org/10.1080/0034340052000320842

UCLG & Cities Alliance. (2018). *Assessing the institutional environment of local governments in Africa*.

UN-HABITAT. (2018). *Lagos City context report* (Global Future Cities Programme CCR Number 7).

United Nations Conference on Trade and Development (UNCTAD). (2022). *Science, technology and innovation for sustainable urban development in a post-pandemic world*. https://unctad.org/publication/science-technology-and-innovation-sustainable-urban-development-post-pandemic-world

Vallance, P., Tewdwr-Jones, M., & Kempton, L. (2020). Building collaborative platforms for urban innovation: Newcastle city futures as a quadruple helix intermediary. *European Urban and Regional Studies*, *27*(4), 325–341. https://doi.org/10.1177/0969776420905630

van Welie, M. J., Cherunya, P. C., Truffer, B., & Murphy, J. T. (2018). Analysing transition pathways in developing cities:

The case of Nairobi's splintered sanitation regime. *Technological Forecasting and Social Change*, *137*, 259–271. https://doi.org/10.1016/j.techfore.2018.07.059

Watson, V. (2014). African urban fantasies: Dreams or nightmares? *Environment and Urbanization*, *26*(1), 215–231. https://doi.org/10.1177/0956247813513705

Watson, V. (2015). The allure of 'smart city' rhetoric: India and Africa. *Dialogues in Human Geography*, *5*(1), 36–39. https://doi.org/10.1177/2043820614565868

Watson, V. (2021). The return of the city-region in the new urban agenda: Is this relevant in the global south? *Regional Studies*, *55*(1), 19–28. https://doi.org/10.1080/00343404.2019.1664734

Wiig, A., & Silver, J. (2019). Turbulent presents, precarious futures: Urbanization and the deployment of global infrastructure. *Regional Studies*, *53*(6), 912–923. https://doi.org/10.1080/00343404.2019.1566703

Zapata-Barrero, R., & Rezaei, S. (2020). Diaspora governance and transnational entrepreneurship: The rise of an emerging social global pattern in migration studies. *Journal of Ethnic and Migration Studies*, *46*(10), 1959–1973. https://doi.org/10.1080/1369183X.2018.1559990

Appendix 2

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Good Enough Evidence-based Urban Planning: Data and Knowledge in Southern Smart Urbanism

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Abstract

This study explores evidence-based urban planning (EBUP) within three secondary cities in the Global South—eThekwini, Khorog, and Bosaso—emphasizing public sector capacity to utilize data in urban management. Amidst the proliferation of data and advanced analytical tools, many local administrations struggle with effective data use due to limited resources, technology, and governance frameworks. This paper examines how urban planners mobilize, integrate, and apply data to create actionable evidence for city planning, considering the socio-political and technological landscapes that influence these processes. By analyzing qualitative data from interviews and case studies, this research highlights the challenges and potential of EBUP to address urban issues in data-scarce environments. The concept of *good enough* evidence is explored, advocating for practical, adaptable, and locally tailored planning efforts that prioritize immediate urban needs over exhaustive data collection. This approach seeks to balance ambition with practicality, offering a pragmatic pathway for cities facing constraints in resources and capabilities.

Keywords

evidence-based urban planning, data governance, global south, secondary cities, sustainable development

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Key Points for Practitioners

- Considering how different cities mobilize and use data provides planners and policymakers with insights into how data can be better managed and utilized as knowledge to meet urban planning objectives effectively
- Evidence can be assessed not just on accuracy or comprehensiveness but on its fitness for specific intended uses, users, and contexts.
- Recognizing the acceptable boundaries of *good enough* planning practices is crucial for implementing realistic and effective planning strategies that are sensitive to the resource constraints and socio-economic conditions prevalent in developing contexts.

1 Introduction

In many descriptions of the emerging smart, evidence-based approaches to urban management and planning (Engin et al., 2020; Jiang et al., 2019), a key promise is the capacity to provide maximally comprehensive data to base decision making, underpinning a rational approach to spatial transformation, service delivery and policy development (OECD, 2020). This data “deluge” (Kourtit et al., 2020) claims several benefits over traditional planning methods, such as greater geographic

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coverage, reduced data bias, enhanced accuracy and time efficiency (Marasinghe et al., 2024; Pereira et al., 2018). Consequently, many scholars and practitioners have highlighted the potential of new technologies to help developing countries overcome historical challenges (O'Clery et al., 2023), particularly regarding perceived data scarcity (Chirisa et al., 2024; Milan & Treré, 2020) while improving transparency and civic trust (Head, 2010).

However, this technological optimism brings the risk of overemphasizing the importance of data, leading to a race in increasing the levels and granularity to provide indisputable evidence to planning decisions (O'Clery et al., 2023). This push often occurs before understanding of the implications, limitations, and boundaries of the data collected, particularly in relation with capacity and resources of governance structures and the needs of society at large (Herrera & Kapur, 2007). Many of these local administrations continue to struggle with weak capacities to collect, manage, and effectively utilize data for evidence-based urban planning (EBUP) (Agyemang et al., 2024). In the absence of clear guidelines to distinguish between essential and non-essential datasets (Bali Swain & Yang-Wallentin, 2020; Son et al., 2023), prioritize key tasks, and deploy appropriate technologies (Pereira & Prokopiuk, 2024) these cities are often stuck in a cycle of inefficiency (Tan & Taeihagh, 2020). Further, without a clear understanding of short-term achievements versus long-term goals, and being realistic about the limited resources available, local governments in the Global South are placed in a precarious position, unable to effectively manage climate risks and respond to the challenges of rapid urbanization (Echendu & Okafor, 2021; Wiig & Silver, 2019). This situation prompts critical questions about what constitutes *good enough* evidence-based planning systems, that can meet urgent societal needs but are designed and implemented with local circumstances and tenures in mind, in contexts where funding, resources, equipment, and capacity are constrained.

Our study presents a comparative analysis of public sector capacity in three cities in the Global South - eThekwini (South Africa), Khorog (Tajikistan), and Bosaso (Somalia). It examines the obstacles and enablers of EBUP, by studying how data is mobilized to derive evidence and fed into urban planning exercises. Through this approach, our study seeks to explore what constitutes *evidence* in data poor environments, and how it is used throughout the planning process.

Our contribution is threefold. First, we chart how evidence is used as knowledge, identifying the *generative* mode of utilization alongside traditional instrumental, strategic and conceptual modes (McKenzie et al., 2014). This highlights how data resources are often gathered to create value beyond immediate purposes, creating spillover effects when governance structures allow for it. Second, we demonstrate the significance of mapping data flows within urban planning ecosystems to visualize bottlenecks and opportunities in diverse data environments (Bates et al., 2016; Kitchin et al., 2025). In doing this, we highlight how EBUP rarely follows the *good* data value cycle (Van Ooijen et al., 2019) but rather is subject to contextual adjustments that contribute to some level of good outcomes, although far from ideal. Third, we explore and refine the notion of *good enough* applied to evidence based planning (Gabrys et al., 2016; Kayanan et al., 2025), arguing that planning systems cannot aspire to perfection but must be assessed on their fitness for specific intended uses, users, and contexts. This approach advocates for practical, adaptable, and locally tailored planning efforts that prioritize immediate urban needs over exhaustive data collection.

2 Literature Review

2.1 Mobilizing Data as Evidence and Knowledge

Politicians, practitioners, and researchers alike have championed the efficacy of data-driven or evidence-based approaches (Head, 2008; OECD, 2019; Ubaldi, 2013). This trend has intensified with the pervasive digitalization and datafication of governance, particularly within planning practice (Kitchin et al., 2025).

According to the larger body of literature of evidence-based policy (Cairney, 2016; Parkhurst, 2017; Wastell, 2006), evidence should be derived from relevant scientific data and information to construct policy advice or evaluation, using various scientific tools and instruments (Ribeiro et al., 2019; Turnpenny et al., 2015). However, the mobilization of data into evidence doesn't happen in a linear value chain but though a process characterized by feedback loops and ongoing iteration (Van Ooijen et al., 2019). Data informs decision-making processes, which reciprocally influence subsequent data production and collection strategies. Consequently, examining how knowledge circulates—how it is developed, mutated, and consolidated among actors (Borén & Schmitt, 2022) —throughout the data value cycle (Zheng & Pee, 2022) - can help in understanding how knowledge is turned into practice.

Figure 1 provides an illustration of such a (ideal) data value cycle, where data gets aggregated, analyzed, and synthesized (Sterner et al., 2020; Van Ooijen et al., 2019). Each level (rectangles) symbolizes a wide category of products or outcomes shared among practitioners, researchers, policymakers, and community members. Arrows linking levels illustrate data processes important for creating value throughout the levels (Klievink et al., 2018; Thabit et al., 2024). Data collection functionalities used on the primary level can include small-scale ubiquitous technologies such as sensors and large-scale systems such as satellite and airborne remote sensing systems, land survey technologies, geophysical and

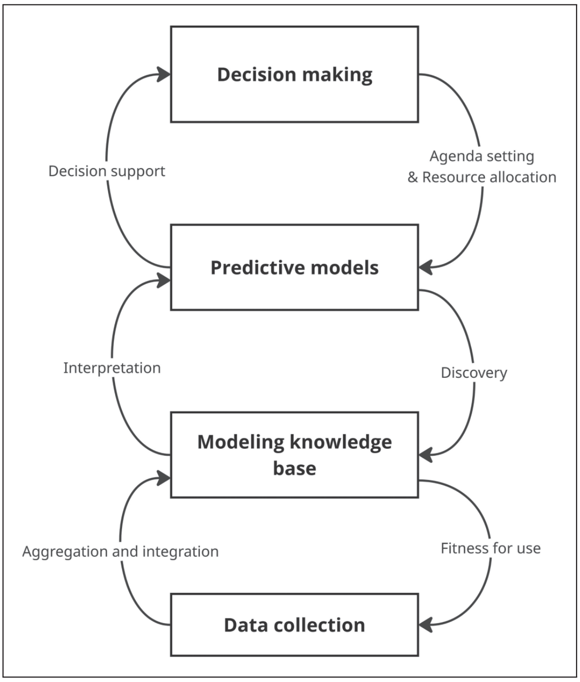

Figure 1. Ideal data value cycle - based on Sterner et al. (2020); Van Ooijen et al. (2019).

biophysical instruments, and technologies used in government surveys and business transactional systems (Bibri, 2018; Kitchin & Lauriault, 2015; Koeva et al., 2022). Intermediary levels technologies require the ability to integrate data from multiple and often disparate sources. A range of data access and processing technologies have emerged under the umbrella term of data platforms that can technically support in the integration of data collected from urban actors and communities into a knowledge base (Sinnott et al., 2015). From there, urban actors can conduct analyses and modeling, e.g., forecasts or scenarios; and further integrate these capabilities for integrated risk analysis (Mora et al., 2021) and finally use data as evidence in specific urban problems, policy decisions, or commercial applications (Nochta et al., 2021).

Each subsequent level enhances the data received from earlier levels by deepening analysis and synthesis, typically leading to a decrease in data volume as it moves from lower to higher levels within specific processing streams. – thus known methaphors of pyramids (Berkman, 2020) or funnels (Cambrosio et al., 2020).

However, literature, guidelines and tools also remark the importance of the reuse and repurpose of data and knowledge across various contexts, ranging from their initial applications to unforeseen uses in other contexts (Mora et al., 2025; Schaepman et al., 2022) and mergeable into cohesive information resource, generating greater value (Van Ooijen et al., 2019). This adaptability would allow for innovative applications within the same environment, such as predictive analytics, decision-support tools and decision making, and create spillover effects through new data resources (Zheng & Pee, 2022).

2.2 Knowledge and Knowing in Planning

The cycle just described tracks the journey from handling raw, unstructured data to identifying complex relationships, thereby generating usable information and knowledge. While this knowledge forms the fundamental basis for taking action, its application in planning is not uniform; rather, it can be categorized into three distinct modes based on the specific aims and how clearly defined the information is (McKenzie et al., 2014). These uses can be *instrumental*, where data is transferred as knowledge directly from scientists to decision-makers, who base their visible decisions on technical reasons (Acuto et al., 2021; Davoudi, 2006b). In *conceptual* uses, knowledge enriches and expands understanding of topics, influencing how individuals think about policy issues (van Kerkhoff & Lebel, 2006). Through this engagement, decision-makers and stakeholders become aware of new challenges and potential solutions, gradually shaping their beliefs and values. This iterative process can redefine the policy agenda over time and may even change behaviors among individuals and organizations, potentially leading to policy shifts if external circumstances provide opportune moments. Additionally, evidence can be *strategical* in advocating for specific interventions, advance new policy proposals, or reinforce existing beliefs and values (Boswell, 2008).

This perspective highlights the varied nature of how evidence is utilized in planning, emphasizing that it cannot be separated from its institutional setting, broader societal influences, or existing power dynamics and norms (Ansell & Geyer, 2017; Krizek et al., 2009). Urban actors have to combine their data in ways that not only get individual datasets to travel from their sources to decision makers (Cronemberger & Gil-Garcia, 2024) but also ensure that these datasets integrate to form a trustworthy body of information (Sterner & Elliott, 2023). Constructing evidence require in fact assurances about quality and accuracy, but also legitimacy, accountability, sovereignty, privacy, licensing, and many other non-technical issues are necessary prerequisites to data use and reuse (Sheehan & Leonelli, 2025). As such, data used as evidence is the result of processes of interaction, dialogue, negotiation and decision-making among urban actors involved in the development of social norms and institutions (Rekola & Paloniemi, 2022; Rossi et al., 2025). This suggests that the meaning of evidence is rarely definitive (Davoudi, 2006a; Faludi & Waterhout, 2006), and as much social and political as technical in character (Nochta et al., 2021).

2.3 Good Enough Evidence

The varied modes of evidence utilization underscore that knowledge alone constitutes a necessary but insufficient basis for decision-making. In practice, only a fraction of available evidence is actually used (Choo, 2005), and action is often required before an evidence base is fully complete (Moser, 2013).

This discrepancy implies that the uneven adoption of evidence-based planning is not solely attributable to lack of capacity or will among organizations, practitioners, and decision-makers. Rather, it is equally driven by gaps in access to resources and insufficient institutional capacities to execute data processes.

Furthermore, digital systems are often introduced progressively, with varying specifications and standards (Datta & Hoefsloot, 2024). These systems frequently support divergent data models and are managed across siloed units with alternative priorities. This fragmentation hinders the data value cycle. This is particularly acute in the Global South, a context that struggles with systemic resource constraints and infrastructural deficits (Datta, 2018; Tonnarelli & Mora, 2024). Here, the challenge is compounded by acute data scarcity, where the absence of reliable baseline information often renders standard analytical tools ineffective (Milan & Treré, 2020). In these contexts rapid transformation dynamics and urbanization processes often transcend the capacity of evidence-based approaches to cope (Parnell & Pieterse, 2014).

Consequently, recent studies highlight the importance of evaluating the feasibility of technology based on the human, financial, and technical resources required for its deployment in specific contexts (Tonnarelli & Mora, 2025b). The principle of 'fitness-for-use' is employed across diverse disciplines to denote the degree to which a product, service, or system can adequately fulfill its intended function within a reasonable resource expense (Rijke et al., 2012; Tonnarelli & Mora, 2025b). Specifically, it assesses whether an organization can quickly and effectively achieve its objectives with its available resources, while also considering requirements for ongoing maintenance and potential future improvements.

A parallel can be drawn with the concept of "good enough governance" in international development studies. This framework recognizes that resources and political will are often limited, especially in fragile states, making the pursuit of perfection unrealistic (Grindle, 2004). Instead, it prioritizes addressing key governance challenges such as rule of law, effective public administration, inclusivity, transparency, and accountability, even if these elements are not fully developed (Grindle, 2007).

Along these lines, a *good enough* evidence-based planning system might not be the most rigorous, efficient or accurate in its operation, but could still be performing reasonably and sufficiently (Kayanan et al., 2025), by utilizing "good enough" processes, technologies and data (Bialski, 2024; Collins et al., 1994; Gabrys et al., 2016).

Given bureaucratic complexities, resource constraints and financial limitations inherent in urban governance, simply sustaining a functioning workflow is a significant accomplishment. Rather than chasing a perfect and encompassing knowledge, the goal is to build evidence that is effective enough to foster development and serve the public, tailored to the specific needs and constraints of the society or context (Saidi et al., 2024).

Leveraging on these concepts, in the next sections we will examine how the principles evidence-based planning are applied in concrete urban planning scenarios. By exploring the defined purposes of EBUP and the boundaries of acceptable evidence, this exploration aims to clarify what *good enough* truly entails in the context of urban planning and whom it ultimately serves.

3 Methodology

3.1 Case Studies

We used a qualitative approach to analyze the different declinations of EBUP in three secondary cities in developing countries and how these systems are evidence-based: eThekwini (South Africa), Khorog (Tajikistan), and Bosaso (Somalia).

In targeting our comparative case studies (Yin, 2018), we sought representing different level of development (least developed, lower-middle and middle income countries) that nonetheless have invested in capacity and technology to improve their urban planning systems. In all the cases, this shift was supported at different capacities by projects of the United Nations Human Settlements Programme (UN-Habitat), an agency that explicitly champions evidence-based planning as a cornerstone of sustainable urban governance.

Beyond this institutional support, these contexts share a history of profound post-1990s transformation, which necessitated fundamental shifts in governance and planning paradigms. eThekwini is one of the metropolitan authorities established in the post-apartheid South Africa. Since its foundation, eThekwini has emphasized digital technology in its long-term development strategy (Odendaal, 2011), and has now developed a well-established policy that links digital innovation to a comprehensive political agenda for urban sustainability enhancement (Söderström et al., 2021; Tonnarelli & Mora, 2025b). Khorog, emerging as a strategic urban center in a newly independent Tajikistan (Dörre & Schütte, 2020), has adopted a proactive approach to urban planning by integrating data-driven technologies to enhance urban development and resource management (Hertlein, 2020; Middleton, 2016). Bosaso, in the autonomous region of Puntland, since the collapse of the Somali State in 1991 has been making efforts towards re-building an effective governance system, particularly in land management (Tonnarelli, 2024; Tonnarelli & Sophianos, 2025), and it is regarded as an example of functioning local administration within the region. Table 1 provides an overview of the case studies.

3.2 Data Collection

The data collection followed a phased approach. Semi-structured interviews were carried out with fourteen stakeholders focusing initially on eThekwini and Khorog. Interviewees included three distinct groups: (i) local representatives from the two cities, (ii) experts and practitioners from UN-Habitat, and (iii) external actors such as donors, financing institutions and private sector data providers. A snowball sampling method was used, with an entry point stakeholder from each group typically providing recommendations on other relevant interviewees.

The findings from this first round of interviews were presented and discussed in a focus group discussion involving interviewees from UN-Habitat, Khorog and eThekwini.

The feedback was used to develop an updated set of questions which was used in a new round of semi-structured interviews covering Bosaso. This covered thirteen stakeholders following the same group categories and sampling method applied in the first phase. See Annex A for a list of the interviews.

Data triangulation (Johansson, 2007) was carried on digital datasets and integrated analytical documents published by UN and government agencies and referenced in the interviews and documents.

As previous affiliates of UN-Habitat, the authors' insider positionality (Bandauko, 2024) provided access to stakeholders and documents (Chavez, 2008). However, this presented the risk of several biases, including social desirability bias through responses aligned with institutional priorities (Schulz, 2020) and selection bias through network-based recruitment (Collier et al., 2004; Geddes, 1990). To mitigate this, we triangulated interviews with document reviews (Bell-Martin & Marston Jr, 2021) and enforced a rigorous coding protocol. The analysis involved multiple iterative cycles to systematically refine categories, ensuring that emerging themes were consistent and strictly grounded in the data rather than institutional assumptions.

3.3 Data Analysis

Interview transcripts and focus group discussion were analyzed using a thematic-coding approach (Gioia et al., 2012). An abductive method of analysis allowed the identification of codes and concepts, linking empirical data and dimensions of instrumental, conceptual and strategic evidence use.

The coding process was conducted in three key stages. Initially, one author identified the primary concepts through direct engagement with the data, which were subsequently reviewed and discussed with a second author. Finally, both authors held periodic discussions to refine the overall coding results and data structure (Skjott Linneberg & Korsgaard, 2019).

The information generated from this review is synthesized in the overall coding structure in Table 2. Annex B presents some of the most representative quotes extracted during the coding process. Additionally, the information extracted from

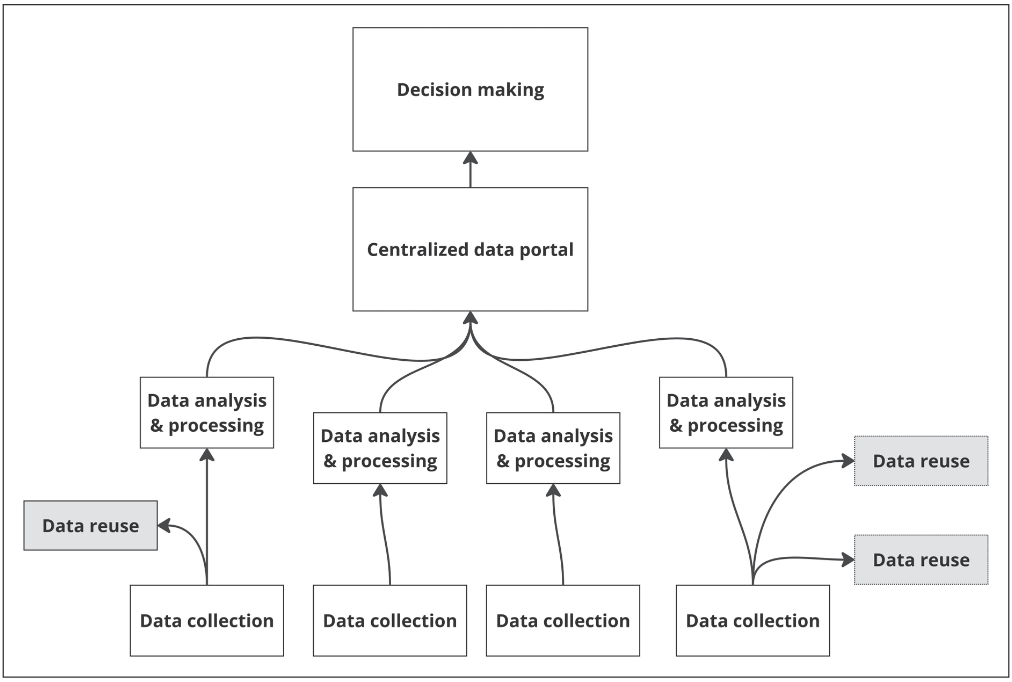

Figure 2. Data value cycle, eThewkini – grey rectangles denote external actors.

interviews and document review was used to map data flows within urban planning ecosystems in each of the cities, based on the ideal data value cycle (Sterner et al., 2020; Van Ooijen et al., 2019) The results are also depicted in Figures 2, 3 and 4.

4 Findings

4.1 How is Data Mobilized to Derive Evidence for Urban Planning Exercises?

4.1.1 eThekwini. In eThekwini, the approach to collecting and using data for urban planning has historically operated without a systematic framework, resulting in a fractured landscape where information flows are dictated by the isolated operational demands of specific municipal departments. The information gathered is primarily oriented towards the operational demands of municipal departments, covering diverse areas such as planning applications, traffic incidents, and flood occurrences. While these data points serve immediate administrative needs, they are not always integrated into a cohesive evidence base for strategic planning.

Consequently, for major planning initiatives like the Spatial Development Framework (SDF), the main planning document at urban level, the municipality has typically relied on external consultants rather than internal staff for data collection. The evidence gathered for these plans is determined on an ad hoc basis, although various departments, including those responsible for transport and land use, are solicited for input. This process of collecting data specifically for each project, without a standardized protocol, leads to inconsistencies and gaps in the information used to inform city planning.

To resolve these fragmentation issues, the city has developed Strat Hub, a centralized platform designed to serve as a unified access point for all spatial data owned by the municipality[1]. This system restructures the data flow: rather than remaining trapped in silos or extracted by consultants, spatial data is curated by each respective municipal department and channeled into this unified repository. This centralization mandates a harmonized system of metadata management, theoretically ensuring that all departments contribute to a shared, standardized resource. By aiming to eliminate redundant collection efforts, the architecture of Strat Hub is intended to transform the flow of information from a series of disconnected trickles into a cohesive stream accessible to decision-makers and the public alike.

When analyzing this system, distinct patterns emerge regarding how these bulk of data is utilized as knowledge and evidence. The platform has proven highly effective in fostering conceptual utilization. By providing a unified access point,

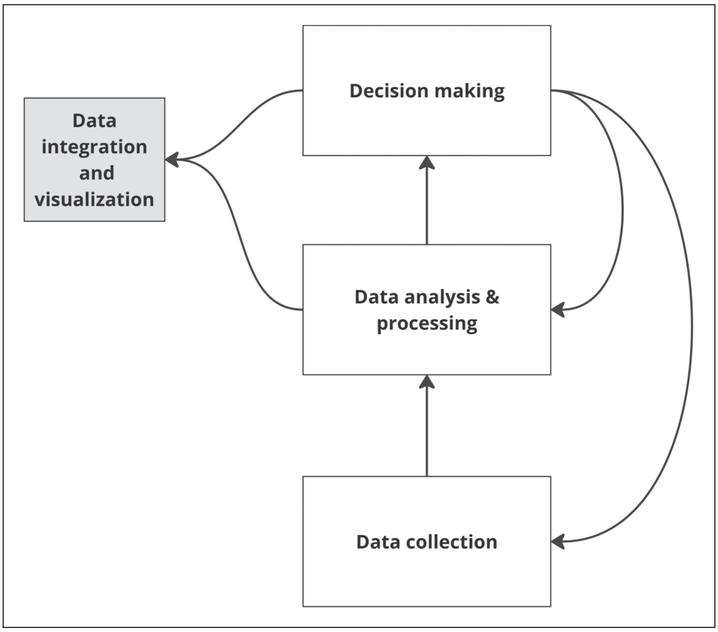

Figure 3. Data value cycle, Khorog - grey rectangles denote external actors.

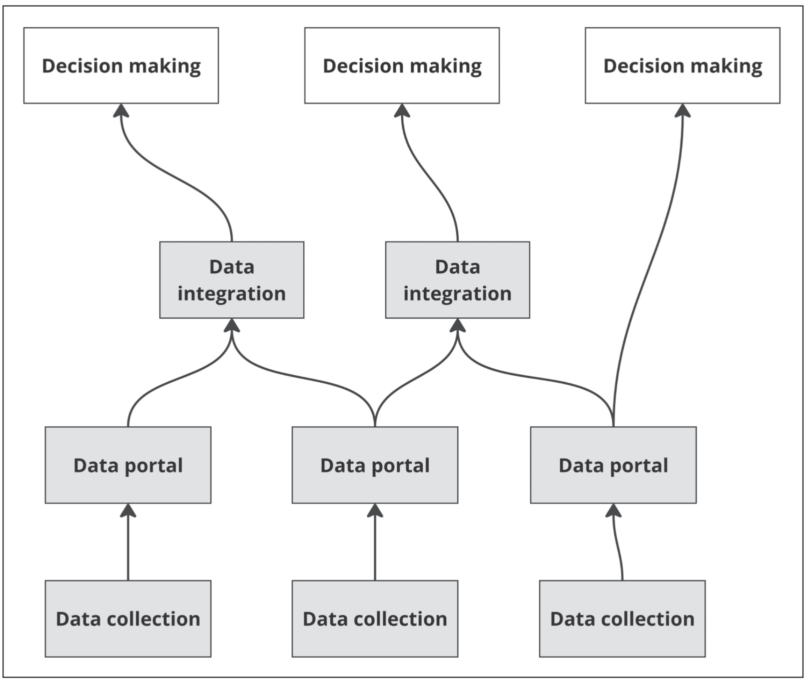

Figure 4. Data value cycle, Bosaso - grey rectangles denote external actors.

Table 1. Case Studies.

Country & Region	eThekwini South Africa	Khorog Tajikistan	Bosaso Somalia (Puntland)
Development Level	Middle Income	Lower-Middle Income	Least Developed
Historical Context (Post-1990s)	Post-Apartheid Transformation: Established as a metropolitan authority following the end of apartheid, requiring a fundamental shift in governance paradigms.	Post-Independence Emergence: Developed as a strategic urban center following Tajikistan's independence, necessitating new management structures.	Post-Conflict Reconstruction: Re-building effective governance since the collapse of the Somali State in 1991; located in an autonomous region.
Focus of EBUP & Governance	Comprehensive Political Agenda: Links digital innovation directly to urban sustainability. Features a well-established policy framework and long-term digital strategy.	Proactive & Data-Driven: Integrates data-driven technologies specifically to enhance urban development and resource management.	Foundational Governance: Focuses on re-building functioning administration, with specific efforts directed toward effective land management systems.
Commonalities	All have invested in capacity and technology to improve urban planning systems. All underwent profound post-1990s transformations requiring governance shifts. All received support from UN-Habitat to champion evidence-based planning		

Table 2. Coding Structure.

Concept	Theme	Aggregate Dimension
Addressing established knowledge	Framing	Conceptual
Designing rules		
Approaching stakeholders	Translating	
Mediating among stakeholders		
Raising public awareness		
Building credibility and legitimacy	Co-producing	
Tracing processes		
Identifying when to advance change	Timing	Strategic
Identifying when to decelerate transition		
Distracting attention of stakeholders	Tactical and deliberation	
Informing political debates		
Discerning complexity	Analysis and foresight	Instrumental
Identifying windows of opportunities		
Assessing risks		
Envisioning possible scenarios		
Monitoring and evaluation	Organizational reference	
Global outreach and reporting		
Asking for more than you expect	Value adding	Generative
Providing opportunities		
Attracting investment		
Developing new products	Influencing	
Developing new standards		
Citing or referencing	Transmission	
Providing reference knowledge		
Publicising research and presenting findings		

Table 3. Modes of Knowledge Use in the Cases.

Mode of Use	eThekwini (South Africa)	Khorog (Tajikistan)	Bosaso (Somalia)
Conceptual *(Enriching understanding & shaping values)*	The “Strat Hub” platform successfully broadens decision-maker perspectives by visualizing complex intersections (e.g., land use vs. flood risk), establishing a “single source of truth” that reframes policy issues.	Interventions by NGOs (AKAH/UN-Habitat) use visual boards to create a “common language” regarding natural hazards, shifting the collective mindset from viewing disasters as fate to manageable spatial realities.	Lacks a shared conceptual framework due to fragmented donor agendas. However, isolated thematic groups demonstrate how bottom-up collaboration can build localized conceptual consensus.
Strategic *(Advocacy, persuasion & consensus building)*	Policymakers leverage platform to demonstrate the benefits of sustainable compromises, successfully earning buy-in from grassroots and institutional stakeholders for specific mandates.	Public access to hazard maps empowers residents to question risky developments and demand accountability. Evidence is used to advocate for safer expansion patterns that might otherwise face resistance.	Resource competition and data hoarding prevent the formation of a unified strategic vision. The lack of sharing precludes the use of evidence for city-wide advocacy.
Instrumental *(Direct technical application for decision-making)*	While data exists, the platform functions as a static repository rather than a real-time tool. Data quickly becomes outdated, causing external actors to bypass the system, undermining its daily technical utility.	Official national plans fail instrumentally as they exclude hazard data. Conversely, the parallel NGO data ecosystem serves as an essential, functional tool for immediate safety zoning decisions.	Effective within the boundaries of specific projects or community of practice. The city lacks a comprehensive instrument for governance, as data does not flow horizontally or inform broader systemic operations.
Generative *(Spillover effects & innovation)*	The centralized governance model enforces standardization but restricts external contribution. The rigid framework prevents the data ecosystem from evolving or being reused for unforeseen applications.	Translation of technical data (English to Russian) and open dissemination lowers barriers to entry, allowing local stakeholders to repurpose the knowledge base for challenges beyond the original project scope.	Rigid silos act as a bottleneck. While some collaborative groups successfully repurpose data, widespread spillover effects are blocked by the competitive, non-reciprocal data culture.

Strat Hub allows decision-makers to visualize complex intersections—such as the relationship between land use changes and flood risks—thereby broadening their understanding of urban dynamics and reframing how they perceive policy issues. Parallel to this, the evidence is successfully leveraged for strategic utilization. Policymakers use the platform’s scenarios to demonstrate to government officials how compromises for sustainable development yield superior outcomes compared to alternatives. This strategic deployment of evidence has been helpful in earning necessary political buy-in from both grassroots and institutional stakeholders, validating specific planning mandates.

However, the system faces significant challenges in other modes of use. Despite its conceptual value, the platform struggles with instrumental utilization. Because Strat Hub functions as a static repository of data snapshots rather than a real-time resource, the information becomes outdated quickly. Consequently, external actors often bypass the platform to contact departments directly for the most current figures, undermining the platform’s role as a technical tool for daily decision-making.

Finally, while the centralized governance model ensures standardization, its rigid framework severely inhibits collaborative innovation. It restricts external experts from contributing to data curation or applying the data to novel, unforeseen applications. This lack of flexibility stifles the potential for positive spillover effects, preventing the data ecosystem from evolving to meet the needs of a broader range of users.

4.1.2 Khorog. In Tajikistan, the trajectory of urban planning is governed by a rigid, top-down data flow dictated by national legislation, which enforces a standardized inventory of required information for the drafting of any new general plan. This statutory framework aims to streamline procedures across the country, creating a uniform pipeline where data is collected by the national planning authority and fed into local master plans. However, this centralized mechanism acts as a filter that frequently excludes critical, localized realities. In the case of Khorog, where rockfalls and avalanches pose severe natural hazards, the standardized data collection protocols fail to capture these unique environmental constraints. Consequently, vital context-specific information is omitted from the official planning process, rendering the resulting plans structurally blind to the very risks they are meant to manage. This disconnect is exacerbated by an administrative opacity: while urban plans are technically public documents, the foundational data remains confidential, and the plans themselves lack spatialized analysis or evidence-based narratives to explain their rationale. As a result, these documents are largely perceived as legislative formalities rather than functional technical guides, leading to suboptimal implementation and a profound lack of public trust.

Against this backdrop of institutional rigidity, interventions by international actors such as UN-Habitat and the Aga Khan Agency for Habitat (AKAH) have introduced a parallel data ecosystem designed to bridge these information gaps. By analyzing these interventions, we can observe a distinct shift in how knowledge is utilized across the four modes.

The intervention has been most transformative in terms of conceptual utilization. By disseminating visual boards and maps that explicitly highlight hazard-prone areas, these organizations have provided a “common language” for risk. This enriches the stakeholders’ understanding of their environment, shifting the collective mindset from viewing disasters as unpredictable acts of fate to understanding them as spatial realities that can be mapped and managed.

This shift in understanding facilitates strategic utilization. The transparency provided by these public-facing maps empowers residents to question potentially risky developments in their localities. Furthermore, the use of management scenarios helps illustrate the benefits of compromise, allowing data to be used strategically to build consensus and advocate for safer urban expansion patterns that might otherwise face resistance.

In terms of instrumental utilization, the contrast is stark. While the official national plans fail to serve as effective technical instruments due to the exclusion of hazard data, the parallel data resources created by AKAH and UN-Habitat have become essential tools for immediate decision-making regarding safety zones and land suitability.

Finally, these efforts demonstrate how translating and locally adapting data can unlock its broader potential. By making English technical data widely accessible in Russian, the initiatives have created a foundational knowledge base for local stakeholders to repurpose. This reduces barriers to entry, allowing the data to generate positive spillover effects and be applied to unforeseen local challenges beyond the original projects’ scope.

4.1.3 Bosaso. In Bosaso, the landscape of data collection, analysis, and use is primarily dominated by external actors and international organizations. These entities typically concentrate their efforts on isolated projects with clearly defined spatial, temporal, and thematic boundaries.

Data movement within this framework is almost exclusively flowing from field activities up to the policy-making levels, with very little reverse flow where insights from policy could inform and enhance field operations. This one-way communication leads to a situation where top-down standards and policies are often misaligned with on-the-ground realities. These standards are frequently overlooked or adapted in an ad hoc manner to fit specific local circumstances, which undermines their effectiveness and the overall quality of data governance.

Moreover, there exists a competitive environment where different actors vie for limited resources, including financial and human capital. This competition makes these entities reluctant to share data, particularly within themes that are closely related, as each group seeks to maintain its advantage and autonomy. This reluctance to share further perpetuates the issues of data replication and inconsistency.

Despite this prevalence of fragmentation and competition, an analysis of the exceptions—specifically the collaborative efforts between certain communities of practice—reveals how different modes of knowledge utilization emerge.

Instrumental utilization remains highly localized. This allows individual projects to utilize data effectively for their specific goals. The collaborative practices highlight a shift where data quality and immediate applicability are enhanced when thematic groups align their methodologies. However, the lack of overall integration means the city lacks a functioning instrument for comprehensive governance.

In terms of strategic utilization, the landscape is currently defined by its absence. The reluctance to share data due to competitive pressures prevents the formation of a unified strategic vision. The identified need for a “central guidance system" represents a demand for a tool that could facilitate strategic alignment, bridging the divides between competing interests to allow for city-wide advocacy rather than project-specific survival.

Conceptual utilization is similarly fractured. Without a central mechanism to harmonize standards, there is no shared conceptual framework for the city's development. However, the grassroots collaboration between specialized thematic groups demonstrates how conceptual consensus can be built from the bottom up, creating robust methodologies that challenge the ad hoc nature of the dominant system.

Finally, the potential for data to generate extended value is evident but under-realized. While communities of practice have successfully repurposed data—proving that lowered competitive barriers allow information to serve broader contexts—rigid silos and a lack of central guidance remain bottlenecks. These structural issues stifle positive spillover effects and prevent the widespread reuse of evidence.

5 Emerging Themes and Common Lessons

5.1 EBUP Objectives and Evidence Definition

While interviewees acknowledged that a clear objective is critical for developing persuasive narratives and supporting coherent urban development arguments in EBUP, they frequently struggled to articulate specific, actionable goals for evidence formulation. This disconnect suggests that while the rhetorical value of *being evidence-based* is recognized, the alignment of data collection with precise analytical targets is often secondary. Our analysis emphasizes that this ambiguity is not merely a procedural oversight but reflects the complex ecosystem of multiple, interacting modes of use for evidence—see Table 3 (Jørgensen, 2024; McKenzie et al., 2014).

Within this ecosystem, a hierarchy of objectives appears. The principal objective utilized in these contexts is conceptual. Here, the primary function of evidence is to align planning initiatives with broader political agendas, thereby securing the necessary political support to ensure project implementation. In contested urban environments, data serves less as a mechanism for technical optimization and more as a tool for legitimacy. This political dimension underscores the necessity of prioritizing data governance strategies that are acutely sensitive to specific cultural and institutional contexts (Jørgensen, 2024). By aligning data governance with these realities, urban planners can navigate complex political landscapes, using evidence to bridge the gap between technical necessity and political feasibility. Consequently, while instrumental and strategic modes are present, they are often relegated to a supporting role, limited to the technical formulation of plans and the operational monitoring of urban services and resource allocation (Boswell, 2008; van Kerkhoff & Lebel, 2006).

However, beyond these established categories, an additional mode of utilization—that we termed *generative*—emerges. This mode aims to construct a knowledge base for potential, innovative, and unforeseen applications beyond current necessities. By generating agile and standardized data resources, this mode creates opportunities for positive spillover effects (Van Ooijen et al., 2019): information assets originally collected for a specific purpose—such as traffic monitoring—can catalyze value in adjacent domains, such as real-time flood risk analysis or economic forecasting.

Yet, the realization of this generative potential is severely hampered by a lack of conceptual clarity regarding what constitutes evidence. In all our cases, the data value cycle currently operates as an open loop, where primary data gathering is treated as a one-off expenditure rather than a capital investment. Because data is not standardized for broader analytical products, it effectively "dies" after its initial use. This reveals a prevalent tension between data's fitness for immediate, ad hoc use and its suitability for future repurposing, effectively blocking the accumulation of institutional knowledge (Tonnarelli & Mora, 2025a).

This misalignment precipitates a distinct tension in planning priorities. On one side, the intensifying focus on dynamic data for immediate action suggests a priority shift toward reactive measures—leveraging data to manage immediate crises rather than for sustained, long-term planning (Batty, 2013; Engin et al., 2020). On the other, the emphasis on generative data reuse (Sinnott et al., 2015) underscores the necessity for a more integrated, infrastructural approach to data management. Such an approach aims to bridge the gap between immediate operational needs and long-term strategic goals, transforming data from a consumable good into a renewable asset (Tseng & Nikiforova, 2025; Zuiderwijk et al., 2014).

Complicating this tension is the pervasive narrative of data scarcity (Milan & Treré, 2020), which this analysis suggests is frequently a misinterpretation of structural barriers rather than a physical lack of data. The primary issue is not the absence of data, but the politicized restriction of access to it. In contexts like Khorog and Bosaso, a lack of institutional transparency obscures the existence of data, fostering a false impression of scarcity. In eThekwini, the phenomenon is driven by internal power dynamics, where data is compartmentalized and hoarded by siloed departments to maintain autonomy. Consequently, stakeholders are left requesting new data collection not because the information does not exist, but because they cannot reach it. Thus, our cases point toward a need for systems that are not only dynamic enough to handle rapid urbanization and crises but also structurally open enough to support the political, technical, and generative dimensions of modern urban governance.

5.2 Factors Affecting Evidence use

Based on our comparative analysis, it is evident that the utilization of evidence is a composite outcome shaped by the convergence of planning processes, data product, and contextual conditions (Jiang et al., 2020).

First, the characteristics of the planning and policy process determine whether the evidence finds a functional entry point. Time pressure and the specific rhythm of planning phases are decisive factors. In eThekwini, a temporal misalignment exists where data updates lag behind the decision-making cycle, rendering the evidence technically valid but operationally irrelevant. Similarly, the structural design of the process in Bosaso creates a barrier; the workflow is characterized by a unidirectional, upward extraction of data. This design ignores the operational layer, preventing field staff from utilizing insights and effectively severing the link between evidence generation and ground-level implementation.

Second, the specific characteristics of the evidence significantly influence its uptake (Tonnarelli & Mora, 2025a; Tseng & Nikiforova, 2025). Adaptability to user needs is particularly critical here. In Khorog, the data products developed by AKAH demonstrated high adaptability to the local population's linguistic and technical requirements. This alignment transformed residents into active uptakers of the information. Conversely, in Bosaso, the utility of evidence is constrained by the specifications of the data products themselves, defined by spatial and thematic boundaries that individual projects rather than city level outcome. This siloed approach requires significant collaboration between specialized thematic groups to overcome ad hoc methodologies.

Finally, political context and stakeholder characteristics act as the ultimate determinants of how evidence is deployed (Head, 2010; Ribeiro et al., 2019). In Bosaso, the influence of international actors and the severe resource scarcity fosters a competitive environment that fundamentally alters user attitudes. Rather than viewing data for evidence as a shared public good, stakeholders adopt a protective stance, hoarding information to maintain institutional autonomy. Meanwhile, in eThekwini, political pressure to harmonize diverse stakeholder interests shifts the primary function of evidence from technical optimization to consensus building. Here, the political system incentivizes the use of data to construct unifying narratives rather than for pure instrumental calculation.

5.3 Good Enough Evidence for Good Enough Planning

The comparative assessment of Bosaso, Khorog, and eThekwini reveals that while none of these cities fully comply with the ideal data value cycle or the optimal steps of EBUP (Van Ooijen et al., 2019), functional outcomes are nonetheless generated. This suggests that the question is not whether evidence is objectively *perfect*, but whether it is functionally sufficient for the constraints at hand. Data and the evidence that is derived from it may be *good enough* to fulfill specific, localized planning intents and fit within current institutional constraints, yet the ecosystem as a whole remains insufficient for performing the new, complex tasks demanded by *good* data governance frameworks (Kayanan et al., 2025).

Because formal systems often fall short of the ideal, the functionality of evidence frequently relies on workarounds to bridge the gap between systemic deficits and operational needs. In Khorog, the official system's inability to capture hazard data necessitated a parallel intervention by international NGOs to ensure safety; in eThekwini, the rigidity of the central platform forces users to bypass formal channels to find timely data. In Bosaso, collaboration among communities of practice and other networks creates a more horizontal, reciprocal exchange bypassing silos. These workarounds – and the fact that the system allows them - demonstrate that while the data ecosystem may be structurally flawed, the outcomes can still be *good enough* to support critical decisions if the interventions are adapted to the reality of the environment.

Therefore, the efficacy of particular evidence cannot be evaluated against a universal standard but must be assessed by analyzing the specific context for change and the implications of the intervention. While the concept of *good enough* may lack the precision to prescribe specific technical actions in every real-world context (Grindle, 2007), it offers a strategic lens. Adopting good enough evidence implies that interventions intended to bolster evidence-based planning must be rigorously questioned, prioritized, and made relevant to the unique conditions of individual cities and their data environment—including what data exists, how it is accessed, and its quality (Gabrys et al., 2016). Rather than striving for a blind adoption of global best practices, data strategies need to be assessed in the light of historical evidence, sequence, and timing (Grindle, 2007; Saidi et al., 2024). They should be selected carefully, not for their technical sophistication, but for their contributions to particular ends—such as enhancing spatial equity, mitigating climate risks, or optimizing infrastructure investment—ensuring that the evidence acts as a relevant tool for development rather than an abstract administrative burden.

6 Conclusion and Limitations

This study highlights the complex dynamics of implementing evidence-based urban planning in secondary cities of the Global South, providing insights into the political, institutional, and data-driven challenges that shape these processes. The principal contributions of our analysis are three-fold.

First, we chart the transformation of data into usable knowledge and actionable evidence, highlighting the specific attributes of EBUP and the processual aims that dictate utilization. We identify the *generative* mode of knowledge use, expanding existing frameworks (McKenzie et al., 2014) by recognizing that data resources can create value beyond their initial intended purpose, fostering innovation and spillover effects when governance structures allow for it.

Second, we demonstrate the significance of mapping data flows within urban planning ecosystems (Bates et al., 2016; Kitchin et al., 2025). By tracing the trajectory of data from collection to application, we can identify bottlenecks, inefficiencies, and potential areas for technological and methodological enhancements (Bates, 2018). In doing this, we highlight how EBUP rarely follows the *good* data value cycle (Van Ooijen et al., 2019) but rather is subject to contextual adjustments that contribute to some level of good outcomes, although far from ideal. This mapping therefore serves as a diagnostic tool, providing planners and policymakers with clear insights into how data can be better managed and utilized to meet urban planning objectives effectively.

Third, we explore and refine the notion of *good enough* applied to evidence based planning (Gabrys et al., 2016; Kayanan et al., 2025). We argue that the significance of evidence should be assessed not merely by metrics of accuracy or comprehensiveness, but by its fitness relative to specific purposes, users, and environmental contexts (Kayanan et al., 2025). This paradigm shifts the evaluation focus from abstract rigor to contextual relevance, ensuring that the evidence deployed is aligned with the strategic capabilities and constraints of the urban development goals it serves.

As a practical contribution, our analysis explores the applications of evidence-based urban planning in real scenarios. There remains scattered and scant academic work relating to secondary cities in developing countries, and this paper provides an update in that regard. This exploration reveals the acceptable boundaries of *good enough* planning practices and how they vary among different groups and stakeholders. Recognizing these boundaries is crucial for implementing realistic and effective planning strategies that are sensitive to the resource constraints and socio-economic conditions prevalent in developing contexts.

While this study provides valuable insights, it is not without limitations. The focus on secondary cities, though significant, limits the generalizability of our findings to larger metropolitan areas or different geographical contexts. Additionally, the qualitative nature of our research may not capture all quantitative aspects of data flows and evidence uses in urban planning. Future research could benefit from incorporating quantitative methods to provide a broader statistical context to our qualitative findings. Moreover, as our study primarily involves a small number of case studies, expanding the research to include more cities could offer a more comprehensive view of the challenges and strategies in evidence-based urban planning globally.

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Note

1. Strategic Hub home page: https://strathub.durban.gov.za/

References

Acuto, M., Dickey, A., Butcher, S., & Washbourne, C.-L. (2021). Mobilising urban knowledge in an infodemic: Urban observatories, sustainable development and the COVID-19 crisis. *World Development*, *140*, 105295. https://doi.org/10.1016/j.worlddev.2020.105295

Agyemang, E., Anderson, B., Patiño, J., & Tremolieres, M. (2024). Toward achieving smart cities in Africa: Challenges to data use and the way forward. *Data & Policy*, *6*, e13. https://doi.org/10.1017/dap.2024.11

Ansell, C., & Geyer, R. (2017). 'Pragmatic complexity' a new foundation for moving beyond 'evidence-based policy making'? *Policy Studies*, *38*(2), 149–167. https://doi.org/10.1080/01442872.2016.1219033

Bali Swain, R., & Yang-Wallentin, F. (2020). Achieving sustainable development goals: Predicaments and strategies. *International Journal of Sustainable Development & World Ecology*, *27*(2), 96–106. https://doi.org/10.1080/13504509.2019.1692316

Bandauko, E. (2024). Negotiating the insider–outsider dilemma in urban research: Experiences of a graduate student returning home for fieldwork. *Area*, *56*(2), e12931. https://doi.org/10.1111/area.12931

Bates, J. (2018). The politics of data friction. *Journal of Documentation*, *74*(2), 412–429. https://doi.org/10.1108/JD-05-2017-0080

Bates, J., Lin, Y.-W., & Goodale, P. (2016). Data journeys: Capturing the socio-material constitution of data objects and flows. *Big Data & Society*, *3*(2), 2053951716654502. https://doi.org/10.1177/2053951716654502

Batty, M. (2013). Big data, smart cities and city planning. *Dialogues in Human Geography*, *3*(3), 274–279. https://doi.org/10.1177/2043820613513390

Bell-Martin, R. V., & Marston Jr, J. F. (2021). Confronting selection bias: The normative and empirical risks of data collection in violent contexts. *Geopolitics*, *26*(1), 159–192. https://doi.org/10.1080/14650045.2019.1659780

Berkman, P. A. (2020). Science diplomacy and its engine of informed decisionmaking: Operating through our global pandemic with humanity. *The Hague Journal of Diplomacy*, *15*(3), 435–450. https://doi.org/10.1163/1871191X-BJA10034

Bialski, P. (2024). *Middle tech: Software work and the culture of good enough* (Vol. 36). Princeton University Press.

Bibri, S. E. (2018). The IoT for smart sustainable cities of the future: An analytical framework for sensor-based big data applications for environmental sustainability. *Sustainable Cities and Society*, *38*, 230–253. https://doi.org/10.1016/j.scs.2017.12.034

Borén, T., & Schmitt, P. (2022). Knowledge and place-based development – towards networks of deep learning. *European Planning Studies*, *30*(5), 825–842. https://doi.org/10.1080/09654313.2021.1928042

Boswell, C. (2008). The political functions of expert knowledge: Knowledge and legitimation in European union immigration policy. *Journal of European Public Policy*, *15*(4), 471–488. https://doi.org/10.1080/13501760801996634

Cairney, P. (2016). *The politics of evidence-based policy making*. Springer.

Cambrosio, A., Campbell, J., Vignola-Gagné, E., Keating, P., Jordan, B. R., & Bourret, P. (2020). 'Overcoming the bottleneck': Knowledge architectures for genomic data interpretation in oncology. In S. Leonelli & N. Tempini (Eds.), *Data journeys in the sciences* (pp. 305–327). Springer International Publishing. https://doi.org/10.1007/978-3-030-37177-7_16

Chavez, C. (2008). Conceptualizing from the inside: Advantages, complications, and demands on insider positionality. *The Qualitative Report*, *13*(3), 474–494. https://doi.org/10.46743/2160-3715/2008.1589

Chirisa, I., Odero, K., & Gambe, T. R. (2024). Regional planning: A failed or flawed project for Africa? Taking advantage of big data science on the horizon. *Regional Science Policy & Practice*, *16*(12), 100151. https://doi.org/10.1016/j.rspp.2024.100151

Choo, C. W. (2005). *The knowing organization: How organizations use information to construct meaning, create knowledge, and make decisions*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195176780.001.0001

Collier, D., Mahoney, J., & Seawright, J. (2004). Claiming too much: Warnings about selection bias. In *Rethinking social inquiry: Diverse tools, shared standards* (pp. 85–102). Rowman and Littlefield.

Collins, W. R., Miller, K. W., Spielman, B. J., & Wherry, P. (1994). How good is good enough? An ethical analysis of software construction and use. *Communications of the ACM*, *37*(1), 81–91. https://doi.org/10.1145/175222.175229

Cronemberger, F., & Gil-Garcia, J. R. (2024). Understanding the importance of collaborative problem formulation for data analytics: Key lessons about leadership, governance, and technology. *Information Polity*, *29*(4), 396–414. https://doi.org/10.1177/15701255241304597

Datta, A. (2018). The digital turn in postcolonial urbanism: Smart citizenship in the making of India's 100 smart cities. *Transactions of the Institute of British Geographers*, *43*(3), 405–419. https://doi.org/10.1111/tran.12225

Datta, A., & Hoefsloot, F. I. (2024). The state as auteur: Timing digitisation in Africa's silicon savannah. *Dialogues on Digital Society*, *1*(1), 51–68. https://doi.org/10.1177/29768640241295479

Davoudi, S. (2006a). Evidence-Based planning. *disP - The Planning Review*, *42*(165), 14–24. https://doi.org/10.1080/02513625.2006.10556951

Davoudi, S. (2006b). The evidence – policy interface in strategic waste planning for urban environments: The 'technical' and the 'social' dimensions. *Environment and Planning C: Government and Policy*, *24*(5), 681–700. https://doi.org/10.1068/c0609j

Dörre, A., & Schütte, S. (2020). *Exchange relations and regional development in Gorno-Badakhshan, Tajikistan* (Berlin Geographical Papers, Vol. 50). Centre for Development Studies (ZELF), Freie Universität Berlin.

Echendu, A. J., & Okafor, P. C. C. (2021). Smart city technology: A potential solution to Africa's growing population and rapid urbanization? *Development Studies Research*, *8*(1), 82–93. https://doi.org/10.1080/21665095.2021.1894963

Engin, Z., van Dijk, J., Lan, T., Longley, P. A., Treleaven, P., Batty, M., & Penn, A. (2020). Data-driven urban management: Mapping the landscape. *Journal of Urban Management*, *9*(2), 140–150. https://doi.org/10.1016/j.jum.2019.12.001

Faludi, A., & Waterhout, B. (2006). Introducing evidence-based planning. *disP - The Planning Review*, *42*(165), 4–13. https://doi.org/10.1080/02513625.2006.10556950

Gabrys, J., Pritchard, H., & Barratt, B. (2016). Just good enough data: Figuring data citizenships through air pollution sensing and data stories. *Big Data & Society*, *3*(2), 2053951716679677. https://doi.org/10.1177/2053951716679677

Geddes, B. (1990). How the cases you choose affect the answers you get: Selection bias in comparative politics. *Political Analysis*, *2*, 131–150. https://doi.org/10.1093/pan/2.1.131

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2012). Seeking qualitative rigor in inductive research: Notes on the gioia methodology. *Organizational Research Methods*, *16*(1), 15–31. https://doi.org/10.1177/1094428112452151

Grindle, M. S. (2004). Good enough governance: Poverty reduction and reform in developing countries. *Governance*, *17*(4), 525–548. https://doi.org/10.1111/j.0952-1895.2004.00256.x

Grindle, M. S. (2007). Good enough governance revisited. *Development Policy Review*, *25*(5), 533–574. https://doi.org/10.1111/j.1467-7679.2007.00385.x

Head, B. W. (2008). Three lenses of evidence-based policy. *Australian Journal of Public Administration*, *67*(1), 1–11. https://doi.org/10.1111/j.1467-8500.2007.00564.x

Head, B. W. (2010). Reconsidering evidence-based policy: Key issues and challenges. *Policy and Society*, *29*(2), 77–94. https://doi.org/10.1016/j.polsoc.2010.03.001

Herrera, Y. M., & Kapur, D. (2007). Improving data quality: Actors, incentives, and capabilities. *Political Analysis*, *15*(4), 365–386. https://doi.org/10.1093/pan/mpm007

Hertlein, L.-H. (2020). *Urban livelihood systems in Khorog* (Vol. 51). Centre for Development Studies (ZELF) Institute of Geographical Sciences Freie Universität Berlin.

Jiang, H., Geertman, S., & Witte, P. (2019). Smart urban governance: An urgent symbiosis?. *Information Polity*, *24*(3), 245–269. https://doi.org/10.3233/IP-190130

Jiang, H., Geertman, S., & Witte, P. (2020). Ignorance is bliss? An empirical analysis of the determinants of PSS usefulness in practice. *Computers, Environment and Urban Systems*, *83*, 101505. https://doi.org/10.1016/j.compenvurbsys.2020.101505

Johansson, R. (2007). On case study methodology. *Open House International*, *32*(3), 48–54. https://doi.org/10.1108/OHI-03-2007-B0006

Jørgensen, J. V. (2024). Knowledge utilisation analysis: Measuring the utilisation of knowledge sources in policy decisions. *Evidence & Policy*, *20*(2), 205–225. https://doi.org/10.1332/174426421X16917585658729

Kayanan, C. M., Mutter, S., Davret, J., & Kitchin, R. (2025). The digital turn in planning and the production of 'good enough' planning systems. *European Planning Studies*, *34*(4), 697–718. https://doi.org/10.1080/09654313.2025.2599869

Kitchin, R., Davret, J., Kayanan, C. M., & Mutter, S. (2025). Data mobilities: Rethinking the movement and circulation of digital data. *Mobilities*, *20*(5), 1002–1020. https://doi.org/10.1080/17450101.2025.2481309

Kitchin, R., Davret, J., Kayanan, C. M., & Mutter, S. (2025). Genealogy of a data ecosystem: The digitalisation of planning development and control in Ireland, 2000–2024. *Digital Geography and Society*, *8*, 100124. https://doi.org/10.1016/j.diggeo.2025.100124

Kitchin, R., & Lauriault, T. P. (2015). Small data in the era of big data. *GeoJournal*, *80*(4), 463–475. https://doi.org/10.1007/s10708-014-9601-7

Klievink, B., van der Voort, H., & Veeneman, W. (2018). Creating value through data collaboratives. *Information Polity*, *23*(4), 379–397. https://doi.org/10.3233/IP-180070

Koeva, M., Bennett, R., & Persello, C. (2022). Remote sensing for land administration 2.0. *Remote Sensing*, *14*(17), 4359. https://doi.org/10.3390/rs14174359

Kourtit, K., Elmlund, P., & Nijkamp, P. (2020). The urban data deluge: Challenges for smart urban planning in the third data revolution. *International Journal of Urban Sciences*, *24*(4), 445–461. https://doi.org/10.1080/12265934.2020.1755353

Krizek, K., Forysth, A., & Slotterback, C. S. (2009). Is there a role for evidence-based practice in urban planning and policy? *Planning Theory & Practice*, *10*(4), 459–478. https://doi.org/10.1080/14649350903417241

Marasinghe, R., Yigitcanlar, T., Mayere, S., Washington, T., & Limb, M. (2024). Towards responsible urban geospatial AI: Insights from the white and grey literatures. *Journal of Geovisualization and Spatial Analysis*, *8*(2), 24. https://doi.org/10.1007/s41651-024-00184-2

McKenzie, E., Posner, S., Tillmann, P., Bernhardt, J. R., Howard, K., & Rosenthal, A. (2014). Understanding the use of ecosystem service knowledge in decision making: Lessons from international experiences of spatial planning. *Environment and Planning C: Government and Policy*, *32*(2), 320–340. https://doi.org/10.1068/c12292j

Middleton, R. (2016). History of the development of the Pamir region of Tajikistan (gorno-badakhshan). In H. Kreutzmann & T. Watanabe (Eds.), *Mapping transition in the pamirs: Changing human-environmental landscapes* (pp. 245–265). Springer International Publishing. https://doi.org/10.1007/978-3-319-23198-3_16

Milan, S., & Treré, E. (2020). The rise of the data poor: The COVID-19 pandemic seen from the margins. *Social Media + Society*, *6*(3), 2056305120948233. https://doi.org/10.1177/2056305120948233

Mora, L., Deakin, M., Zhang, X., Batty, M., De Jong, M., Santi, P., & Appio, F. P. (2021). Assembling sustainable smart city transitions: An interdisciplinary theoretical perspective. *Journal of Urban Technology*, *28*(1-2), 1–27. https://doi.org/10.1080/10630732.2020.1834831

Mora, L., Gerli, P., Beckers, D., Thabit, S., & Tonnarelli, F. (2025). *Smart city code: Governance handbook for digital transformation managers in the public sector*. Elsevier. https://books.google.it/books?id=0P8oEQAAQBAJ

Moser, P. (2013). Integrating urban knowledge. In H. T. Andersen & R. Atkinson (Eds.), *Production and use of urban knowledge: European experiences* (pp. 17–34). Springer Netherlands. https://doi.org/10.1007/978-90-481-8936-6_2

Nochta, T., Wahby, N., & Schooling, J. M. (2021). Knowledge politics in the smart city: A case study of strategic urban planning in Cambridge, UK. *Data & Policy*, *3*, e31. https://doi.org/10.1017/dap.2021.28

O'Clery, N., Duque, J. C., Alvanides, S., & Schwanen, T. (2023). Data analytics and sustainable urban development in global cities. *Environment and Planning B: Urban Analytics and City Science*, *50*(4), 857–862. https://doi.org/10.1177/23998083231172884

Odendaal, N. (2011). Splintering urbanism or split agendas? Examining the spatial distribution of technology access in relation to ICT policy in Durban, South Africa. *Urban Studies*, *48*(11), 2375–2397. https://doi.org/10.1177/0042098010388951

OECD. (2019). *The path to becoming a data-driven public sector* (OECD Digital Government Studies, Issue. O. Publishing. https://doi.org/10.1787/059814a7-en

OECD. (2020). *The OECD digital government policy framework: Six dimensions of a digital government* (OECD Public Governance Policy Papers, Issue. O. Publishing. https://doi.org/10.1787/f64fed2a-en

Parkhurst, J. (2017). *The politics of evidence: from evidence-based policy to the good governance of evidence*. Taylor & Francis.

Parnell, S., & Pieterse, E. (2014). *Africás urban revolution* (1 ed.). Zed Books. https://doi.org/10.5040/9781350218246

Pereira, A. P., & Prokopiuk, M. (2024). Informational modeling of cities: Method and challenges for institutional implementation. *Journal of Urban Technology*, *31*(2), 97–115. https://doi.org/10.1080/10630732.2024.2328128

Pereira, G. V., Parycek, P., Falco, E., & Kleinhans, R. (2018). Smart governance in the context of smart cities: A literature review. *Information Polity*, *23*(2), 143–162. https://doi.org/10.3233/ip-170067

Rekola, A., & Paloniemi, R. (2022). Politics of knowledge use: Epistemic governance in marine spatial planning. *Journal of Environmental Policy & Planning*, *24*(6), 807–821. https://doi.org/10.1080/1523908X.2022.2060807

Ribeiro, S. S., Rezende, D. A., & Yao, J. (2019). Toward a model of the municipal evidence-based decision process in the strategic digital city context. *Information Polity*, *24*(3), 305–324. https://doi.org/10.3233/IP-190129

Rijke, J., Brown, R., Zevenbergen, C., Ashley, R., Farrelly, M., Morison, P., & van Herk, S. (2012). Fit-for-purpose governance: A framework to make adaptive governance operational. *Environmental Science & Policy*, *22*, 73–84. https://doi.org/10.1016/j.envsci.2012.06.010

Rossi, S., Harsia, E., Kajosaari, A., & Kyttä, M. (2025). The citizens have participated – what now? An action research study of factors impacting the use of participatory citizen knowledge in planning processes. *European Planning Studies*, *33*(1), 124–146. https://doi.org/10.1080/09654313.2024.2416001

Saidi, Y., Labidi, M. A., & Ochi, A. (2024). Economic growth and extreme poverty in sub-saharan African countries: Non-linearity and governance threshold effect. *Journal of the Knowledge Economy*, *15*(2), 7819–7851. https://doi.org/10.1007/s13132-023-01421-7

Schaepman, M., Tarantino, M., Aggarwal-Khan, S., Biller-Andorno, N., de Giorgi, G., Ducrest, J., Messerli, P., Phakeng, M., Türk, V., & Stoffel, M. (2022). Are our data ready for the next global challenges? Resilient data for resilient societies and economies. *Environmental Science & Policy*, *138*, 146–148. https://doi.org/10.1016/j.envsci.2022.10.006

Schulz, P. (2020). Recognizing research participants' fluid positionalities in (post-)conflict zones. *Qualitative Research*, *21*(4), 550–567. https://doi.org/10.1177/1468794120904882

Sheehan, N., & Leonelli, S. (2025). Reconciling data actionability and accountability in global health research: The case of SARS-CoV-2. *Global Public Health*, *20*(1), 2436422. https://doi.org/10.1080/17441692.2024.2436422

Sinnott, R. O., Bayliss, C., Bromage, A., Galang, G., Gong, Y., Greenwood, P., Jayaputera, G., Marques, D., Morandini, L., Nino-Ruiz, M., Nogoorani, G., Pursultani, H., Rabanal, R., Sarwar, M., Voorsluys, W., & Widjaja, I. (2015, 13-15 August). The urban data re-use and integration platform for australia: Design, realisation, and case studies. 2015 IEEE International Conference on Information Reuse and Integration.

Skjott Linneberg, M., & Korsgaard, S. (2019). Coding qualitative data: A synthesis guiding the novice. *Qualitative Research Journal*, *19*(3), 259–270. https://doi.org/10.1108/QRJ-12-2018-0012

Söderström, O., Blake, E., & Odendaal, N. (2021). More-than-local, more-than-mobile: The smart city effect in South Africa. *Geoforum*, *122*, 103–117. https://doi.org/10.1016/j.geoforum.2021.03.017

Son, T. H., Weedon, Z., Yigitcanlar, T., Sanchez, T., Corchado, J. M., & Mehmood, R. (2023). Algorithmic urban planning for smart and sustainable development: Systematic review of the literature. *Sustainable Cities and Society*, *94*, 104562. https://doi.org/10.1016/j.scs.2023.104562

Sterner, B., & Elliott, S. (2023). How data governance principles influence participation in biodiversity science. *Science as Culture*, *33*(3), 366–391. https://doi.org/10.1080/09505431.2023.2214155

Sterner, B. W., Gilbert, E. E., & Franz, N. M. (2020). Decentralized but globally coordinated biodiversity data [Hypothesis and Theory]. *Frontiers in Big Data*, *3*, https://doi.org/10.3389/fdata.2020.519133

Tan, S., & Taeihagh, A. (2020). Smart city governance in developing countries: A systematic literature review. *Sustainability*, *12*(3), 899. https://doi.org/10.3390/su12030899

Thabit, S., Sancino, A., & Mora, L. (2024). Strategic public value(s) governance: A systematic literature review and framework for analysis. *Public Administration Review*, *85*(3), 885–906. https://doi.org/10.1111/puar.13877

Tonnarelli, F. (2024). *Bosaso city strategy*. UN-Habitat. https://www.undp.org/somalia/publications/bosaso-city-strategy-2024

Tonnarelli, F., & Mora, L. (2024). Smart urbanism in Africa: When theories do not fit with contextual practices. *Regional Studies*, *58*(9), 1767–1777. https://doi.org/10.1080/00343404.2023.2235407

Tonnarelli, F., & Mora, L. (2025a). Data in crisis: Mobility and fitness-for-use in decentralized ecosystems. *Environmental Science & Policy*, *174*, 104267. https://doi.org/10.1016/j.envsci.2025.104267

Tonnarelli, F., & Mora, L. (2025b). Responsible AI for cities: A case study of GeoAI in African informal settlements. *Journal of Urban Technology*, *32*(3), 111–137. https://doi.org/10.1080/10630732.2025.2450755

Tonnarelli, F., & Sophianos, S. (2025). Upgrading fit-for-purpose land administration systems: Challenges and opportunities in Bosaso, Somalia. *Survey Review*, *57*(404), 422–437. https://doi.org/10.1080/00396265.2025.2455369

Tseng, H.-L., & Nikiforova, A. (2025). Navigating the high-value dataset landscape from determination to impact: Lessons from Taiwan's OGD ecosystem. *Information Polity*, *29*(4), 467–483. https://doi.org/10.1177/15701255241297864

Turnpenny, J. R., Jordan, A. J., Benson, D., & Rayner, T. (2015). The tools of policy formulation: An introduction. In *The tools of policy formulation* (pp. 3–30). Edward Elgar Publishing.

Ubaldi, B. (2013). *Open government data: Towards empirical analysis of open government data initiatives* (OECD Working Papers on Public Governance, Issue. O. Publishing. https://doi.org/10.1787/5k46bj4f03s7-en

van Kerkhoff, L., & Lebel, L. (2006). Linking knowledge and action for sustainable development. *Annual Review of Environment and Resources*, *31*, 445–477. https://doi.org/10.1146/annurev.energy.31.102405.170850

Van Ooijen, C., Ubaldi, B., & Welby, B. (2019). *A data-driven public sector: Enabling the strategic use of data for productive, inclusive and trustworthy governance* (OECD Working Papers on Public Governance, Issue. O. Publishing. https://doi.org/10.1787/09ab162c-en

Wastell, D. G. (2006). Information systems and evidence-based policy in multi-agency networks: The micro-politics of situated innovation. *The Journal of Strategic Information Systems*, *15*(3), 197–217. https://doi.org/10.1016/j.jsis.2005.11.001

Wiig, A., & Silver, J. (2019). Turbulent presents, precarious futures: Urbanization and the deployment of global infrastructure. *Regional Studies*, *53*(6), 912–923. https://doi.org/10.1080/00343404.2019.1566703

Yin, R. K. (2018). *Case study research and applications* (Vol. 6). Sage Thousand Oaks, CA.

Zheng, H., & Pee, L. G. (2022). Research knowledge utilisation for societal impact: Information practices based on abductive topic modelling. *Journal of Information Science*, *50*(1), 129–144. https://doi.org/10.1177/01655515221081354

Zuiderwijk, A., Janssen, M., & Davis, C. (2014). Innovation with open data: Essential elements of open data ecosystems. *Information Polity*, *19*(1–2), 17–33. https://doi.org/10.3233/IP-140329

Authors Biographies

Francesco Tonnarelli is a researcher focusing on governance mechanisms of digital transition and their impact on land administration and urban planning in the Global South and small urban contexts. As an urban planner he has concentrated on technical and policy advice to national and local governments with specific focus on capacity building and innovation as an enabling tool for sustainable urban projects.

Jonathan Weaver is a sustainable development specialist with experience supporting local governments and private sector clients in East Africa, the Middle East, and South and East Asia. He his work has focused on delivering innovative, climate-responsive projects in vulnerable and emerging contexts. Jonathan has held technical field roles with UN agencies and currently works with the World Bank Group, supporting private sector clients across East Asia and the Pacific.

Annex A: List of Interviews.

1	National Level Secondary City Advisor	eThekwini Municipality
2	Senior Manager – Spatial Planning	eThekwini Municipality
3	Senior Manager –Data	eThekwini Municipality
4	Senior Technical Officer	eThekwini Municipality
5	Technical Officer	Khorog Municipality
6	Senior Manager	Tajikistan National Planning Authority
7	Programme Manager	Aga Khan Agency for Habitat
8	Senior Management	UN-Habitat
9	Senior Technical Manager	UN-Habitat
10	Programme Officer	UN-Habitat
11	Technical Officer	UN-Habitat
12	Urban Specialist	World Bank
13	Programme Manager	Swiss State Secretariate for Economic Cooperation
14	Earth Observation Specialist	GAF AG
15	Technical expert - Civil engineering	East Africa University
16	Manager – GIS	Bosaso Municipality
17	Senior Manager - Land Administration	Bosaso Municipality
18	Technical officer - Land Administration	Bosaso Municipality
19	Technical officer - Urban Finance	Technical officer
20	Technical officer - Urban Planning	Puntland Ministry of Public Works
21	Technical officer - Urban Planning	Puntland Ministry of Public Works
22	Technical officer - Urban Planning	UN-Habitat
23	Technical officer - Urban Finance	UN-Habitat
24	Technical officer - Urban Finance	UN-Habitat
25	Manager – GIS	UN-Habitat
26	Manager - Urban Planning	UN-Habitat
27	Technical officer - Urban planning	UN-Habitat

Annex B: Sample of the Most Significant Coded Passages From Interviews.

First-Order Coding	Representative Quotations
Addressing established knowledge	We reframed the narrative. When they see their spatial dependencies on the screen, things that didn't seem related suddenly go together
	It is difficult to challenge the current thinking when every donor brings their own report and no one agrees on the baseline numbers
Designing rules	Sometimes it is just about shaping a shared, visual concept that everyone from schoolchildren to elders could understand and respect
Approaching stakeholders	Objective is to get a balance… bring a lot of stakeholders in and getting a lot of data to analyse and inform…
	so you can approch th Mayor not with a spreadsheet, but with a map showing exactly which wards has a certain issue
Mediating among stakeholders	Once you explain your findings, and then you say, Look, your cost will increase if you extend this pipeline to that many kilometres, then they understand it
	My job is often just mediating between the agencies to get them to agree on a common map of the IDP camps
	So once the maps, the data ware there, they were as the bridge, mediating between the international technical experts and the local residents who actually knew the terrain
Raising public awareness	We are trying to raise awareness about climate risks, but without clear data visualizations, the public doesn't engage
	The publication of hazard zones now means there is an awareness of where 'red zones' are. If there are structures in these zones, people can ask, why did this happen?
Building credibility and legitimacy	The Strat Hub builds credibility because for the first time, everyone is looking at the same numbers
	The local government struggles to build legitimacy because they don't have any number, they rely entirely on external consultants
Tracing processes	It is impossible to trace why certain areas get funding. the process is opaque and driven by donor preference, not data
	We documented the mapping process step-by-step so the municipality could replicate it later without us.
	We can now trace the decision-making process back to the specific data layer that justified the investment
Identifying when to advance change	After the last flood, they were ready to listen, so we advanced the relocation plan immediately
	We realised we just couldn't keep up with the influx of people and the growth of the city. We needed new ways of monitoring that, and that is when we came together from different thematic areas sitting together, exchanging their ideas and encouraging them for information exchange.
Identifying when to decelerate transition	That presentation persuaded the ministry that pausing now to look for for safer expansion patterns was better than dealing with a disaster later
Distracting attention of stakeholders	Decision makers have different incentives when using evidence for example Government stakeholders wanted to invest in streetlights in central areas to improve the status of the area. The actual need for streetlights was more in residential areas.
	Its the old tactic of highlight the efficiency gains when the budget cuts hit. Some people are very deliberate when choosing the evidence for their decisions
Informing political debates	Our goal is to arm the local government and the donors with spatial evidence so they can debate resource allocation based on facts and not feelings or clan dynamics
	Politicians often override the technical recommendations because they see a need from business or community to invest in an area
Discerning complexity	We realized this wasn't just a tech problem; it was a mix of social habits, economic incentives, and legal hurdles—a truly complex mess
	It is hard to discern the true picture of the city when the data is so fragmented across different sectors
Assessing risks	There is historical weather data, there are quasi-real time and real-time data from sensors, at least a few, and from satellites, and there are those forecasting models. That's how we prepared for the supernino

Continued.

First-Order Coding	Representative Quotations
Envisioning possible scenarios	We used the model to show the politicians two scenarios: one where we upgrade the infrastructure, and one where we don't
	We want to handle the trends, where planning applications are coming in, where they are being refused…
Monitoring and evaluation	But if you don't link the data with the evidence-based planning principles, what is actually changing… those planning instruments become outdated
	we started having a lot of people, throwing data at us asking to resolve their reporting issue, because it's mostly a reporting issue… So, the data is collected for operational reasons, which means the data has a lot of gaps for technical analytics
Global outreach and reporting	Looking at the global evidence base or looking at fragile and context fragile and conflict affected states, looking at evidence from similar context and synthesizing it and then doing a bit of primary data, and that would mostly be like key informant interviews and stuff at a more localized level to now contextualize global evidence to our specific locations to understand, to better understand the context and design interventions that are relevant to the context that we're operating in.
	So and we are different agencies reporting to similar things or indicators.Then we have to refer to the United Nations Strategic Framework at country level, there was also a review done in the last year or 2022, which is also the instrument to connect to the global level. To look on and for comparison, where the different countries are stand standing.
Asking for more than you expect	Objective is to make decisions that provide or get the best value for money in terms of the use of scarce resources
	We demanded that the NGO use open-source standards rather than their proprietary tools. We asked for this interoperability so that the water data collected today could eventually be integrated with health data tomorrow, catalyzing value across different sectors
Providing opportunities	By opening up access to these datasets, we are providing an opportunity for everyone out there to identify issues and challenges that we perhaps have missed for years
	We provided an opportunity for local stakeholders to repurpose our hazard maps for totally different sectors, like tourism and agriculture, which was never the original intent
Attracting investment	Once you can have land tenure mapped, you can expect donors to build, you can expect diaspora to invest
Developing new products	We have this property data, that is for taxes. But it can be used for building permits, in can be used spatial planning, it can be used for so many things if you just have the will
	We pivoted from just data collection and profiling to developing 'intelligence products' like Decision Support Systems, where you actually can change scenarios
Developing new standards	We are trying to develop a set of metadata so that different other cities can actually talk to each other
	What we tested here is now being used as a base in the rest of the country, and they are piloting in other regions as well. We were the testbed
Citing or referencing	Global open-data standards must be in our methodology. That is because we are not building just for us, but can be cited and utilized by international researchers to model regional climate resilience patterns
	We strictly cite and adhere to metadata standards. We do this to ensure that our data is a standardized resource; if we don't reference the correct protocols now, the data can't be 'mashed up' with external climate models in the future
Providing reference knowledge	The Strat Hub is designed to be the ultimate reference point for any spatial query in the city
	Building this standardized reference allows adjacent agencies to trust and reuse our figures for their own operational needs
	They were always citing the official census, even if it's old, because it's the only 'legitimate' number the government accepts. But now there is also this new survey, and people actually use that
Publicising research and presenting findings	We struggle to publicise findings due a whole set of reasons that you know, the competition and the politics of course. If we could openly present our stuff, it would likely bring a lot value in the sector

Appendix 3

Publication III

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Data in crisis: Mobility and fitness-for-Use in decentralized ecosystems

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ABSTRACT

This study examines data mobility and fitness-for-use within decentralized data ecosystems in crisis contexts, using Somalia as a case study. Data practices are increasingly central to managing natural disasters, conflicts and the consequences of climate change, spanning short-term emergencies to long-term development and global sustainability. However, they face substantial challenges due to the dynamic and fragmented nature of data generation and storage, necessitating robust mechanisms for data sharing and reuse. The discussion has largely centered on the unspecified reuse of data globally, highlighting a significant gap in understanding the situatedness and contextuality of data for effective reuse and repurpose. By analyzing how data are processed, disseminated, and reused in various contexts across Somalia, we find that data's fitness-for-use is not an inherent quality but a dynamic status achieved through deliberate coordination and negotiation among actors. We identify a fundamental tension between vertical data aggregation, which sacrifices local detail for global comparability, and horizontal sharing, which is context-rich but prone to creating fragmentation. A strategy for decentralized but coordinated crisis data may lie not in greater standardization, but in fostering flexible interoperability frameworks and supporting the communities of practice in translating data across diverse institutional and methodological divides.

1. Introduction

The vulnerability of communities and ecosystems to climate change, natural disasters and conflict is on the rise (Wamsler, 2013), and the growth of poorly planned and built settlements in many parts of the world amplifies the factors that cause such disasters (Li et al., 2021). Governments, international organizations, private companies and community-based groups have begun to integrate data collection and evaluation strategies into crisis response, to better and more quickly respond to emergencies (Karlsrud, 2014; Wittmer et al., 2025). Data allow humanitarian organizations to innovate how they react to emergency events, including improve coordination of post-disaster relief efforts (Kondraganti et al., 2024), the ability to harness local knowledge to create more targeted relief strategies (Schröder-Bergen et al., 2022), and tools to predict and monitor disasters in real time (Meier, 2015).

The potential of data is even more crucial at a time when most actors are advocating for the intersection of short-term emergency relief with long-term development efforts, to address both immediate needs and underlying vulnerabilities in a coordinated and sustainable manner (Schreiber and Swithern, 2023; Howe, 2019). Crisis datasets should be fit for reuse and repurpose across various contexts, ranging from their initial applications to unforeseen uses in other contexts (Burns, 2015; Schaepman et al., 2022) and mergeable into cohesive information resource, generating greater value (Sterner et al., 2020). This adaptability would allow for innovative applications within the same environment, such as predictive analytics, decision-support tools and decision making (Crawford and Finn, 2015; Schneider et al., 2023; Taylor and Schroeder, 2015), and facilitates global comparability (Acuto and Leffel, 2020). A commonly proposed solution to ensure such integration involves standardizing all data under a unified classification system (Shalash et al., 2022; Qadir et al., 2016) and consolidating them into global repositories (Telford, 2020; Kondraganti et al., 2024).

However, data practices in crises face several challenges, as they involve a wide array of actors, technologies, and data sources operating across various scales and contexts (Berens et al., 2016; Haak et al., 2018). In such ecosystems, data are often collected and shared dynamically by multiple stakeholders who are often disconnected (Givoni, 2016) resulting in a decentralized form of data generation and knowledge production (Jacobsen and Fast, 2019; Martin de Almagro, 2021). Moreover, the data infrastructure is diffused, with information stored in

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diverse platforms and formats, making integration and coordination both a challenge and a necessity (Kondraganti et al., 2024). This distributed nature enables localized responses (Schröder-Bergen et al., 2022) but requires robust mechanisms for data sharing, reuse and integration among different actors and systems (Read et al., 2016). Thus, crisis response epitomizes a decentralized and diffused ecosystem (Vergne, 2020) where data flows mirror the complex, multifaceted realities of environments in distress. This highlights the need for an increased attention from practitioners and decision-makers on improving data mobility among different groups of stakeholders: humanitarian and development actors (Schreiber and Swithern, 2023) but also communities, local authorities, and national and international organizations (Porto de Albuquerque et al., 2021).

Studies examining data practices in crisis fall short in explaining the dynamics of decentralization, particularly how data are adapted and utilized across various uses and contexts. Research has highlighted the potential for structural transformations through enhanced data flows across a broad spectrum of stakeholders, which could influence global policy making, governance, and sustainability initiatives (Aggestam and Mangalagiu, 2020). Yet, it has not adequately addressed how tailored data practices—from collection to processing and interpretation—can either facilitate or impede the effective reuse, repurpose and integration of data (Leonelli, 2020). Additionally, while discussions have problematized data sharing and the mechanisms, incentives, and narratives used to promote data sharing and reuse (Wittmer et al., 2025; Große-Bley and Kostka, 2021), the discourse has primarily focused on the unspecified reuse of data on a global scale (Reichmann, 2022). There remains a significant gap in understanding how data collected for one purpose can be assessed in its fitness for new uses and contexts (Bishop and Hank, 2018).

To bridge this knowledge gap, we employ a qualitative methodology to analyze the Somali data ecosystem as an exemplary case. Our analysis was guided by the following research question: how are data processed, disseminated, re-used and integrated in decentralized data ecosystems? Based on work on data practices and data mobility research, we articulate the social and technical dimensions of fitness-for-use and its importance as a theoretical lens for reuse and integration within decentralized networks and diffused data ecosystem. Our key findings reveal that data are multidimensional constructs shaped by boundaries, modes of utilization, actionability and accountability dynamics, creating a persistent tension between its immediate use and long-term reuse. The primary contribution of this study is to challenge the pursuit of a standardized, universal data product. Instead, we reframe data reuse and integration as a social process centered on shared meaning, collaborative learning, and situated coordination, where data's value is determined through ongoing negotiation and legitimation.

2. Theoretical background

2.1. Data practices in crisis contexts

The widespread adoption of digital devices and platforms in humanitarian operations, disaster response and crisis management has made data production, processing and use a common aspect of emergency response strategies around the world (Roth and Luczak-Roesch, 2020). As essential services and everyday operational activities increasingly move to digital formats, a growing body of scholarship has started examining the impact of socio-material conditions of data lifecycle on crises management approaches. Research has explored various themes, such as the evolving accountability standards in humanitarian efforts (Bierens et al., 2020) and risks and embedded biases affecting non-traditional data sources usage (Santoni and Rufat, 2021; Herfort et al., 2021). Another relevant research focus are the pitfalls of overreliance on data from new information technologies (Crawford and Finn, 2015) such as the lack of democratization in remote sensing technologies (Oluoch et al., 2022) and the disparity between advanced technologies and local capacities and resources (Tonnarelli and Mora, 2025). Collectively, these studies highlight how crisis data serve as a nexus where power dynamics, politics, capital, and colonialism converge and manifest (Burns, 2019; Milan, 2020; Egger, 2023). This body of research is part of the broader field of critical data studies, which scrutinizes the ethical, cultural, and societal impacts of data practices (Medrado and Verdegem, 2024; Kitchin, 2024). Data practices are situated and relational; they take place within complex sociotechnical ecosystems comprising technology, people, organizations, and policies, interacting both internally and with their external environment (D'Ignazio et al., 2024; Lnenicka et al., 2024a).

Many studies on data practices concentrate on how sharing and integrating data are mediated by technological infrastructure such as data portals and dashboards (Fadmastuti et al., 2024). In these studies, data portals are more than web interfaces for databases; they also represent social organizations whose collective activities constitute a spatially and socially distributed network of relationships connecting people and places (Barns, 2019; Nost and Goldstein, 2021). These portals establish their authoritative status integrating multiple datasets to an official one, emphasizing quality, legitimacy, and trustworthiness (Pelizza, 2016). However, this perspective overlooks decentralized ecosystems where key data resources are spread across multiple platforms, and non-platform-based stakeholders (Curry and Sheth, 2018; Kitchin et al., 2025b). These environments often involve a network of participants engaging in a blend of long-term and short-lived interactions that are crucial for the spontaneous exchange of data, knowledge, and resources.

Literature on data practices also concentrates on the interaction and collaboration between actors, as the main components of a data ecosystem (Zulu et al., 2025) in particular on governance and economics (Gelhaar et al., 2021). However, actor-based descriptions of data ecosystems tends to focus on two primary configurations (Gelhaar et al., 2022): hierarchical models, where a central authority dictates standards (Gelhaar et al., 2021), and stable network-based models built on long-term collaboration and explicit coordination (Susha et al., 2023; Gupta et al., 2020). This dual focus often overlooks a third type of configuration: decentralized ecosystems. These are characterized by more loosely interdependent groups of actors who engage through incidental or ad-hoc transactions (Curry and Sheth, 2018). Moreover, little consideration is also given to the relationships with external stakeholders, including funders, users, and other ecosystems (Gelhaar et al., 2021).

We suggest focusing on data transformation and mobility processes (Bates et al., 2016) to allow for a broader examination of decentralized data ecosystems. Following how data are produced, processed, reworked, fused, used, re-used and re-purposed allows to move beyond configurations mediated by a single digital technology and stable actor configurations, as it follows data moving across sites, systems and actors (Kitchin et al., 2025a). Terms like *data flows* or *data streams* have been used to illustrate how data moves through nodes and networks (Tarantino, 2020; McNally et al., 2012). Flows can be subject to data frictions, complex set of factors and processes – such as data practices, protocols and regulations, infrastructural supports, and data politics – that slow and block its progress. (Bates, 2018; Aula, 2019). The concept of *data journeys* expands the idea of mobility by focusing on the socio-material dynamics that affect data's route, embedding data within a network of human and technological influences (Leonelli, 2020: 5). Along these journeys data is curated (Aula, 2019), get searched, extracted and refashioned into bits of information (Bates et al., 2016), assessed in their evidentiary strength (Cambrosio et al., 2020).

2.2. Fitness-for-use and the politics of data movement

Movement and adaptation to various forms of storage, dissemination and utilization implies a process of assessment and evaluation of quality and compatibility to satisfy specific requirement. This evaluative process is foundational to determine the fitness of data for particular uses (Bishop et al., 2019). The concept of *fitness for use* provides a critical framework to analyze and understand the intricate dynamics that drive the successful reuse of data within decentralized ecosystems (Bishop and Hank, 2018). By applying this concept, we can effectively trace and examine data journeys, highlighting the diverse conditions and arrangements necessary for data to be repurposed successfully across varied domains and platforms. These interconnected processes underscore the importance of tailored data management strategies that accommodate the specific needs and contexts of data utilization (Leonelli, 2020), thereby facilitating the efficient and effective reuse of data in complex and decentralized environments.

The principle of 'fitness-for-use' is a concept employed across diverse disciplines to denote the degree to which a product, service, or system can adequately fulfill its intended function within a reasonable resource expense (Rijke et al., 2012; Tonnarelli and Mora, 2025). In data science it is widely used in evaluating scientific models and datasets (Bokulich and Parker, 2021). It is usually formulated as a technical matter – e.g. evaluating whether a dataset matches a particular research or policy problem. Fitness evaluation, on this view, is an activity that can be performed by machine agents on data and their descriptive metadata (Bishop and Hank, 2018). That is, the adaptability of data across different applications is assessed by examining a range of characteristics including data types, formats, and sources, as well as data topics and categories (Lnenicka et al., 2024b).

However, research on data justice (Taylor, 2017), as well as on reasons for data sharing (Wallis et al., 2013) and reuse (Sinnott et al., 2015) shows the intricate socio-political factors that contribute to data reuse beyond data preparation (Edwards et al., 2011). To determine suitability for a particular application or purpose, a user may need to find the data - there might be the need for integration of data from multiple sources, which means compare, contrast and evaluate them, determining their conceptual boundaries and how these can be crossed in the journey. In this sense, fitness for use summarizes the discovery and evaluation of data from the re-user/consumer's perspective (Bishop and Hank, 2018), depending on its purpose, objective and goals (Parker, 2020) rather than an objective property of data. Specifically, the evaluation will be based on the intended modes of utilization (McKenzie et al., 2014; Zheng and Pee, 2022) and on the different types of data products and services that need to be generated.

At the same time, though, the material contribution of data producers and curators also affect judgements about data fitness-for-use, e. g. because their contribution entails legal obligations for other parties or because of norms about data ownership (Sterner and Elliott, 2023; Bergmann, 2016). Additionally, often the input of additional actors is required or legitimate in determining whether a data resource is fit-for-use by other actors, e.g. because the data are about them as subjects or because they have an oversight role (Marino et al., 2024; D'Ignazio et al., 2024). For example, CARE data principles asserts the rights of Indigenous Peoples to determine which, when, and how data about them and their lands will be collected, categorized, distributed, and used (Radosevic et al., 2023). In this view, fitness for use can be seen through the lens of data governance, in particular actionability and accountability (Sheehan and Leonelli, 2025). That is the assemblage of mechanisms, norms, and policies that confer credibility, validity, and authority to data produced, on one side, and regulates the rights and responsibilities to access and use it, on the other.

The fitness-for-use concept should therefore be understood as social as well as technical status that people attribute to a body of data with specific characteristics, in relation to some further utilization, and within determined data governance practices (Sterner and Elliott, 2023; Bergmann, 2016). Within the vast amounts of data generated in crisis, from diverse sources with varying formats and quality (Mulder et al., 2016) stakeholders negotiate shared criteria for the legitimacy of using the data as evidence not only in crisis response, but also further specific environmental problems, policy decisions, or commercial applications (Nochta et al., 2021; Wilson, 2011). We therefore place emphasis on understanding how the material conditions of data production, evaluation, and fitness for use drive the circulation of data.

2.3. Data solutions and challenges in Somali crises

Somalia faces one of the world's most complex and prolonged humanitarian crises, driven by armed conflicts, weak governance, and recurring climatic shocks that sustain widespread poverty and humanitarian needs. Since the collapse of the Siad Barre regime in 1991, the absence of a strong central government has resulted in over two decades of lawlessness, violent conflicts, displacement, property destruction, and fragile institutions (Bakonyi, 2018). In 2012, a federal government was established with United Nations (UN) support, but political conflict continues to hinder progress toward stability and improved service delivery. Many citizens remain heavily reliant on humanitarian aid to cope with these ongoing challenges (Mosley, 2015).

Years of civil war and ongoing conflict have eroded Somalia's data and statistical infrastructure and capacity (Hoogeveen and Nguyen, 2019; Hoogeveen and Pape, 2020), but have also pushed humanitarian and development agencies to come up with new solutions. For many years, Somalia has provided important opportunities for innovation and learning and for developing new approaches to data in a conflict-affected and fragile context. For example, the Integrated Food Security Phase Classification (IPC) system (Fredriksen, 2015) and cash-based programming through mobile money (Owino, 2020; Randa, 2018) were pioneered in the country before becoming a standard in humanitarian response. Similarly, geospatial techniques and high-resolution imagery were tested in the country to model the spatial population distribution (Pape and Wollburg, 2019), as well as migration forecasting and groundwater monitoring solution using Artificial Intelligence (Schneider et al., 2023; Veness and Buytaert, 2025). Recognizing data and statistics as key for long-term development and state-building, great efforts were also allocated to rebuilding a spatial data infrastructure with open standards (Von Hagen, 2007), set up local land administration systems (Nuh et al., 2024; Tonnarelli and Sophianos, 2025) and solutions for urban and regional profiling and planning (Migliorisi and Tonnarelli, 2023; Tonnarelli, 2023).

Because data are needed for all sectors and themes, a large number of partners supporting data and statistics have emerged, often with different priorities and mandates. In particular, international financial institutions and a wide range of UN agencies, programs and funds, many of which have recently been mandated to collect additional data on specific SDG indicators (Bexell and Jönsson, 2017). This large number of providers with different priorities render co-ordination more challenging (Lange, 2020). In addition, different priorities of donors can also result in fragmented data systems that leave synergies untapped (Tonnarelli and Mora, 2024).

As the above review suggests, Somalia can serve as an illustrative example of a data ecosystem where crisis data are mobilized across multiple actors, scales and levels (Hagmann et al., 2022). This example highlights not only the challenges of data mobility but also the critical role of data in driving transformations toward sustainability.

3. Methodology

3.1. Data collection

This study employs an exploratory single-case study method (Yin, 2018), using the Somali data ecosystems as unit of analysis. This approach is well-suited because there is a scarcity of established information on data mobility within decentralized data ecosystems like Somalia (Quintão et al., 2021). This allows for the inductive development of insights that can serve as a foundation for future research, rather than testing pre-existing theory.

Following Kitchin (2017) and Dencik (2019), who advocate for research that examines the contextual details of specific datafication projects, we focus on the journeys of selected crisis data produced within the Somali data ecosystem, and in particular in selected UN projects with a relevant data component, through a qualitative approach staged in phases.

In the initial phase we identified data programs and datasets to explore through a desk review on various documents. These include numerous policy and strategical documents, such as the UN Sustainable development cooperation framework (UNSDCF), the Somalia National Development Plan (NDP) and National Strategy for the Development of Statistics, and several documents related to specific projects. Obtained primarily from UN institutional websites, they capture the integration of digital objectives into projects and programmes, reflecting underlying assumptions and policy choices, offering insights into how data governance has been framed (Redden, 2018). Other materials examined include government reports, websites, statistical data and figures, pieces of news stories and editorials. Appendix A presents the sources used in our study.

Building on the literature review, we conducted semi-structured interviews (Galletta and Cross, 2013; Brinkmann and Kvale, 2018) to gain deeper insights on data characteristics, modes of utilization, and data governance practices. We used a purposive sampling strategy (Campbell et al., 2020) targeting individuals in key roles, including project managers and technical officers from UN agencies, as well as data experts and practitioners from various levels of the Somali administration, donors, and private data providers. Recruitment was facilitated through our professional networks and connections within the Somali UN system. Other interviewees were added through snowball sampling (Johnson and Onwuegbuzie, 2004) to ensure a broad range of perspectives. A total of 26 participants were involved – see Appendix B for a list. Prior to each interview, participants received a clear description of the study's aims, the intended use of the data, and the interview protocol. Verbal informed consent was obtained and recorded from all participants before the interviews began. All identifying information related to individuals and their specific projects has been anonymized in the manuscript. These interviews were particularly valuable as they allowed actors to articulate their different perspectives in their own words (Magnusson and Marecek, 2015).

Data triangulation (Johansson, 2007) was carried out analyzing two additional data sources. On one side, digital datasets and integrated analytical documents published by UN and government agencies and referenced in the interviews and documents. These included geodata and other non-geographical datasets and statistics, surveys, dashboards and factsheets. This approach allowed us to more contextually understand the characteristics of the data, potential conflicts, and integration efforts mentioned in the interviews. Appendix C presents a list of the data products analyzed.

On the other side, one of the authors gathered observational data in their active involvement in the Somali UN system since 2022. Observation data allowed to capture the decision-making and related successes and ongoing challenges in data mobilities.

As a staff member and consultant for UN-Habitat in Somalia, one of the authors was intimately familiar with the topic under study. This insider positionality (Bandauko, 2024) facilitated substantive discussions and built credibility with participants (Berkovic et al., 2020; Chavez, 2008). It also provided preferential access to key stakeholders, as well as to project documentation (Chavez, 2008). However, this presented the risk of several biases, including selection bias through network-based recruitment (Collier et al., 2004; Geddes, 1990) and social desirability bias through responses aligned with institutional priorities (Schulz, 2020) - methodological challenges common in high-risk, low-information contexts (Bell-Martin and Marston Jr, 2021). At the same time, this positionality may have foregrounded themes of inter-agency coordination, technical interoperability, and the challenges of project-based data collection, which we highlight as a possible limitation of the study. The phased approach of our research was designed to mitigate such biases, triangulating the interviews with an extensive review of policy documents and datasets (Bell-Martin and Marston Jr, 2021). Additionally, a second author with no professional connection to the UN system collaborated on defining the research aim, developing the coding scheme, and conducting peer debriefing sessions (Eppich et al., 2019), providing an outsider perspective to challenge potential biases and ensure a more balanced interpretation.

3.2. Data analysis

Interview transcripts and documents were analyzed using a thematic-coding approach (Gioia et al., 2012). This was an iterative process that involved coding sample text, reviewing coding consistency and revising the coding rules to improve consistency. Our analysis began by pinpointing first-order concepts in these excerpts, covering areas like data resources, datasets accessibility, and collaborations. The coding scheme was then used to categorize the content into various themes for an in-depth review. Themes were then grouped into three theoretical dimensions that emerged inductively from the data. The information generated from this review is synthesized in the overall coding structure

Table 1
Coding structure (n = Number of coded passages in interviews).

Concept	Theme	Aggregate Dimension
Project time horizon (n = 31)	Time	Boundaries
Evolution and sequencing (n = 24)		
Validity (n = 20)		
Updates (n = 14)		
Coverage (n = 37)	Space	
Scale (n = 9)		
Granularity (n = 17)		
Background Knowledge (n = 26)	Theme	
Mandate (n = 27)		
Identity (n = 12)		
Trust (n = 13)	Human-Centric Information Gathering	Actionability and accountability
Authority To Control (n = 28)		
Legitimacy Assessment (n = 5)		
Power To Grant Access (n = 11)		
Competition/Incentives to not share (n = 5)		
Responsibility To Share (n = 8)		
Communication Channels (n = 11)	Collaboration and Communities of Practice	
Corporate Structure and Methodologies (n = 16)		
Familiarity (n = 32)		
Joint Programming (n = 23)		
Immediate Use (n = 29)	Implementation	Modes of Utilization
Local Action (n = 14)		
Real Time Applications (n = 18)		
Selection and synthesis (n = 12)	Knowledge Base	
Data Streamlining and Coherence (n = 24)		
Baseline Validation (n = 30)		
Upstream Coordination (n = 19)		
Downstream Integration (n = 9)		
Monitoring And Evaluation (n = 22)	Policy and Decision Making	
Agenda Setting (n = 21)		
Global-Local Linkages (n = 16)		

in Table 1 (Skjott Linneberg and Korsgaard, 2019). Appendix D presents some of the most representative quotes extracted during the coding process.

4. Results

4.1. Space, time, and conceptual boundaries

Beside characteristics such as types and formats, our analysis recognized the notion of boundaries when determining how data moves from one use to another, and its fitness across three dimensions: space, time, and theme.

Boundaries have an obvious space connotation, referring to scale and coverage of datasets. Project can span from international or cross-country initiatives, like SDG reporting, to programs covering the whole country, particular region, or single location. These different scales of operation vary "from one region to another based on access as well on security issues" (int.04) but also based on "need and vulnerability, for a more rational resource allocation" (int.11). One visible example was the spatial data mapped in OpenStreetMap, an open geographic database – see Fig. 1. Thanks to mapping projects such as the ones of Humanitarian OpenStreetMap Team (HOTOSM), which allows various actors to create mapping tasks related to emergency that the community help to map, many areas around the two only perennial river of the country are mapped at a high level of granularity. This is because this region is "actually the more interesting ones for most of the people" (int.08), hosting most of the population and urban centers, and therefore attracting most international. These humanitarian-driven mapping projects create a paradox: areas where access is challenging – like informal settlements - or blocked entirely – like crisis-affected areas, are some of the most accurately mapped. At the same time, they leave over-mapped patches – where disasters occur - among territories that remain 'missing' from open and accessible maps. To use data from various sources, there is the need to understand whether these data overlap in terms of scale and granularity. Interviewees working in larger geographical regions struggled to match data, either adding features from one or subtracting from the other. "[…] we have done a new mapping of all the districts in Somalia because we realized that the maps used by the others were very outdated and incomplete and missing. Some of these districts were not even plotted on the right location on the map" (int.23). Through the same process, several map features were more recent and updated more often.

This also relates to a second dimension of boundary, time. Data "are basically being collected with regards to specific projects or programs, with a determined timeline" (int.01). These dynamics result in continuous rediscussions of formats, entry, curation, and archival modes. Data compatibility and reuse therefore depends on the sequencing of project, as this affects the reliability of data updates and (meta)data consistency. Only a handful of programs continues in successive phases and therefore offer a more reliable and relatively stable data flow. However, in each

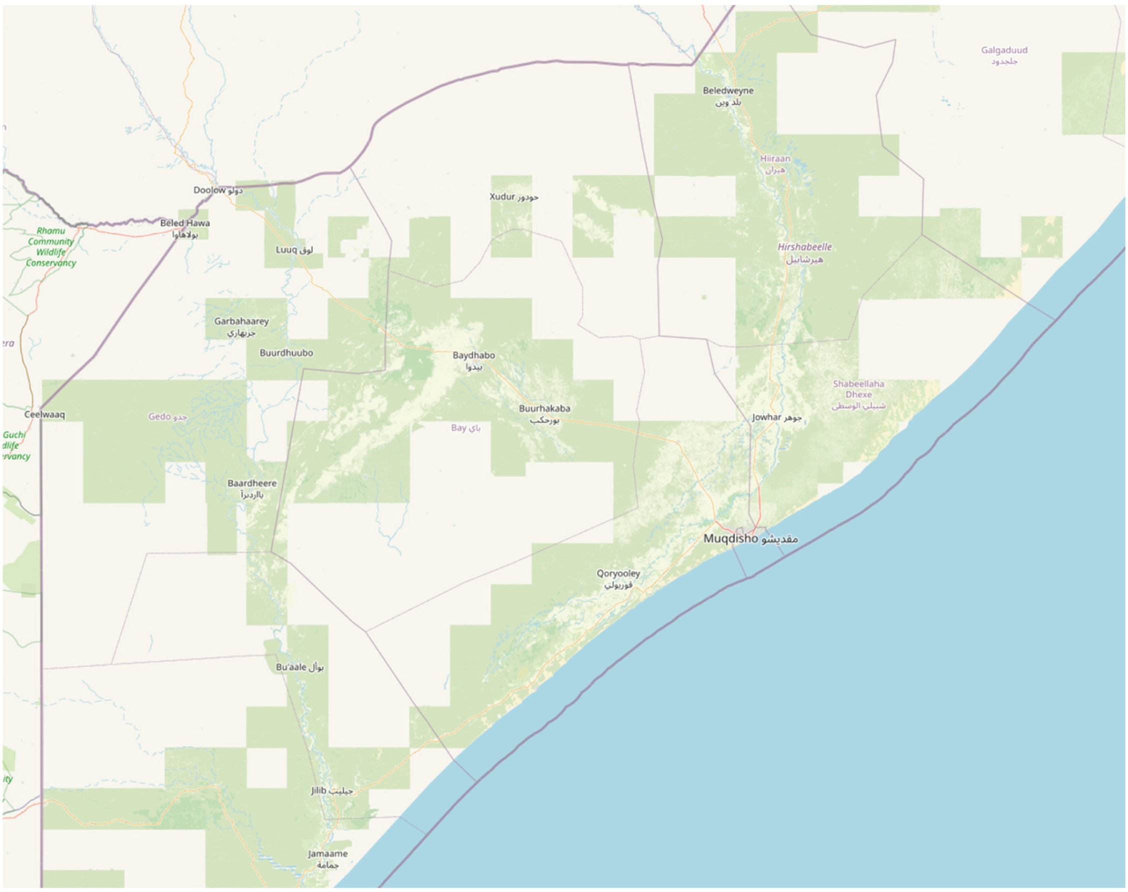

Fig. 1. OpenStreetMap of Southern Somalia, with visible over-mapped patches - OSM.

phase there is a revision on information to be collected, to focus on particular topics, introduce new tools and technologies or streamline data processes with the local administration. For instance, the GIS-based property survey initiated under the Joint Programme for Local Governance (JPLG) in 2008 collected detailed data on property type, use, and ownership, including georeferenced building footprints. The survey was intended for allowing property taxation, with the co-benefits at improving land security and spatial planning. New surveys in 2016 and 2022 did not update previous data but substituted them, progressively reducing the scope to minimal details for tax purposes (use and size of the building). The lack of continuity between surveys has resulted in duplicated efforts, loss of historical comparability, and diminishing data quality over time. “You have to acknowledge the datasets are not perfect, being done for a certain purpose and at a certain time” (int.05).

Several interviews also highlighted mandates as both a common distinguishing factor and a barrier in accounts of data-sharing and reuse. Each actor’s primary mandate shapes their specialized knowledge base and perspectives on what constitutes valuable datasets and how these should be utilized and interpreted. “Even the definitions, like how people defined administrative boundaries and urban versus rural areas has been like a difficult question” (int.07). For example, UNHCR or WFP have specific mandates on refugees and food security. FAO and UN-Habitat, as the un agency responsible for agriculture and urbanization, respectively, bring broader but territorially distinct perspectives—emphasizing rural and urban contexts. Organizations like UNDP or the World Bank adopt a more holistic view in line with their broader development aims. Thematic silos contribute to data gaps and inconsistencies. For instance, when mapping the city of Bosaso, the Camp Coordination and Camp Management (CCCM) Cluster collects detailed, standardized population statistics on camps for internally displaced persons (IDPs) in urban areas but excludes host communities from its surveys. Conversely, property registration systems contain detailed household-level information on host communities but fail to account for IDPs – see Fig. 2.

4.2. Modes of utilization

A clear broader categorical distinction between modes of data utilization emerged from interviews, representing the differing perspectives of actors within the ecosystem and therefore a different kind of methodological divide in assessing fitness for use.

A first mode of utilization focuses on immediate use and real time applications for practical projects or concrete services, particularly for emergency response and humanitarian action. As “the mechanisms in place to store and manage that data […] can be crippling” (int.22) little emphasis is put towards data reuse by external parties. This often results in stand-alone, snapshot collections rather than live-managed systems. For example, raw displacement data were published periodically by the CCCM Cluster as plain text files, with no metadata standard and no Application Programming Interface (API) for discovery and aggregation. To repurpose the data, users had to download them locally for cleaning and analysis.

An additional mode consists of aggregated data products, aimed at building a knowledge base and providing decision support models locally. Here actors, including development actors and government entities such as the National Bureau of Statistics, focus on aggregating existing datasets. The challenge extends beyond simply merging datasets; it also includes ensuring distinct data products function cohesively. For example, UN-Habitat’s urban profiles involve locating, cleaning, integrating and analyzing diverse data sources—such as demographic statistics, features extraction and land use from satellite imagery, economic activity from business registries, and property data from municipal records—to offer a comprehensive view of a city or region. Utilizing data in a secondary capacity, data latency is less of a concern compared to their coverage and consistence. For example, one of the tasks that the Somalia and Land Information Management Project (SWALIM) covers “is actually to convert in digital format environmental data from historical records and publications” (int.08).

Another mode of utilization aligns explicitly with the Sustainable Development Goals (SDGs) and national development agendas, establishing global linkages. This mode often relies on high-level aggregators and synthetic indicators — such as the Somalia SDG Tracker — that aim at comprehensive national coverage. The aspiration is to create a "one-stop shop" (int.21) for macro-level data on a wide range of topics. By prioritizing breadth and international comparability, these platforms can become disconnected from daily operations. An example is the data for SDG indicator 11.3.2, which measures urban land consumption. The indicator was calculated using standardized global methodologies, sourcing data from remotely sensed maps of population and built-up areas. This approach imposes a rigid rural-urban dichotomy that has “limited application on the ground, in a cultural context where historically residence was nomadic or seasonal […] with a constellation of scattered, mobile settlements” (int.13).

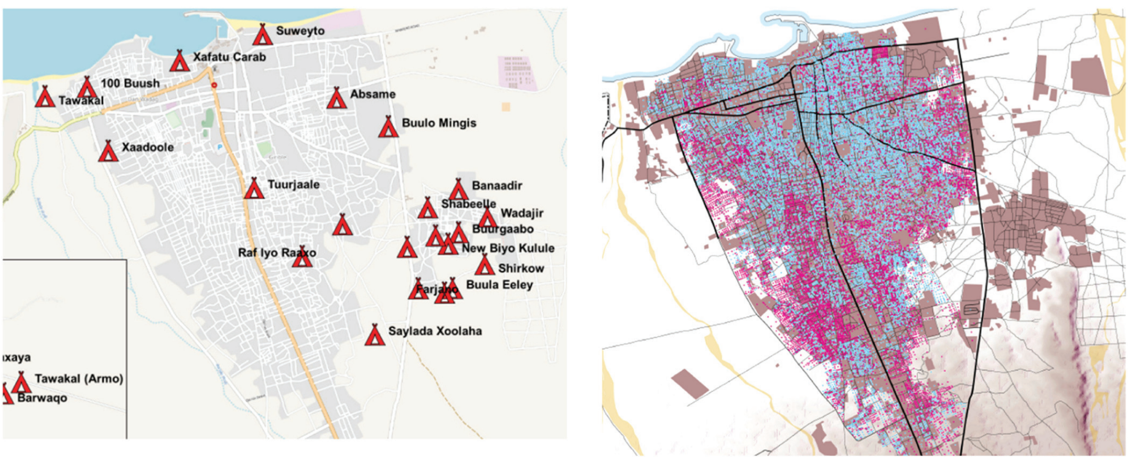

Fig. 2. Bosaso: IDP sites verification (on the left - Somalia CCCM Cluster) and Property survey (on the right – UN-Habitat).

4.3. Actionability and accountability

Interviews highlighted significant dynamics in data exchange. Challenges exist on the sharing side where, for instance, data from humanitarian organizations often does not extend beyond its primary use unless safeguards - such as on beneficiary confidentiality or political sensitivity - are firmly in place. Moreover, interviewees expressed concerns over the risk of misuse or misinterpretation. Same data could be used for various purposes, but the use must be sanctioned by the data owner, and fitness of the data depends on the governing institution's interpretation of it. In order to ensure appropriate use, actors need not only a common data format but also shared understanding of underlying assumptions and data processing techniques. Additionally, while numerous data portals exist, they often lack cross-integration and tend to function more as static, offline snapshots rather than dynamic, interconnected systems. On the receiving end, several interviewees highlighted a related issue: discomfort with using data not directly collected: "Let's say we tend to use what we produce. We are more comfortable with it" (int.08). This is not merely a matter of insufficient data preparation and documentation. Instead, it is tied to an institutional reward system, where donors' recognition and funding often favor the creation of new datasets over the reuse or integration of existing ones, even when these might lead to replication. "I think the incentive structure is probably not set up to encourage agencies to be more transparent about data" (int.12). Many interviewees described the careful process of ensuring data do not conflict with or encroach upon the projects and associated funding of other actors. However, these practices also help shape problem spaces in data work. For example, both UNHCR, with its Protection & Return Monitoring Network (PRMN) and IOM, through its Displacement Tracking Matrix (DTM), collected and analyzed data on IDPs with large overlaps, replications, and inconsistencies. To justify their coexistence, they reviewed scope and complementarity of their methodologies: "…these systems, they now complement each other, they are completing the whole picture of the IDP population in Somalia." (int.10).

Interviews also indicated the essential role of human-centric, face-to-face methods to compare, align and legitimize datasets. Rather than relying solely on metadata and reputation of source, users often depend on peer recommendations for data selection: "whether I'm lost in their dataset, I would try to enter in contact with the gentlemen who collected the data" (int.01). This alignment work typically takes place within thematic clusters, coordination meetings and communities of practice who share knowledge, tools, and methods for common problems. These networks of practitioners support collaborative sense-making, enabling participants to align datasets by developing shared standards, refining methodologies, and exchanging expertise. Balancing collaboration and competition, communities of practice are instrumental in addressing gaps in data integration and ensuring its effective application across varied organizational contexts, although on a mostly technical level. A more traditional example of data integration occurs in project collaboration, where two or more actors jointly commit effort toward a shared initiative. This is partly due to the tailored nature of the integration process. Rather than repurposing pre-existing data from a repository, one agency may actively produce or prepare specific data tailored to the needs of a partner agency following consultations. Such interactions help establish processes for data integration between agencies, aligning different approaches and modes of data utilization.

5. Discussion

Our results indicate that, in decentralized and distributed ecosystems, data can be viewed as multidimensional constructs shaped by boundaries, modes of utilization, and actionability and accountability dynamics. Below, we examine how these dimensions collectively shape the challenges and opportunities for data integration, reuse, and governance in such environments. We then present recommendations for strengthening the coherence and effectiveness of the crisis data ecosystem.

5.1. Dynamic situatedness along data journeys

Our study highlighted a tension between immediate use of data and fitness-for-reuse and repurpose. Data are embedded in space, time and conceptual boundaries that shape their sustainability and adaptation for new uses (Inman and Ribes, 2018; Hopman, 2024; Loukissas, 2016). Assessing data's fitness for reuse is further complicated by contrasting operational constraints, time horizons, accountability methods, and political drivers (Roth and Luczak-Roesch, 2020; Burns, 2015). These dimensions show data as dynamic constructs influenced by evolving contexts (Barry Born, 2021). In decentralized ecosystems, data are made compatible and meaningful through deliberate efforts by actors working collaboratively and competitively to bridge gaps within these shifting frameworks (Yao et al., 2025).This perspective moves beyond a static notion of "situatedness" (Bergmann, 2016: 977) of data practices. It acknowledges that data are constantly shaped and morphed, meaning its situatedness is continuously redefined as it travels (Kitchin et al., 2025a). This dynamic nature reveals the effort required to both design fit-for-use data packages and reinterpret external datasets for new projects (Burns, 2014; Martin de Almagro, 2021).

To optimize data movements, it is important to balance standardization and generalization with customization and specialization, fostering contextual fitness-for-use by tailoring formats and methods to specific end-user needs, from immediate crisis response to long-term policymaking (Marino et al., 2024; Givoni, 2016). However, this process extends beyond the technical tasks of data preparation and documentation. Effective data reuse relies on collaborative practice to connect tasks and workers (Neang et al., 2021). It necessitates building relationships and coordinating with stakeholders to define the value of the data transfer, plan the logistical details, assign responsibilities, and establish the appropriate documentation standards.

Crisis data, therefore, form a complex ecology of collaborations. In a site like Somalia, the work of data production, reuse and integration is constantly under construction, embedding relationships between collectors, aggregators, and policymakers into data formats and practices. The interplay among practitioners forges new relations between agencies, disciplines, and methods. This is a trend common to several fields where diverse groups must collaborate to respond to cross-sectoral challenges (Veness and Buytaert, 2025). While data-centric models promise value through movement (Leonelli, 2020) owners often don't know the potential uses for their data. The core problem is not motivating participation in established processes but negotiating complex and emergent collaborations. This necessitates a focus beyond format standardization toward a mutual discovery of what is feasible and appropriate in data journeys.

5.2. Hierarchical aggregation and horizontal fragmentation

From our study, modes of data utilization appear to be structured in hierarchical layers. Different processes aggregate data products, important to create a link between concrete, focused and narrow project implementation to more holistic, broad policy making. The middle level of aggregation noted in our study, similar to models of science-policy integration (Eddy et al., 2014), is important to maintaining the functional integrity of both domains, while allowing effective and efficient integration. However, the flow of data across organizations and technology infrastructures is neither straightforward nor singular. Raw data generated by implementers undergo refinement into information and further distillation into knowledge through complex, non-linear processes (Burns, 2014; Martin de Almagro, 2021).

On one side, hierarchical aggregation pulls data upwards for broad-scale analysis. This serves broader geographical scales and more encompassing classifications, enabling agenda setting and global comparability, but progressively disconnects the refined data from on-the-ground realities. As a result, data flow one way, as opposed to a cyclical quality enhancement system and data lifecycle (Sterner et al., 2020). On the other side, collaboration among communities of practice and other networks creates a more horizontal, reciprocal exchange (Nicolini et al., 2022). These networks aim at impacting concrete decision-making contexts (Panizzolo, 2025), rather than a highly standardized, global data product intended to be fit-for-use across most contexts. However, this integration is often limited to a technical level or confined within programmes boundaries due to mandate silos and competition. This causes vertical data multiplication, and results in replications, overlaps, and inconsistencies.

5.3. *Strategies for decentralized but coordinated crisis data*

Our analysis suggests that strategic and tactical data uses should be supported through targeted action that bridges the gap between immediate data collection and long-term policy needs (Aggestam and Mangalagiu, 2020). The insistence by practitioners working within different traditions to tailor their data practices and related tools as closely as possible to their existing methods and commitments makes sense given that such methods and commitments have been adapted over years (Read et al., 2016), and yet makes it difficult to agree on common standards and norms (Roth and Luczak-Roesch, 2020). This reluctance, coupled with a project-driven, short-term funding system, encourages an uncontrollable and unsustainable proliferation of resources for management and analysis of data. Collaboration among stakeholders is central to overcoming these trends. Establishing forums or communities of practice facilitates the exchange of tools, methodologies, and experiences, enabling alignment across diverse mandates (Panizzolo, 2025). With no single authority to exert centralized control over crisis data, decentralized ecosystems generate loosely connected networks of mid-level aggregators. Decentralized but coordinated crisis data ecosystems would necessitate orchestration strategies (Gupta et al., 2020) and facilitating the transition from informal social networks to formalized governance and infrastructure (Nicolini et al., 2022; Panizzolo, 2025). Shared governance models can help mediate overlapping responsibilities, reducing redundancies and fostering complementary data usage. (Lee et al., 2006)

Mechanisms for iterative updates, information consistency, and long-term preservation strategies must go along with building local capacity to ensure datasets remain relevant and accessible for future use (Ford and Graham, 2016). These measures align with efforts to bridge gaps in spatial and thematic coverage, addressing imbalances caused by accessibility challenges or strategic priorities.

Trust and legitimacy also appear as key aspects determining effective data utilization (Crawford and Finn, 2015). Face-to-face, human-centric exchanges between data producers and users foster trust, refine methodologies, and ensure meaningful data alignment (Read et al., 2016). By integrating these strategies, organizations can achieve a balanced approach to data standardization and customization, creating data ecosystems that are both functional and adaptable. This approach could help in producing and utilizing data effectively for a range of purposes, from localized tactical interventions to broader strategic planning, supporting equitable and informed decision-making.

6. Limitations

While this study offers valuable insights into the crisis data ecosystem in Somalia, several limitations warrant acknowledgment.

First, the study focus on a single case study, Somalia, characterized by protracted conflict, complex governance structures, and a mature humanitarian and development presence. These specific dynamics shape the data practices observed. Consequently, the generalizability of our findings to other settings—such as rapid-onset natural disasters (e.g., earthquakes, typhoons) or different political landscapes—may be limited. Comparative research is essential to build a more robust theory of crisis data ecosystems. Future studies should explore contrasting cases to analyze how factors like state capacity, the nature of the crisis, and the level of technological infrastructure influence data collaboration, reuse, and governance.

Second, the reliance on semi-structured interviews introduces a degree of subjectivity, as insights are shaped by the perspectives and experiences of stakeholders. Future work should integrate quantitative analysis—such as social network analysis of data-sharing relationships or content analysis of data-sharing agreements—to validate and complement our qualitative findings (Johnson and Onwuegbuzie, 2004). Furthermore, although we sought a diverse range of participants, government actors, both at the national and local levels, were underrepresented. This omission means our analysis lacks the crucial perspective of state institutions that are often key producers, consumers, and regulators of (crisis) data (Dencik, 2019; Reutter, 2022). Targeted research is needed to understand the perspectives of government officials, exploring their unique challenges, capacities, and priorities in the data ecosystem. This could involve different recruitment strategies or partnerships with public administration researchers to gain better access.

Third, this study provides a cross-sectional snapshot of the data ecosystem at a particular point in time. Data practices, collaborations, and technological infrastructures are not static; they evolve in response to funding cycles, shifting political priorities, technological innovations, and the trajectory of the crisis. Our methodology does not fully capture these dynamics. Longitudinal studies that track data ecosystems over several years are needed to understand their evolution (Ven, 2007; Langley et al., 2013). Such research could reveal how data-sharing agreements are formed and dissolved, how communities of practice sustain themselves (or fail), and how technological platforms adapt over time. Additionally, a deeper dive into the specific socio-technical infrastructures (e.g., platforms like the humanitarian data exchange, or bespoke government systems) and their role in enabling or constraining data flow would offer a more complete picture of the ecosystem's mechanics (Ribes and Lee, 2010).

7. Conclusions

This study investigated how data are processed, disseminated, reused, and integrated in a decentralized ecosystem, using Somalia as an illustrative case. By putting forth the notion of data mobilities and data fitness-for-use (Sterner and Elliott, 2023; Kitchin et al., 2025a), our research moves beyond simplistic, technology-centric views of data sharing to reveal the complex socio-technical dynamics that shape data's journey (Bates, 2018). We find that the value of crisis data is not inherent but contingent on continuous processes of evaluation, negotiation, and legitimation (Bergmann, 2016; Thabit et al., 2024).

Our analysis identified three key findings. First, we established that crisis data are multidimensional constructs whose fitness-for-use is shaped by boundaries, modes of utilization, actionability and accountability dynamics. These factors create a tension between data collected for immediate, tactical response and its suitability for long-term, strategic reuse, leading to data of varying quality, scale, and purpose.

Second, this study demonstrates that human-centric collaboration is the essential mechanism for bridging these divides. Contrary to the prevailing focus on universal standards and centralized platforms, data integration in practice relies on the deliberate, social labor of practitioners. Through thematic clusters, coordination meetings, and communities of practice, actors build trust, negotiate shared meaning, and collaboratively align disparate datasets. These informal and formal networks provide the social infrastructure that enables data to travel across technical and institutional boundaries.

Third, our research uncovered two competing data flows that define the ecosystem's structure: a vertical, hierarchical aggregation and a horizontal, fragmented exchange. The vertical flow pulls data upwards for broad-scale analysis, achieving global comparability at the cost of local context. In contrast, the horizontal flow within communities of practice fosters reciprocal, context-rich exchange but is often confined within institutional silos, leading to redundancy and inconsistency. This dual dynamic creates a complex landscape of interconnectivity and fragmentation.

Our analysis reframes the central challenge of crisis data from one of technical standardization to one of situated coordination. It contributes to the growing body of literature on data ecosystems and offers practical recommendations for fostering more inclusive, effective, and sustainable data practices in crisis settings. These findings encourage further exploration of how data can drive systemic transformations, aligning immediate responses with long-term developmental goals. To build a more effective, equitable, and sustainable data ecosystem, we must look beyond the data and focus on the human relationships, collaborative practices, and governance models that give it meaning and power.

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Author statement

We certify that all authors have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

CRediT authorship contribution statement

Francesco Tonnarelli: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Luca Mora:** Writing – review & editing, Supervision.

Declaration of Competing Interest

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Supplementary material

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Data availability

Data will be made available on request.

References

Acuto, M., Leffel, B., 2020. Understanding the global ecosystem of city networks. Urban Stud 58 (9), 1758–1774. https://doi.org/10.1177/0042098020929261.

Aggestam, F., Mangalagiu, D., 2020. Is sharing truly caring? Environmental data value chains and policymaking in Europe and Central Asia. Environ. Sci. Policy 114, 152–161. https://doi.org/10.1016/j.envsci.2020.07.012.

Aula, V., 2019. Institutions, infrastructures, and data friction – reforming secondary use of health data in Finland. Big Data Soc 6 (2), 2053951719875980. https://doi.org/10.1177/2053951719875980.

Bakonyi, J., 2018. Seeing like bureaucracies: rearranging knowledge and ignorance in Somalia. Int. Political Sociol. 12 (3), 256–273. https://doi.org/10.1093/ips/oly010.

Bandauko, E., 2024. Negotiating the insider–outsider dilemma in urban research: experiences of a graduate student returning home for fieldwork. Area 56 (2), e12931. https://doi.org/10.1111/area.12931.

Barns, S., 2019. Negotiating the platform pivot: from participatory digital ecosystems to infrastructures of everyday life. Geogr. Compass 13 (9), e12464. https://doi.org/10.1111/gec3.12464.

Barry Born, T., 2021. Proactive state geographies: geocoded intelligence in London's 'suburban shanty towns. Environ. Plan. D Soc. Space 39 (4), 609–626. https://doi.org/10.1177/02637758211030925.

Bates, J., 2018. The politics of data friction. J. Doc. 74 (2), 412–429. https://doi.org/10.1108/JD-05-2017-0080.

Bates, J., Lin, Y.-W., Goodale, P., 2016. Data journeys: capturing the socio-material constitution of data objects and flows. Big Data Soc 3 (2), 2053951716654502. https://doi.org/10.1177/2053951716654502.

Bell-Martin, R.V., Marston Jr, J.F., 2021. Confronting Selection Bias: the Normative and Empirical Risks of Data Collection in Violent Contexts. Geopolitics 26 (1), 159–192. https://doi.org/10.1080/14650045.2019.1659780.

Berens J., Raymond N., Shimshon G., et al. (2016) The Humanitarian Data Ecosystem: the Case for Collective Responsibility. Stanford Center on Philanthropy and Civil Society. Available at: https://pacscenter.stanford.edu/publication/the-humanitarian-data-ecosystem-the-case-for-collective-responsibility/.

Bergmann, L., 2016. Toward speculative data: "Geographic information" for situated knowledges, vibrant matter, and relational spaces. Environ. Plan. D Soc. Space 34 (6), 971–989.

Berkovic, D., Ayton, D., Briggs, A.M., Ackerman, I.N., 2020. The view from the inside: positionality and insider research. Int. J. Qual. Methods 19, 1609406919900828. https://doi.org/10.1177/1609406919900828.

Bexell, M., Jönsson, K., 2017. Responsibility and the United Nations' sustainable development goals. Forum Dev. Stud. 44 (1), 13–29. https://doi.org/10.1080/08039410.2016.1252424.

Bierens, S., Boersma, K., Van Den Homberg, M.J.C., 2020. The legitimacy, accountability, and ownership of an impact-based forecasting model in disaster governance. Polit. Gov. 8 (4), 445–455. https://doi.org/10.17645/pag.v8i4.3161.

Bishop, B.W., Hank, C., 2018. Measuring FAIR principles to inform fitness for use. Int. J. Digit. Curation 13 (1), 35–46. https://doi.org/10.2218/ijdc.v13i1.630.

Bishop, B.W., Hank, C., Webster, J., et al., 2019. Scientists' data discovery and reuse behavior: (Meta)data fitness for use and the FAIR data principles. Proc. Assoc. Inf. Sci. Technol. 56 (1), 21–31. https://doi.org/10.1002/pra2.4.

Bokulich, A., Parker, W., 2021. Data models, representation and adequacy-for-purpose. Eur. J. Philos. Sci. 11 (1), 31. https://doi.org/10.1007/s13194-020-00345-2.

Brinkmann, S., Kvale, S., 2018. Doing interviews. SAGE Publications Ltd, London.

Burns, R., 2014. Moments of closure in the knowledge politics of digital humanitarianism. Geoforum 53, 51–62. https://doi.org/10.1016/j.geoforum.2014.02.002.

Burns, R., 2015. Rethinking big data in digital humanitarianism: practices, epistemologies, and social relations. GeoJournal 80 (4), 477–490. https://doi.org/10.1007/s10708-014-9599-x.

Burns, R., 2019. New Frontiers of Philanthro-capitalism: digital Technologies and Humanitarianism. Antipode 51 (4), 1101–1122. https://doi.org/10.1111/anti.12534.

Cambrosio, A., Campbell, J., Vignola-Gagné, E., et al., 2020. Overcoming the bottleneck': knowledge architectures for genomic data interpretation in oncology. In: Leonelli, S., Tempini, N. (Eds.), Data Journeys in the Sciences. Springer International Publishing, Cham, pp. 305–327. https://doi.org/10.1007/978-3-030-37177-7_16.

Campbell, S., Greenwood, M., Prior, S., et al., 2020. Purposive sampling: complex or simple? Research case examples. J. Res. Nurs. 25 (8), 652–661. https://doi.org/10.1177/1744987120927206.

Chavez, C., 2008. Conceptualizing from the inside: advantages, complications, and demands on insider positionality. Qual. Rep. 13 (3), 474–494. https://doi.org/10.46743/2160-3715/2008.1589.

Collier, D., Mahoney, J., Seawright, J., 2004. Claiming too much: warnings about selection bias. In Rethinking social inquiry: Diverse tools, shared standards. Rowman and Littlefield, pp. 85–102.

Crawford, K., Finn, M., 2015. The limits of crisis data: analytical and ethical challenges of using social and mobile data to understand disasters. GeoJournal 80 (4), 491–502. https://doi.org/10.1007/s10708-014-9597-z.

Curry, E., Sheth, A., 2018. Next-generation smart environments: from system of systems to data ecosystems. IEEE Intell. Syst. 33 (3), 69–76. https://doi.org/10.1109/MIS.2018.033001418.

D'Ignazio, C., Cruxên, I., Martinez Cuba, A., et al., 2024. Geographies of missing data: spatializing counterdata production against feminicide. Environ. Plan. D Soc. Space. https://doi.org/10.1177/02637758241275961, 02637758241275961.

Dencik, L., 2019. Situating practices in datafication – from above and below. Routledge. DOI: 10.4324/9781351247375-18.

Eddy, B.G., Hearn, B., Luther, J.E., et al., 2014. An information ecology approach to science-policy integration in adaptive management of social-ecological systems. Ecol. Soc. 19 (3), 40. https://doi.org/10.5751/ES-06752-190340.

Edwards, P.N., Mayernik, M.S., Batcheller, A.L., et al., 2011. Science friction: data, metadata, and collaboration. Soc. Stud. Sci. 41 (5), 667–690. https://doi.org/10.1177/0306312711413314.

Egger, C., 2023. The politics and spaces of public-private partnerships in humanitarian tech innovations. Environ. Plan. C Polit. Space 42 (5), 708–724. https://doi.org/10.1177/23996544231206822.
Eppich, W.J., Olmos-Vega, F.M., Watling, C.J., 2019. Grounded theory methodology: key principles. In: Nestel, D., Hui, J., Kunkler, K., Scerbo, M.W., Calhoun, A.W. (Eds.), Healthcare Simulation Research: A Practical Guide. Springer International Publishing, pp. 127–133. https://doi.org/10.1007/978-3-030-26837-4_18.
Fadmastuti, M., Nowak, D., Crompvoets, J., 2024. Flood data platform governance: identifying the technological and socio-technical approach(es) differences. In: In Environmental Science & Policy, 162, p. 103938. https://doi.org/10.1016/j.envsci.2024.103938.
Ford, H., Graham, M., 2016. Provenance, power and place: linked data and opaque digital geographies. Environ. Plan. D Soc. Space 34 (6), 957–970. https://doi.org/10.1177/0263775816668857.
Fredriksen, A., 2015. Crisis in 'a normal bad year': spaces of humanitarian emergency, the integrated food security phase classification scale and the Somali famine of 2011. Environ. Plan. A Econ. Space 48 (1), 40–57. https://doi.org/10.1177/0308518X15597446.
Galletta, A., Cross, W.E., 2013. Mastering the semi-structured interview and beyond: from research design to analysis and publication. NYU press.
Geddes, B., 1990. How the cases you choose affect the answers you get: selection bias in comparative politics. Political Anal. 2, 131–150. https://doi.org/10.1093/pan/2.1.131.
Gelhaar, J., Becker, F., Groß, T., 2022. Characterization of relationships in data ecosystems. 3rd Conf. Prod. Syst. Logist. https://doi.org/10.15488/12159.
Gelhaar, J., Groß, T., Otto, B., 2021. A taxonomy for data ecosystems. Proc. 54th Hawaii Int. Conf. Syst. Sci.
Gioia, D.A., Corley, K.G., Hamilton, A.L., 2012. Seeking qualitative rigor in inductive research: notes on the gioia methodology. Organ. Res. Methods 16 (1), 15–31. https://doi.org/10.1177/1094428112452151.
Givoni, M., 2016. Between micro mappers and missing maps: digital humanitarianism and the politics of material participation in disaster response. Environ. Plan. D Soc. Space 34 (6), 1025–1043. https://doi.org/10.1177/0263775816652899.
Große-Bley, J., Kostka, G., 2021. Big data dreams and reality in Shenzhen: an investigation of smart city implementation in China. Big Data Soc 8 (2), 205395172110451. https://doi.org/10.1177/20539517211045171.
Gupta, A., Panagiotopoulos, P., Bowen, F., 2020. An orchestration approach to smart city data ecosystems. Technol. Forecast. Soc. Change 153, 119929. https://doi.org/10.1016/j.techfore.2020.119929.
Haak, E., Ubacht, J., Homberg, M.Vd, et al., 2018. A framework for strengthening data ecosystems to serve humanitarian purposes (pp). Digital Government Research: Governance in the Data Age. Association for Computing Machinery, Delft, The Netherlands, p. 85. https://doi.org/10.1145/3209281.3209326.
Hagmann, T., Wasuge, M., Musa, A.M., 2022. The political economy of aid data procurement and analysis in Somalia. Swiss Agency for Development and Cooperation (SDC), Bern, Switzerland.
Herfort, B., Lautenbach, S., Porto de Albuquerque, J., et al., 2021. The evolution of humanitarian mapping within the OpenStreetMap community. Sci. Rep. 11 (1), 3037. https://doi.org/10.1038/s41598-021-82404-z.
Hoogeveen, J., Nguyen, N.T.V., 2019. Statistics reform in africa: aligning incentives with results. J. Dev. Stud. 55 (4), 702–719. https://doi.org/10.1080/00220388.2017.1417583.
Hoogeveen, J., Pape, U., 2020. Data collection in fragile states: innovations from Africa and beyond. Springer Nature. https://doi.org/10.1007/978-3-030-25120-8.
Hopman, R., 2024. Snails, time, data: on the politics of mass-digitization and the possibility of data drift. Big Data Soc 11 (3), 20539517241267760. https://doi.org/10.1177/20539517241267760.
Howe, P., 2019. The triple nexus: a potential approach to supporting the achievement of the sustainable development goals? World Dev 124, 104629. https://doi.org/10.1016/j.worlddev.2019.104629.
Inman, S., Ribes, D., 2018. Data streams, data seams: toward a seamful representation of data interoperability. DRS International Conference 2018. Design Research Society, Limerick, Ireland, pp. 25–28. doi: 10.21606/drs.2018.359.
Jacobsen, K.L., Fast, L., 2019. Rethinking access: how humanitarian technology governance blurs control and care. Disasters 43 (S2), S151–S168. https://doi.org/10.1111/disa.12333.
Johansson, R., 2007. On case study methodology. Open House Int 32 (3), 48–54. https://doi.org/10.1108/OHI-03-2007-B0006.
Johnson, R.B., Onwuegbuzie, A.J., 2004. Mixed methods research: a research paradigm whose time has come. Educ. Res. 33 (7), 14–26. https://doi.org/10.3102/0013189X033007014.
Karlsrud, J., 2014. Peacekeeping 4.0: harnessing the potential of big data, social media, and cyber technologies. In: Kremer, J.-F., Müller, B. (Eds.), Cyberspace and International Relations: Theory, Prospects and Challenges. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 141–160. https://doi.org/10.1007/978-3-642-37481-4_9.
Kitchin, R., 2017. Thinking critically about and researching algorithms. Inf. Commun. Soc. 20 (1), 14–29. https://doi.org/10.1080/1369118X.2016.1154087.
Kitchin, R., 2024. Critical data studies: an A to Z guide to concepts and methods. John Wiley & Sons.
Kitchin, R., Davret, J., Kayanan, C.M., et al., 2025b. Genealogy of a data ecosystem: the digitalisation of planning development and control in Ireland, 2000–2024. Digit. Geogr. Soc. 8, 100124.
Kitchin, R., Davret, J., Kayanan, C.M., et al., 2025a. Data mobilities: rethinking the movement and circulation of digital data. Mobilities 1–19. https://doi.org/10.1080/17450101.2025.2481309.
Kondraganti, A., Narayanamurthy, G., Sharifi, H., 2024. A systematic literature review on the use of big data analytics in humanitarian and disaster operations. Ann. Oper. Res. 335 (3), 1015–1052. https://doi.org/10.1007/s10479-022-04904-z.
Lange, S., 2020. Key trends in development co-operation for national data and statistical systems. OECD Dev. Policy Pap. 31. https://doi.org/10.1787/1ce044d2-en.
Langley, A., Smallman, C., Tsoukas, H., et al., 2013. Process studies of change in organization and management: unveiling temporality, activity, and flow. Acad. Manag. J. 56 (1), 1–13. https://doi.org/10.5465/amj.2013.4001.
Lee, C.P., Dourish, P., Mark, G., 2006. The human infrastructure of cyberinfrastructure. In: Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work. Association for Computing Machinery, Banff, Alberta, Canada, pp. 483–492. DOI: 10.1145/1180875.1180950.
Leonelli, S., 2020. Learning from data journeys. In: Leonelli, S., Tempini, N. (Eds.), Data Journeys in the Sciences. Springer International Publishing, Cham, pp. 1–24. https://doi.org/10.1007/978-3-030-37177-7_1.
Li, H., Xu, E., Zhang, H., 2021. Examining the coupling relationship between urbanization and natural disasters: a case study of the Pearl River Delta, China. Int. J. Disaster Risk Reduct. 55, 102057. https://doi.org/10.1016/j.ijdrr.2021.102057.
Lnenicka, M., Nikiforova, A., Luterek, M., et al., 2024b. Understanding the development of public data ecosystems: from a conceptual model to a six-generation model of the evolution of public data ecosystems. Telemat. Inform. 94, 102190.
Lnenicka, M., Nikiforova, A., Clarinval, A., et al., 2024a. Sustainable open data ecosystems in smart cities: a platform theory-based analysis of 19 European cities. Cities 148, 104851.
Loukissas, Y.A., 2016. A place for big data: close and distant readings of accessions data from the Arnold Arboretum. Big Data Soc 3 (2), 2053951716661365. https://doi.org/10.1177/2053951716661365.
Magnusson, E., Marecek, J., 2015. Doing interview-based qualitative research: a learner's guide. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781107449893.
Marino, A., Berardi, A., Mistry, J., et al., 2024. Space technologies for development? Practicing sovereignty, beyond inclusion. Environ. Plan. D Soc. Space, 02637758241295514. https://doi.org/10.1177/02637758241295514.
Martin de Almagro, M., 2021. Indicators and success stories: the UN sustaining peace agenda, bureaucratic power, and knowledge production in post-war settings. Int. Stud. Q. 65 (3), 699–711. https://doi.org/10.1093/isq/sqab059.
McKenzie, E., Posner, S., Tillmann, P., et al., 2014. Understanding the use of ecosystem service knowledge in decision making: lessons from international experiences of spatial planning. Environ. Plan. C Gov. Policy 32 (2), 320–340. https://doi.org/10.1068/c12292j.
McNally, R., Mackenzie, A., Hui, A., et al., 2012. Understanding the 'Intensive' in 'Data Intensive Research': data flows in next generation sequencing and environmental networked sensors. Int. J. Digit. Curation 7. https://doi.org/10.2218/ijdc.v7i1.216.
Medrado, A., Verdegem, P., 2024. Participatory action research in critical data studies: interrogating AI from a South–North approach. Big Data Soc 11 (1), 20539517241235869. https://doi.org/10.1177/20539517241235869.
Meier, P., 2015. Digital humanitarians: how big data is changing the face of humanitarian response. CRC Press, Boca Raton, FL.
Migliorisi, A., Tonnarelli, F., 2023. Reconceptualizing the traditional urban-rural settlement definition to territorial approach. In: Eol Chae, A.K. (Ed.), Compendium of Inspiring Practices on Urban-Rural Linkages: Implementation of Guiding Principles and Framework for Action to advance Integrated Territorial Development. UN-Habitat, Nairobi.
Milan, S., 2020. Techno-solutionism and the standard human in the making of the COVID-19 pandemic. Big Data Soc 7 (2), 2053951720966781. https://doi.org/10.1177/2053951720966781.
Mosley, J., 2015. Somal. 'S. Fed. Future. Layer. Agendas risks Oppor.
Mulder, F., Ferguson, J., Groenewegen, P., et al., 2016. Questioning Big Data: crowdsourcing crisis data towards an inclusive humanitarian response. Big Data Soc 3 (2), 2053951716662054. https://doi.org/10.1177/2053951716662054.
Neang, A.B., Sutherland, W., Beach, M.W., et al., 2021. Data integration as coordination. Proc. ACM Hum. Comput. Interact. 4, CSCW3. https://doi.org/10.1145/3432955.
Nicolini, D., Pyrko, I., Omidvar, O., et al., 2022. Understanding communities of practice: taking stock and moving forward. Acad. Manag. Ann. 16 (2), 680–718. https://doi.org/10.5465/annals.2020.0330.
Nochta, T., Wahby, N., Schooling, J.M., 2021. Knowledge politics in the smart city: a case study of strategic urban planning in Cambridge, UK. Data Policy 3, e31. https://doi.org/10.1017/dap.2021.28.
Nost, E., Goldstein, J.E., 2021. A political ecology of data. Environ. Plan. E Nat. Space 5 (1), 3–17. https://doi.org/10.1177/25148486211043503.
Nuh, M., Ruohonen, M., Pekkola, S., 2024. Challenges of ICT4D solutions in Somalia: a case study of land management. In: Chigona, W., Kabanda, S., Seymour, L.F. (Eds.), Implications of Information and Digital Technologies for Development. Springer Nature, Switzerland, Cham, pp. 21–32. https://doi.org/10.1007/978-3-031-66982-8_2.
Oluoch, I., Kuffer, M., Nagenborg, M., 2022. In-between the lines and pixels: cartography's transition from tool of the state to humanitarian mapping of deprived urban areas. Digit Soc 1 (1), 5. https://doi.org/10.1007/s44206-022-00008-0.
Owino, B., 2020. Harmonising data systems for cash transfer programming in emergencies in Somalia. J. Int. Humanit. Action 5 (1), 11. https://doi.org/10.1186/s41018-020-00077-1.
Panizzolo, S., 2025. From conflict to communities: fields' reshuffles and the emergence of communities of practice in humanitarian logistics. Int. Stud. Q. 69 (1), sqaf009. https://doi.org/10.1093/isq/sqaf009.
Pape, U.J., Wollburg, P.R., 2019. Estimation of poverty in Somalia using innovative methodologies. World Bank Policy Research Working Paper, p. 8735.

Parker, W.S., 2020. Model evaluation: an adequacy-for-purpose view. Philos. Sci. 87 (3), 457–477. https://doi.org/10.1086/708691.
Pelizza, A., 2016. Disciplining change, displacing frictions. two structural dimensions of digital circulation across land registry database integration. Tecnoscienza Ital. J. Sci. Technol. Stud. 7 (2), 35–60. https://doi.org/10.6092/issn.2038-3460/17326.
Porto de Albuquerque, J., Anderson, L., Calvillo, N., et al., 2021. The role of data in transformations to sustainability: a critical research agenda. Curr. Opin. Environ. Sustain. 49, 153–163. https://doi.org/10.1016/j.cosust.2021.06.009.
Qadir, J., Ali, A., ur Rasool, R., et al., 2016. Crisis analytics: big data-driven crisis response. J. Int. Humanit. Action 1 (1), 12. https://doi.org/10.1186/s41018-016-0013-9.
Quintão, C., Andrade, P., Almeida, F., 2021. How to Improve the Validity and Reliability of a Case Study Approach? J. Interdiscip. Stud. Educ. 9 (2), 264–275. https://doi.org/10.32674/jise.v9i2.2026.
Radosevic, N., Duckham, M., Saiedur Rahaman, M., et al., 2023. Spatial data trusts: an emerging governance framework for sharing spatial data. Int. J. Digit. Earth 16 (1), 1607–1639. https://doi.org/10.1080/17538947.2023.2200042.
Randa, J., 2018. Somalia economic update, August 2018: rapid growth in mobile money. Stability or Vulnerability? World Bank.
Read, R., Taithe, B., Mac Ginty, R., 2016. Data hubris? humanitarian information systems and the mirage of technology. Third World Q 37 (8), 1314–1331. https://doi.org/10.1080/01436597.2015.1136208.
Redden, J., 2018. Democratic governance in an age of datafication: lessons from mapping government discourses and practices. Big Data Soc 5 (2), 2053951718809145. https://doi.org/10.1177/2053951718809145.
Reichmann, S., 2022. The Narrow Road to Data: Data Sharing for Global, Unspecified Reuse. DOI: 10.31235/osf.io/vtxpg.
Reutter, L., 2022. Constraining context: situating datafication in public administration. N. Media Soc. 24 (4), 903–921. https://doi.org/10.1177/14614448221079029.
Ribes, D., Lee, C.P., 2010. Sociotechnical studies of cyberinfrastructure and e-research: current themes and future trajectories. Comput. Support. Coop. Work (CSCW) 19 (3), 231–244. https://doi.org/10.1007/s10606-010-9120-0.
Rijke, J., Brown, R., Zevenbergen, C., et al., 2012. Fit-for-purpose governance: a framework to make adaptive governance operational. Environ. Sci. Policy 22, 73–84. https://doi.org/10.1016/j.envsci.2012.06.010.
Roth, S., Luczak-Roesch, M., 2020. Deconstructing the data life-cycle in digital humanitarianism. Inf. Commun. Soc. 23 (4), 555–571. https://doi.org/10.1080/1369118X.2018.1521457.
Santoni, V., Rufat, S., 2021. How fast is fast enough? Twitter usability during emergencies. Geoforum 124, 20–35. https://doi.org/10.1016/j.geoforum.2021.05.007.
Schaepman, M., Tarantino, M., Aggarwal-Khan, S., et al., 2022. Are our data ready for the next global challenges? resilient data for resilient societies and economies. Environ. Sci. Policy 138, 146–148. https://doi.org/10.1016/j.envsci.2022.10.006.
Schneider, C., Jimenez, R.M., Kyriazi, S., 2023. Artificial intelligence-based predictive analytics in the humanitarian sector: the case of project jetson. Harnessing data innovation for migration policy. IOM Global Data Institute, p. 66.
Schreiber, D., Swithern, S., 2023. Co-ordination across the humanitarian-development-peace nexus. OECD Development Co-operation Working Papers, p. 114. https://doi.org/10.1787/fd302760-en.
Schröder-Bergen, S., Glasze, G., Michel, B., et al., 2022. De/colonizing OpenStreetMap? Local mappers, humanitarian and commercial actors and the changing modes of collaborative mapping. GeoJournal 87 (6), 5051–5066. https://doi.org/10.1007/s10708-021-10547-7.
Schulz, P., 2020. Recognizing research participants' fluid positionalities in (post-)conflict zones. Qual. Res. 21 (4), 550–567. https://doi.org/10.1177/1468794120904882.
Shalash, A., Abu-Rmeileh, N.M.E., Kelly, D., et al., 2022. The need for standardised methods of data collection, sharing of data and agency coordination in humanitarian settings. BMJ Glob. Health 7 (8), e007249. https://doi.org/10.1136/bmjgh-2021-007249.
Sheehan, N., Leonelli, S., 2025. Reconciling data actionability and accountability in global health research: the case of SARS-CoV-2. Glob. Public Health 20 (1), 2436422. https://doi.org/10.1080/17441692.2024.2436422.
Sinnott, R.O., Bayliss, C., Bromage, A., et al., 2015. The urban data re-use and integration platform for Australia: design, realisation, and case studies. IEEE Int. Conf. Inf. Reuse Integr. 2015, 90–97. DOI: 10.1109/IRI.2015.24.
Skjott Linneberg, M., Korsgaard, S., 2019. Coding qualitative data: a synthesis guiding the novice. Qual. Res. J. 19 (3), 259–270. https://doi.org/10.1108/QRJ-12-2018-0012.
Sterner, B., Elliott, S., 2023. How data governance principles influence participation in biodiversity science. Sci. Cult. 33 (3), 366–391. https://doi.org/10.1080/09505431.2023.2214155.
Sterner, B.W., Gilbert, E.E., Franz, N.M., 2020. Decentralized but globally coordinated biodiversity data. Front. Big Data 3. https://doi.org/10.3389/fdata.2020.519133.
Susha, I., van den Broek, T., van Veenstra, A.-F., et al., 2023. An ecosystem perspective on developing data collaboratives for addressing societal issues: the role of conveners. Gov. Inf. Q. 40 (1), 101763. https://doi.org/10.1016/j.giq.2022.101763.
Tarantino, M., 2020. Navigating a datascape: challenges in automating environmental data disclosure in China. J. Environ. Plan. Manag. 63 (1), 67–86. https://doi.org/10.1080/09640568.2019.1659132.
Taylor, L., 2017. What is data justice? The case for connecting digital rights and freedoms globally. Big Data Soc 4 (2), 2053951717736335. https://doi.org/10.1177/205395171773633.
Taylor, L., Schroeder, R., 2015. Is bigger better? the emergence of big data as a tool for international development policy. GeoJournal 80 (4), 503–518. https://doi.org/10.1007/s10708-014-9603-5.
Telford, S., 2020. The humanitarian data exchange: critical decisions, key results and the road ahead. OCHA, Geneva.
Thabit, S., Sancino, A., Mora, L., 2024. Strategic public value(s) governance: a systematic literature review and framework for analysis. Public Adm. Rev. 85 (3), 885–906. https://doi.org/10.1111/puar.13877.
Tonnarelli, F., 2023. Baidoa city strategy. UN-Habitat, Nairobi.
Tonnarelli, F., Mora, L., 2024. Smart urbanism in Africa: when theories do not fit with contextual practices. Reg. Stud. 58 (9), 1767–1777. https://doi.org/10.1080/00343404.2023.2235407.
Tonnarelli, F., Mora, L., 2025. Responsible AI for cities: a case study of GeoAI in African informal settlements. J. Urban Technol. 32 (3), 111–137. https://doi.org/10.1080/10630732.2025.2450755.
Tonnarelli, F., Sophianos, S., 2025. Upgrading fit-for-purpose land administration systems: challenges and opportunities in Bosaso, Somalia. Surv. Rev. 57 (404), 422–437. https://doi.org/10.1080/00396265.2025.2455369.
Ven, A., 2007. Engaged scholarship: a guide for organizational and social research. Oxford University Press, Oxford.
Veness, W.A., Buytaert, W., 2025. Towards an evidence base for groundwater data investments. Environ. Sci. Policy 164, 104014. https://doi.org/10.1016/j.envsci.2025.104014.
Vergne, J., 2020. Decentralized vs. distributed organization: blockchain, machine learning and the future of the digital platform. Organ. Theory 1 (4), 2631787720977052. https://doi.org/10.1177/2631787720977052.
Von Hagen, C., 2007. Towards a spatial data infrastructure for Somalia using open source standards. J. Spat. Sci. 52 (1), 157–169. https://doi.org/10.1080/14498596.2007.9635110.
Wallis, J.C., Rolando, E., Borgman, C.L., 2013. If we share data, will anyone use them? Data sharing and reuse in the long tail of science and technology. Plos One 8 (7), e67332. https://doi.org/10.1371/journal.pone.0067332.
Wamsler, C., 2013. Cities, disaster risk and adaptation. Routledge, London. https://doi.org/10.4324/9780203486771.
Wilson, M.W., 2011. Data matter(s): legitimacy, coding, and qualifications-of-life. Environ. Plan. D Soc. Space 29 (5), 857–872. https://doi.org/10.1068/d7910.
Wittmer, J., Prouse, C., Arefin, M.R., 2025. Digitalizing sewage: the politics of producing, sharing, and operationalizing data from wastewater-based surveillance. Environ. Plan. C Polit. Space. https://doi.org/10.1177/23996544241313454, 23996544241313454.
Yao, X., McCosker, A., Kang, Y.-B., 2025. Deepening the data divide: marginalised perspectives and non-profit priorities in Australian data sharing reforms. Big Data Soc 12 (1), 20539517241311585. https://doi.org/10.1177/20539517241311585.
Yin, R.K., 2018. Case study research and applications, 6. Sage, Thousand Oaks, CA.
Zheng, H., Pee, L.G., 2022. Research knowledge utilisation for societal impact: information practices based on abductive topic modelling. J. Inf. Sci. 50 (1), 129–144. https://doi.org/10.1177/01655515221081354.
Zulu, K., Ezeani, E., Salimi, Z., et al., 2025. Determinants of effective participatory multi-actor climate change governance: insights from Zambia's environment and climate change actors. Environ. Sci. Policy 167, 104040. https://doi.org/10.1016/j.envsci.2025.104040.

Appendix 4

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Upgrading fit-for-purpose land administration systems: challenges and opportunities in Bosaso, Somalia

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Upgrading fit-for-purpose land administration systems: challenges and opportunities in Bosaso, Somalia

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Fit-for-purpose land administration (FFPLA) approaches offer a solution to the lack of land governance strategies in the Global South, emphasizing flexibility, inclusivity, and scalability. However, FFPLA projects primarily focus on establishing land administration systems, with less attention given to ensuring their sustainability, ongoing maintenance and scale up. This study analyzes the evolution of the land and property registry in Bosaso, Somalia, utilizing the Framework for Effective Land Administration (FELA) to guide the assessment. Findings reveal that challenges remain in maintaining, expanding and upgrading land information management systems from their initial purpose to broader land-related services.

Keywords: Fit-for-purpose land administration, Upgradability, Urban land management, Digital infrastructure, Africa, Post-conflict

1. Introduction

In the Global South, rapid urbanization, widespread informality, and climate change are challenging the effectiveness of traditional spatial analyses and urban planning methods (Parnell and Pieterse 2014). In particular, access to land for most people remains insecure, posing significant risks of poverty, hunger, forced evictions, and social conflicts (Antonio *et al.* 2021). The delivery of land administration services is often inadequate due to weak legal systems, complex procedures, and poor institutional arrangements (Hull and Whittal 2016). In Sub-Saharan Africa, customary and informal land tenure systems and religious-derived law prevail over statutory forms of tenure and are typically unrecorded in official registries (Toulmin 2009). In countries emerging from years of conflict, such as Somalia, official registries are often incomplete, inconsistent, or nonexistent, exacerbating land issues (UN-Habitat 2015). The growing competition for land is driven by population increases, land use changes due to climate change, conflict dynamics, and pressure from large-scale land-based investment projects (German *et al.* 2011).

The 2030 global agenda recognizes the need to build affordable, equitable, and sustainable land administration systems to identify the way land is occupied and used, an urgency reflected in several targets of the sustainable development goals (SDGs), particularly SDGs 1, 2, 5, 11 and 15[1] (Balas *et al.* 2021). Implementing sustainable and affordable land administration systems has the potential to strengthen security of tenure for all and effective management of land use and natural resources. This, in turn, will enable political aims such as economic growth, social equity and environmental sustainability to be better supported, pursued and achieved. However, conventional systematic survey and cadastral mapping approaches, using total stations or theodolites, have been found to be of limited value. At the contemporary land tenure recording rate, it would take centuries to deliver adequate coverage (Koeva *et al.* 2017). There is a growing demand for land governance systems that are not only inclusive but also quick, cost-effective, and simple to implement (Zevenbergen *et al.* 2016).

To address the land registration gap, the principles of fit-for-purpose land administration (FFP LA) approach has in the past decade gained momentum, proposing locally suited methodologies based on alternative, effective, and scalable solutions in favour of conventional practices in land administration (Enemark *et al.* 2014a). The FFPLA approach recognizes the need to be flexible in the spatial, institutional, and legal frameworks without being limited by stringent standards of technical accuracy and legal requirements (UN-Habitat 2016). Their application leverages emerging technologies to accelerate the roll out of these approaches, such as the use of satellite imagery, demarcation of land holdings through automatic feature extraction algorithms, geo-cloud services for data storage and analysis, and apps for community mapping (Koeva *et al.* 2017).

The FFPLA paradigm was applied in numerous countries across the African continent (Antonio *et al.* 2021). In Somalia, attempts in streamlining land administration with a fit-for-purpose approach date back decades. Yet, only a few studies have attempted to look at land administration reform and its linkage with local governance building (Haas 2017). Land has been central

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in the academic and public policy debate. The focus has primarily been on the complex relationships between land, power, clans, and conflict (Bakonyi *et al.* 2019). Additionally, there is significant discussion about the link between land and politics in post-conflict state building (Tahir 2023). To a lesser extent, the ambiguity of legal pluralism and the informality of the land market have also been considered (Goodfellow *et al.* 2024).

FFPLA projects in Somalia are numerous, but often conceived as stand-alone and rarely take into account the wider shifts in cultural values, social norms and local-level political structures required for a contextualized land tenure administration system set up (Barry 2018). Moreover, despite maintenance and updating being one of FFPLA principles, the practical implementation of projects often focuses on the initial setup of systems without fully committing to their ongoing development, maintenance, and long-term sustainability (Augustinus and Tempra 2021) – a problem remarked in several FFPLA applicataions in other contexts (Bennett *et al.* 2021).

At the same time, much attention is devoted to the opportunities of FFP approaches for land tenure, and the description, recording and securing of land rights (Enemark *et al.* 2014b). How other aspects of land administration – such as land valuation, land use, and land development – are making use of Fit-For-Purpose (FFP) solutions is still not being sufficiently researched.

Against this background, our research explores the challenges posed by the long-term sustainability of FFPLA projects by analyzing the progressive efforts in building and further improving the property register and land administrative system in the urban area of Bosaso District in the State of Puntland, Somalia. We do so by applying the Framework for Effective Land Administration (FELA), a comprehensive set of policy guidelines on land administration systems developed by an expert group on land administration and management from the United Nations Committee on Global Geospatial Information Management (UN-GGIM 2020). Through this approach, our study seeks to explore the challenges in transitioning from setting up to maintaining, expanding, and upgrading fit-for-purpose land administration systems, and the extent to which fit-for-purpose approaches and emerging technologies are applied across broader urban land administration and management activities. The remainder of this article is organized as follows. Section 2 provides an overview of FFPLA with a focus on maintenance, expanding and upgradability, and it introduces the FELA framework. Section 3 describes our case study in Bosaso and the methodology that we used to conduct the analysis. Section 4 details the findings of the study, while Section 5 discusses their theoretical and practical implications. Section 6 concludes by indicating the limitations of our study and providing recommendations for future research.

2. Background

2.1. Fit for purpose land administration and upgradability

Faced with the growing challenges of rapid urbanization, the significant gap in land registration, and the difficulties of extending land administration to non-Western concepts, the land sector developed the 'continuum of land rights' metaphor. This concept broadens the notion of land tenure beyond conventional private and public typologies to include forms of landholding such as customary and communal (Enemark *et al.* 2014a).

As a technical response, the idea of Fit-For-Purpose Land Administration (FFPLA) emerged, emphasizing that any land administration system should be designed and implemented with local circumstances and tenures in mind, and should be adaptable for improvement over time. More specifically, fit-for-purpose land administration should consist of seven primary qualities: it should be flexible, inclusive, participatory, affordable, reliable, attainable, and upgradeable (Enemark *et al.* 2014b, Tan *et al.* 2021).

In particular, with the term upgradability, it is suggested that a system and its data should be constructed with a 'minimum viable' mindset in initial stages (UN-Habitat 2016), but that over time the system itself and the data held within it could be improved.

Despite the quantity and novelty of the approaches applying the FFPLA approach, the emphasis of the majority of projects remains in the establishment of the system (Barry 2018). The prominence of technology innovations is emphasized as a way to lower price, require less expertise, and in general make deployment and operation as quick and effective as possible within available human, financial, and technical resources (Koeva *et al.* 2017). At best, projects have considered the requirements for ongoing operation and upkeep (van der Molen 2002, Ercan 2023, Fayyad and Al-Sinnawi 2023), particularly when projects financially supported by international donors and development agencies come to a conclusion (Biraro 2015).

In this vein, Bennett *et al.* (2021) unpack the upgradability concept under the overarching theme of system maintenance, with two distinguished levels of change. On one side, the *update*, meant as and day-to-day upkeep, including grouping and redefining spatial updates (i.e. land subdivision, readjustment, or consolidation), updates to rights (i.e. land transfer, inheritance), and the length of time that a land right, restriction, or responsibility may apply. On the other side, the *upgrade,* encompassing institutional and organizational components (laws, business model, etc.), information quality (granularity and detail of the data, and their geographical scope) and technology.

A system development should also trickle through wider land management functions. The overwhelming majority of FFPLA projects, particularly in the African context, are conceived to advance land tenure. In particular, FFP is portrayed as a pro-poor activity aimed at guaranteeing land tenure security and associated rights for all, and particularly the most vulnerable groups (Unger *et al.* 2023). This is achieved though recording and therefore protecting land rights (Koeva *et al.* 2020), and reconciling customary and formal land tenure systems (Arko-Adjei and Akrof 2019). While it is within the philosophy of the fit-for-purpose approach to start small and scale up, projects that concentrate on other components of land administration services are still insufficiently explored (Kelm *et al.* 2021). These land administration services encompass land value, which includes the valuation and taxation of land and properties; land use, which covers the planning and control of the use of land and natural resources; and land development, which entails implementing utilities, infrastructure, construction works, and urban and rural developments (Palmer *et al.* 2009). Additional services can make use of structures and technologies made available by the initial setups, or bring forward new ones that need to be integrated (Kelm *et al.* 2021).

The breadth to which land management functions are aggregated beyond the specific focus of a single project are therefore a key area in understanding how a system is upgraded following a FFPLA approach and how this is transformed through digital technologies.

2.2. Assessing upgradability: a framework

Globally, fit-for-purpose solutions are proposed by many academic and professional experts to achieve sustainable solutions for land management systems. However, an agreed methodology for assessing their implementation and related challenges has not yet been developed (Rahmatizadeh *et al.* 2018, Hendriks *et al.* 2019, Milindi Rugema *et al.* 2022). To enhance understanding and describe land administration situations, the Framework for Effective Land Administration (FELA) (UN-GGIM 2020) is gaining increasing momentum (Metaferia *et al.* 2023). The FELA, developed by an expert group on land administration and management from the United Nations Committee on Global Geospatial Information Management (UN-GGIM)[2], is designed to provide a roadmap for policymakers and practitioners in land administration to strengthen secure and reliable relationships between people and land, thereby contributing to sustainable development efforts (de Zeeuw *et al.* 2020).

The FELA pathways include the following: (1) governance and institutions; (2) law and policy and legal; (3) finance; (4) data and processes; (5) innovation; (6) standards; (7) partnerships; (8) capacity and education; and (9) communication and engagement – see Figure 1.

These pathways are modulated in order to be relevant and guide implementation at local level, paying attention to available capacity, means, assets and local insights or advice. As such, FELA has been identified as a relevant framework for conducting country-specific assessments in various FFPLA case studies (Ahsan *et al.* 2023, Unger *et al.* 2023). The very notion of a pathway encapsulates but also a progressive route towards achieving sustainable and adaptive systems, with relevance to the specific challenges of upgradability (Bennett *et al.* 2021).

These pathways can help put in relation current (or the evolution of) results on land tenure, land value, land use, and land development functions with the land administration update and upgradability challenges and developed solutions.

2.3. Land administration in Bosaso, Somalia

Bosaso is the third most populous urban centre in Somalia, and one the major ports in the Gulf of Aden. The city is part of the State of Puntland, a portion of territory in the North of the country which emerged after the collapse of the Somali state in 1991. The state declared its authonomy in 1998 in the absence of a unified national government, but never sought indipendence and joined the Federal Government of Somalia once it was formed in 2012. However, this authonomy kept the state safe from the violent conflicts, wars and insurgencies that continued and continue in the South. Puntland has been building its own central administration and local district authorities, making significant strides in governance and democratization (Johnson and Smaker 2014, Hoehne 2015).

At the same time, Puntland, and the costal region of Bosaso in particular, experience some of the harshest climatic conditions in the country, exacerbated by climate change (Muse *et al.* 2023). These environmental pressures are disrupting the traditional territorial organization, which has historically relied on pastoralism and the

Figure 1. FELA pathways – UN-GGIM, Integrated Geospatial Inforation Framework (2018).

communal management of land through customary arrangements (Markakis 2004). This upheaval is driving significant rural-to-urban migration, triggering land privatization and land grabbing, and fuelling social conflict (Hagmann *et al.* 2020).

Additionally, relative peace and stability, economic opportunities mostly related to livestock export and port activities, and a pursued long-time approach of local and state authorities to designate and manage areas for internally displace people (IDP), have attracted a large share of the country's internal migration (UN-Habitat 2024). This has contributed to an urbanization boom during the last 30 years.[3] The situation is expected to accelerate due to anticipated increase of economic activities connected to the port expansion and modernization (Dua *et al.* 2020).

As a consequence, the city has been experiencing a striking shift from communal, customary and public tenure arrangements to individual and exclusive land ownership. Private land holding have been rapidly increasing since the collapse of the Somalia State at beginning of the 90s and boomed with the Diaspora investments of the last decade (UN-Habitat 2024). This privatization of land has occurred with no attention to social equity, allocation for basic services and public facilities, and not regard to environmentally sensitive areas, setting the city in a trajectory that could threat its very survival (Hagmann *et al.* 2020).

To address this issue, the Municipality of Bosaso has been making efforts towards building a land information and administration systems that could help managing these trends. Thanks to the prolonged effort, the city has now developed a well-established policy that links property registration with land taxation and land-related conflict mitigation.

Bosaso serves as an excellent case study as many Somali cities are now following a similar development trajectory, especially when it comes to land administration and particularly property registration. Given its extensive and well-documented experience in establishing a robust land system, Bosaso provides valuable insights and lessons learned that can guide other urban centres in their developmental efforts. These advancements not only have repercussions on recovery and reconciliation in post-conflict settings but also lay the groundwork for functioning government entities capable of delivering essential services to their residents, thereby promoting stability and sustainable growth.

3. Research methods

3.1. Case study

A study of the evolution of a land administration systems calls for a process perspective supported by longitudinal qualitative data (Ven 2007, Langley *et al.* 2013). The case study covers the period of 2008–2024 based on primary and secondary data collected within 2022–2024. In particular, the analysis carried out in this research concentrates upon district specific interventions under three UN Projects.

The United Nations Joint Programme on Local Governance and Decentralized Service Delivery (UN JPLG) run between 2008 and 2023 through three five-year iterations and was implemented by five UN agencies (UNDP, UNICEF, UN-Habitat, ILO and UNCDF). JPLG tackled land administration as an essential component for its two main programme objectives: administrative and fiscal devolution. In particular, land-based taxation was identified as a key source of revenue for the local governments. Under these premises, UN-Habitat collaborated with Bosaso's local authorities to create a GIS-based property survey as a base for property taxation and various its various connected services.

The Land and Property Tax Revenues for Service Delivery, Reconstruction, Citizenship Building and Sustaining Peace in Fragile States (LBF) Project, run by UN-Habitat, also targeted Bosaso as a key location for enhancing and streamlining land-based finance between 2021 and 2022.

The Saamyenta (*Impact* in Somali) Programme (full title: Saameynta – Scaling up solutions to displacement in Somalia), scheduled to run between 2022 and 2025 and implemented by IOM, UNDP and UN-Habitat, is continuing these efforts, planning to support the Municipality in expanding data collection targeting areas settled by displacement affected communities (e.g. IDPs and refugees) and previously not surveyed. The main target for the project is to improve land tenure security for displaced people by applying tools for FFPLA and land value capturing.

3.2. Data analysis

The primary data are based on various documents covering the entire time period of analysis. These include, on one side, various official documents and reports on the development of JPLG, LBF and Saamyenta. On the other side, we considered numerous policy documents like Bosaso District Development Frameworks, its city-wide strategies, and laws and regulations developed in Puntland and Somalia. Other materials examined include government reports, websites, statistical data and figures, pieces of news stories and editorials, as well as brochures pertaining to processes of land administration, urban planning and development. Appendix 1 presents the sources used in our study.

Second, we conducted unstructured interviews with project managers and technical officers from the Bosaso Municipality, the Puntland Ministry of Public Works, Transport and Housing (MoPW), and UN-Habitat, together with land experts and practitioners in the context of Somalia. A total of 17 participants were involved. When selecting interviewees, we aimed for a diverse representation across various organizational levels, from senior management to frontline staff, and balanced between participants directly involved in the JPLG, LBF and Saamyenta project and those with an external viewpoint. Therefore, our sample includes project team members with technical expertise and a comprehensive understanding of the land administration system's development and implementation, as well as officials knowledgeable in urban planning processes, innovation dynamics, and data management within Bosaso, Puntland and Somalia. Crucially, several interview participants have been active in shaping Bosaso's land administration since in the early 2000s, thus allowing for reflections on key past events, and to get a better understanding of the contextual conditions, challenges and opportunities underpinning them. See Appendix 2 for a list of the interviews.

An additional secondary data source, especially for fact triangulation, were observational data gathered by authors in their active involvement in the three projects since 2016.

Observation data allowed to capture the decision-making and related successes and ongoing challenges in developing land aministration system within that period.

Documents and interview transcripts were analyzed using a thematic-coding approach (Gioia *et al.* 2012). An abductive method of analysis allowed the identification of codes and concepts, linking empirical data and theoretical dimensions that aligned with the FELA pathways. The coding process was conducted in three key stages. Initially, one author identified the primary concepts through direct engagement with the data, which were subsequently reviewed and discussed with a second author. Finally, both authors held periodic discussions to refine the overall coding results and data structure (Skjott Linneberg and Korsgaard 2019).

4. Findings

4.1. Governance and institutions

In 2008, Bosaso local government and Puntland in general lacked evolved systems and procedures for land administration, and those in use were largely ad-hoc in nature. Therefore, when JPLG first launched, it envisioned three primary objectives related to land administration. First, to enhance and streamline revenue collection, with property taxation proposed as a more stable and reliable source of income compared to tariffs on livestock and market activities, which, until 2008, were the municipality's sole significant revenue sources. Second, to improve existing tenure security practices, particularly through property surveys aimed at enhancing land administration processes and resolving boundary disputes amidst widespread privatization and informal encroachments IDPs. Third, to generate relevant, reliable, and granular information on the rapidly expanding urban centre, supporting urban profiling and planning efforts. This broad value proposition, present in most documents at the beginning the period analyzed, was understandably ambitious for a nascent administration.

Governance challenges compounded these efforts, with responsibilities fragmented and overlapping across various state ministries and municipal authorities. Within the municipality itself, the evolving administrative structure exhibited similar ambiguities. While roles and responsibilities were nominally delineated, they often operated flexibly, responding to immediate needs rather than adhering to standardized procedures.

Consequently, the founding phase of Bosaso land administration began with small teams of typically a municipal unit, a state ministry and one UN agency focusing on specific mandates to gather resources and lead change. For example, the Land Department worked with the Ministry of Public Works and UN-Habitat's land team, the planning department with the Ministry of Interior and UNDP, while the Revenue Department worked with the Ministry of Finance, UN-Habitat's municipal finance experts and UNCDF. Although under the umbrella of the same overarching programme, interaction among these teams were very limited.

Despite incremental improvements and policy development, discussed in the following sections, this approach persisted throughout the years. Local interviewees pointed to impatience with ever-increasing working groups and coordination meetings, most of which they saw as redundant and slowing progress on the field, while the actual work was done on the field in small, isolated team. From the UN side, competition over funds and the need to report progress on project indicators pushed actors to focus on specific activities rather than systemic coordination.

Additionally, the initial implementation focused on tax and revenue collection, which received the largest share of resources. In line with the FFP approach, this objective was prioritized because it was regarded as the most urgent and relatively more achievable, with potential benefits expected to cascade to other services. For the remaining goals, the emphasis remained on laying the legal and strategic groundwork for phased implementation, such as 'initial steps toward strategic planning' and studies assessing existing legal frameworks and dispute resolution mechanisms. Despite the initial comprehensive goals, the relative success of property tax implementation and the subsequent increase in own-source revenue for the district did not translate towards the other objectives. Rather, this achievement progressively attracted more focus, overlooking the integration with other departments, entrenching the siloed operational environment in the municipality. This disconnect was echoed in the way the urban administration evolved – see Figure 2. The urban area of Bosaso is currently divided into four urban villages, and multiple sub-zones. These sub-zones were created specifically for the sake of the property registration exercise, but do not align with urban landmarks or community recognized boundaries. The arbitrariness of these geographical subdivision is remarked by the fact that they were freely renominated and reshaped within subsequent surveys, in 2008, 2016 and 2022. The city is also divided into 16 districts, that do not correspond to the four Zones and their respective subzones. These districts have a dedicated administrative body responsible for service delivery (schools, health centres), and recognized physical boundaries. These are also the districts referred to in land title deeds. Beyond their lack of mutual correspondence, both urban villages and urban district boundaries to date are limited to the urban area between the Eastern and the Western Bypasses. As the city already exceeds those roads, this unclear governance system contributes to a number of issues. For example, land titles released for properties indicate a sub-district at the discretion of the municipal officer issuing the document. Land title deeds for the Gribble IDP relocation site, south-east of the city, were associated with Gribble A sub-village; areas around 'Fun City' real estate development, south-west of the city, were associated with Wadajir.

4.2. Law and policy

Legal pluralism in land administration existed and still exist in Puntland and Somalia at large. Shar'ia law was recognized in both the State (2009) and the Federal Constitution (2012), and customary law plays an important role in land governance particularly in rural areas where the capacity to implement formal legislation is

Figure 2. Boundary comparison: property registration (left) and administrative urban villages (right) – the authors.

low. Religious and customary law provide important contributions to land governance. At the same time the Puntland and Somalia Constitution recognized all previous laws until they were repealed. The Constitutions also included certain clauses on land, which became supplemented by a number of new acts. However, according to most interviews and as noted in various documents, these were largely incomplete and poorly defined. As previous laws were not explicitly repealed, contradictions and confusions abounded. This resulted, over the years, in a substantial absence of effective formal authority governing land use and land tenure, allowing landowners and market forces to determine land appropriation and acquisition. In Bosaso, public notaries emerged as the primary issuers of title deeds for real estate transactions. Although licenced by the Ministry of Justice and the Office of the President of Puntland, their operations lacked stringent oversight, and multiple claims on individual plots are not infrequent.

Only in 2020, the Urban Land Management Law (ULML) for Puntland was enacted by the Puntland Parliament. Interviewees described how the Law resolved the institutional unclarity over land administration, offering an opportunity to address and nurture innovative solutions for land governance in conjunction with the challenges of urbanization. Among the forward-looking provisions, 30% of the newly urbanized area has to be acquired into public property to be later allocated for public space and facilities. The law regulates land-related taxes, and includes provisions for data exchange from the municipalities to line ministries, particularly property records and on spatial trends and land management issues. However, its application has proven difficult. Some of the interviewees remarked the lack of provisions over communal land tenure, although most interviews reiterated that ‘everything is private in Bosaso’.

After four years of enactment of the law, guidance notes or directives are yet to developed, for example on the details of land acquisition and compensation. Due to the limited capacity to produce comprehensive town plans, planned expansions are designed as continuous grids of plots rather than guiding mixed-land use development towards vibrant and self-sustaining neighborhoods. This approach maximizes short-term tax revenue for the municipality and avoids the challenging issues related to compensation. Additionally, competition over resources still hamper collaboration and transfer of best practices among different public entities. Some ambiguity also exists in the notion of ‘urban’ inscribed in the law title but never defined or spatially quantified in the country. Particularly in rural contexts, this could cause frictions between the municipality and state ministries, particularly the Ministry of Public Works and the Ministry of Agriculture, claiming authority respectively for ‘urban’ and ‘rural’ land. Moving forward there was wide appreciation among interviewees of the need for a comprehensive land policy. This would require the commitment and determination of all stakeholders for a unified land legislative framework and to work in synergy. It will also require the reform and clarification of several other laws, the development and capacity building of institutions and a commitment by the government to ensure transparency and justice. It also requires the strengthening of communal land tenure and women's rights to land.

4.3. Finance

As mentioned, the municipality, with wide support from international agencies, have invested big efforts in land and property taxation, also due to the low reliability of the transfers from the central government. Since the first property survey in 2008, land-based revenue, and more significantly property tax, become a key part of Bosaso's budget, accounting for 19% of own source revenue and 15% of the total budget in 2022.[4] The relative success in increased land-based revenue has favoured over the years a rent-seeking behaviour in the municipality, which promotes development of properties even in the absence of planning and against environmental safeguards with the purpose of extending its revenue base. Interviewees noted that expanding the number of taxable properties has proven an easier target than improving the taxing system. The fee determination for property tax has not changed since its introduction, and currently applies the same rate to every property, multiplied by the property footprint area and property height (where not assessed, height is considered 3.5 m). This simplified approach, taking into account only straightforward and easy to collect information, was meant to speed up its application and simplify management. However, it does not differentiate between high-value and low-value properties. It also doesn't consider the level of essential services and infrastructure in the area, or the financial ability of the taxpayer. This results in remarked inequalities and unfair tax applications. A simplified land-valuation through a so-called banding system is currently being explored, and the generic initial data for parameters could be obtained using the current property registration. Some enhancements were introduced, for example allowing mobile tax payment mechanisms in 2022, with invoices to be distributed and paid through USSD codes to mobile phones. Nevertheless, so far simplified collection but did not result in higher compliance.

4.4. Data and processes

The GIS-based property survey was initially created in 2008, and later updated with a new survey in 2016 and more recently in 2022. The first survey used a questionnaire to capture the resident's details, a tape measure for the property dimensions and a hand-held global positioning system (GPS) device to take coordinate readings for the property. Data clerks then entered this information on a municipal database, cleaning each entry by removing duplicates, identifying the gaps in information and classifying the type of property by the general category of formal, informal, public and private and further into subcategories appropriate to the purpose for which the land is used. This was linked to a financial management system for tax purposes. Municipality staff were trained on the uses and maintenance of the GIS database.

Each subsequent survey has increased the number of the records. However, the detail and quality of the data has progressively reduced. The original database allowed for a rich amount of information to be collected, from land use to materials and condition of the building and surrounding road infrastructure, to occupant data. It also included the georeferenced footprint of buildings and demarcated land holdings derived from satellite imagery. The latest survey, conducted in 2022, reduced the amount of information collected to the bare minimum for tax purposes (use, size and height of the building). This is due to lack of standards on initial capture and maintenance, but also to the absence of quality control and enforcement. The surveys were also not undertaken as updates but as completely new exercises: there is no correspondence between older and newer databases, meaning that ready-recorded properties were surveyed again, and comparability is hard when not impossible.

Additionally, to date the database is currently hold by the Revenue Department and not in use by the Land Unit. Each registered property was assigned a unique identifier code, recorded not only digitally but also painted or stenciled on the main façade – in the latest exercise, reported on a metal plate installed on the property – see Figures 3–5. Conversely, land titles are still paper-based, and do not include the identifier code and the geographical location of the land, but only a description of bordering properties and position within the administrative zones and subzones. With no innovation processes embedded to promote and enable data exchange within the municipality, updates are only sporadic.

The geographical coverage of the database has also continued to be confined to the area between the Western and the Eastern bypass, omitting the rest of the city – see Figure 6. This excluded several key economic activities (for example, the two main livestock facilities), but also the main cluster of IDP settlements. This has left approximately 20% of the population with no formally recognized tenure exposing them to higher risks of new displacement.

4.5. Innovation

As noted throughout the previous sections, there has been a lack of innovation and a few changes to the land administration system in Bosaso. The few exceptions concentrate on the Revenue Department, particularly in the way property tax is managed, with more advanced software improving processes and simplifying collection. In the Land Unit most of the operations remain manual and paper-based. Interviewees expressed strong interest in adopting the latest technologies, noting that the lack of legacy IT infrastructure – or any significant infrastructure – makes implementation easier. However, some cautioned that technology-intensive solutions requiring advanced IT expertise face challenges in a jurisdiction where such skills are scarce.

4.6. Standard

Bosaso's land administration efforts started as need-based, context-driven, and focused on addressing immediate local challenges, prioritizing practicality over broader integration or standardization. The siloed governance and institutional structures discussed earlier have further exposed significant gaps in cross-comparability and interoperability. The absence of standardized protocols for data sharing – within Bosaso, across other urban centres, and at state or national levels – undermines efforts to build a cohesive system. This lack of uniformity prevents the kind of cross-city and nationwide comparability necessary for coordinated policymaking, efficient resource allocation, and broader strategic

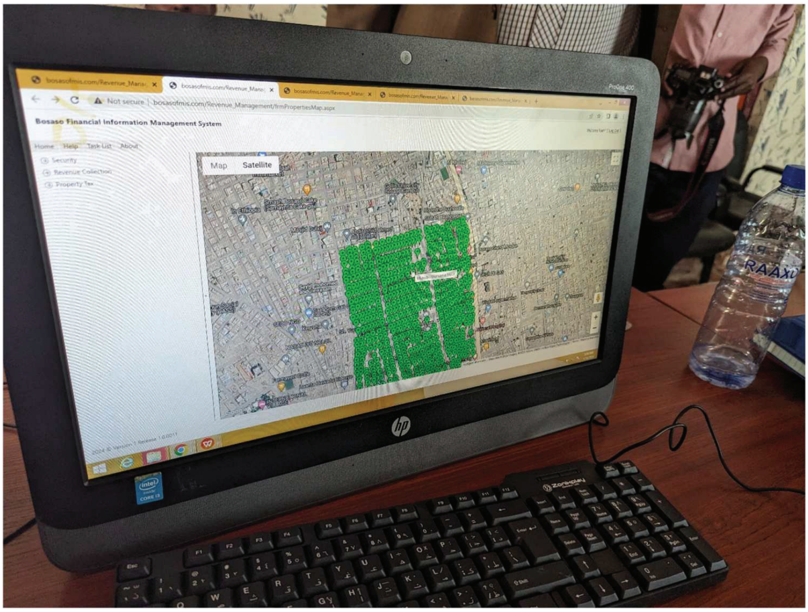

Figure 3. GIS property map of one city district shown in a computer screen of the revenue department – the authors.

planning. Several interviewees emphasized the need for a stronger push towards these objectives, particularly as Bosaso, being comparatively more advanced than most urban centres in Somalia, is expected to serve as a model of best practices. However, this potential is not being realized due to a lack of comparable and interoperable systems. Additionally, the database's sensitive nature, containing information on property ownership and taxation, further complicates its utilization. The analysis highlighted the lack of a robust anonymization process, together with safeguards for data security and privacy, making sharing and open publication not feasible. Most interviewees agreed that these challenges require a concerted effort across tiers of government to establish standardized systems, but at the moment this goal does not figure in any document.

Figure 4. Property tag with the unique property identifier – the authors.

Figure 5. Façade of a building with the property tag installed on the gate. On the sides, the codes from the previous property surveys painted or stenciled – the authors.

4.7. Partnerships

Interviews highlighted that early partnerships were marked by significant dependency, with international agencies' funding and expertise heavily influencing priorities, methods, and timelines, often decided at national and state levels. Local administrators frequently complained of being excluded from consultations, limiting effective resource use. Over time, this dynamic has shifted. Although reliance on external funds remains, local authorities have grown more aware of their agency and now advocate more effectively for their needs and priorities. For instance, a planned property survey in Bosaso was delayed when the 2018 expansion of JPLG's scope to new municipalities redirected funds away from the city. The survey only took place in 2022 after Bosaso successfully lobbied to join the LBF project. The survey was also carried out by the Municipality in collaboration with the MoPW with only the supervision of UN-Habitat. Bosaso is also nurturing its relationship with local universities and private companies to expand its pool of professionals for collaboration in the land sector.

4.8. Capacity and education

The municipality was initially burdened with a high number of inefficient and unskilled staff hired on a tribal basis, rather than expertise. Through the years Bosaso, and the State of Puntland, have consolidated structure and staff charts and invested in training newly recruited employers, surveyors and collectors. Since 2008 the number of staff in the municipality has shrunk by almost a third, increased female representation up to 28%, and now shows higher levels of education across all departments. However, salaries remain very low, and stayed fixed, fixed, with no consideration for productivity or quality. This causes a very high turnover and related dispersion of knowledge and expertise. At the same time, tax and finance staff has been prioritized over the Land Unit. This has meant the depletion of the land records, with the result that, as highlighted before, property registration very rarely corresponds to an update of the land database.

A remedy conceived by JPLG was capacity injections at ministerial level to fill with a limited number of experts the needs of multiple towns. This way, when needed, Bosaso relies on state ministries rather than international agencies to fill temporary capacity gaps for specific gaps. For example, the last city-wide GIS property survey was conducted by the MoPW and the district with MoPW's urban planning unit and short-term collectors, while fix-term employees are embedded in the municipal administration for the long-term maintenance of the system. Still, a key challenge remarked by all interviews is retaining staff, particularly as several positions are connected to donor funding and not renewed as projects expired. Salaries constitute the largest share in the municipal budget but still do not match needs.

Additionally, land-associated services would require a constant investment in training, educational curricula, and technological equipment. However, IT, software licences and surveying tools are mostly provided by international agencies under specific projects, and the municipality is unable to finance new procurements on its own.

4.9. Communication and engagement

While residents participated during the community mapping exercises and field verification in all surveys, broader participatory approaches were noticeably absent.

Through JPLG, Bosaso set up a planning process designed to include opportunities for citizens and stakeholders to participate in public meetings after the fiscal

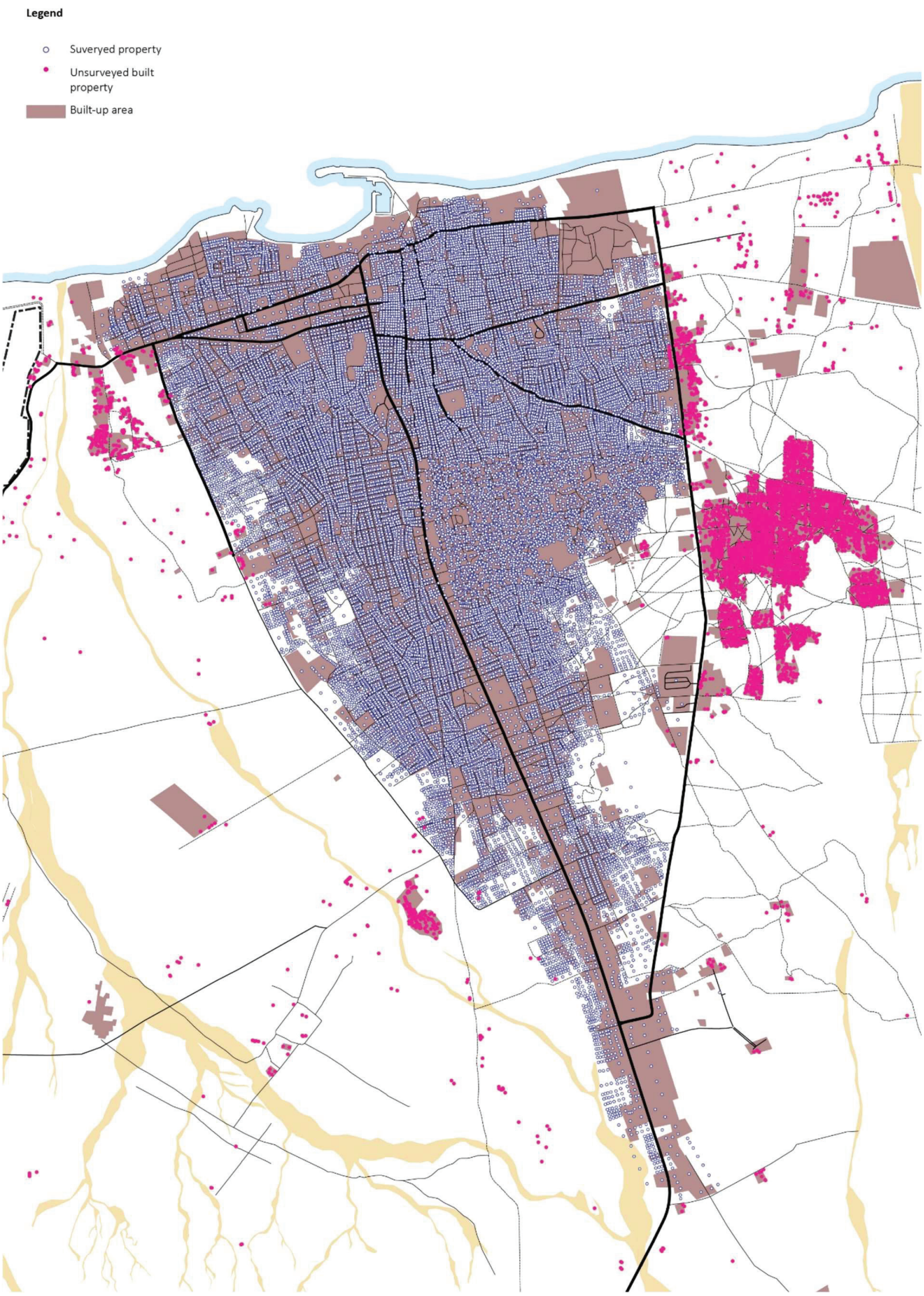

Figure 6. Property registration coverage, with the large IDP cluster south-east of the City – the authors.

year's close. These meetings are intended to review progress on plan implementation and compare actual expenditures against budgeted allocations. However, such meetings do not cover specific issues of land administration or urban planning, and have not yet been institutionalized as a regular practice.

Traditional methods of citizen engagement, which could have positioned residents as valuable feedback providers, were also notably absent throughout the years. Interviews highlighted this as a missed opportunity to cultivate a trust-based relationship between the community and the administration.

5. Discussion

The case of Bosaso and its progress in FELA's pathways show the challenges in moving from the initial fit-for-purpose set up to generating scalable solutions that contribute to sustainable development. In this section, we provide a cross-cutting analysis of the findings, presenting three key propositions for advancing from the establishment phase to the maintenance, expansion, and upgrading of fit-for-purpose land administration systems. Since these propositions are based on a single case study, their purpose is to consolidate overarching insights and offer statements for validation in future research.

A 'fit-for-purpose' design can be implemented in stages but requires unified strategies, spatial clarity and inclusive governance.

In Bosaso, aligned with the FFP approach, a strategy prioritizing the most attainable goals – namely, land and property taxation – has been employed. This has made the municipal Revenue Department a well-functioning unit but left behind several other sections of the local authority and therefore affected several other key land administration functions, for example, building permit, development control and environmental oversight. The initial broader motivation, which could be considered 'multi-purpose' land administration, has narrowed over time, leading to divergent objectives, redundancy in plans, land conflicts and overlapping responsibilities in the execution of many land administration projects.

Fragmented authority across various public institutions served as a barrier to effective land administration in Bosaso. Land administration involves numerous stakeholders from both public and private sectors, making the formation of strong partnerships and the presence of a central authority to guide the entire process essential (Bennett and Alemie 2016). The absence of unified strategies led by a central authority and the lack of coordination and cooperation among a city's operational networks hinder governments' efforts to implement land administration projects swiftly and effectively (Cordella and Paletti 2019).

Land administration is not only a functional responsibility but has also strong spatial aspects (Milindi Rugema *et al.* 2022). Clearly defined administrative boundaries are essential for overcoming fragmented institutional mandates and the lack of coordination mechanisms across public service institutions (Owusu 2009). In Somali cities, in fact, the sub village has also an administrator who works as an intermediary between the locals and the municipality. Clearly demarcated boundaries should then formally recognized by the city council through a bylaw and streamlined throughout administrative processes and procedures to ensure consistency and legitimacy. This would support clear mandate at ground level for accountability and transparency (Safo *et al.* 2024) This would further support the actual delivery of land-related services, including proper urban and land use planning, as well as the provision of basic services and infrastructure necessary for land development and urban renewal (Yeboah *et al.* 2013). Clear spatial demarcations facilitate better coordination for data collection, management, and aggregation (Owusu 2009). If these measures are not implemented, the result is a fragmented land governance system that benefits only a few individuals who have access to resources and can exploit loopholes.

Fit-for-purpose land administration can support urban management with highly valuable public information only through Integration, Standards, and Capacity.

Emerging 'smart' or 'data-driven' urban management approaches highlight the promise of reusing and repurposing data across contexts and aggregating it across scales to enable informed decision-making (Engin *et al.* 2020, Curran and Smart 2021). In Bosaso, this potential is not being fully realized. On the internal level, the administration should focus on building a knowledge base that supports future scenario modelling, risk analysis, and evidence-based decision-making (Kelm *et al.* 2021). On the broader state level, there is a need for enhanced cross-city monitoring and policy development to support coordinated agenda setting linked to state and national priorities. This means going beyond the naive faith in new and disruptive tool and concentrating in the setting of national and international standards (Borgogno and Colangelo 2019). This approach would maximize the benefits of the land administration system, turning data into a powerful tool for sustainable urban development. Integration and interoperability between spatial planning, land valuation, and land management, are some of the challenges that upgrading entails in the context of Bosaso and Somalia.

Overcoming silos within the administration and in the wider data ecosystem means investing in digital infrastructure – as often associated with FFP approaches (Koeva *et al.* 2017) – but also, simultaneously, in people. This dual investment fosters a more integrated approach, enhancing the capacity for effective data reuse and better coordination across different levels of government (Bharosa 2022). By modernizing digital infrastructure and equipping personnel with the necessary skills and tools, administrations can streamline processes, reduce redundancies, and improve the accuracy and accessibility of data (Calzada 2017). This integration ensures that data is not only collected and stored efficiently but also shared and utilized effectively across departments and agencies (Chatterjee and Kar 2015). As a result, it facilitates more informed decision-making, promotes transparency, and enables a more cohesive and responsive governance structure (Bresciani *et al.* 2018). Ultimately, this holistic investment strategy leads to more sustainable and equitable land administration practices, benefiting society.

Long-Term Investment Strategies and Economies of Scale are key for sustainability and scale-up.

Efforts on capacity building within local offices must be supported by adequate funding from both internal and external sources and sustained beyond the typical duration of development projects (Magis and Zevenbergen 2014). To ensure a truly 'fit-for-purpose' design, key tasks must be prioritized and carefully executed, even within strict funding deadlines (Bennett and Alemie 2016). Conducting a thorough user needs assessment before initiating a project is essential for aligning outcomes with stakeholder requirements (Ho *et al.* 2018). Longer-term considerations also require greater attention, including instituting updating procedures (Biraro 2015, Bennett *et al.* 2021).

Additionally, successful initiatives are more likely to be scaled up and shared across different services when they offer prospects for economies of scale – reducing unit costs while increasing efficiencies and creating incentives to capitalize on these benefits (Bundgaard and Borrás 2021). Bosaso has made substantial progress in improving its property information system, primarily to expand its property tax base. However, enhancing land-based valuation assessments and ensuring efficient expenditure for public service delivery could further reinforce the social contract and improve tax compliance (Delbridge *et al.* 2022). Addressing the challenges of moving beyond short-term thinking will require a transformative shift in the administration's strategic and political mindset, as well as the mobilization of technical and analytical capacities to improve land governance (Ranchod 2020).

The private sector offers significant potential to address capacity gaps and improve efficiency (Klievink *et al.* 2016). However, for these partnerships to succeed, local governments must develop strong steering capacities to manage public-private partnerships, ensuring that collective interests and public value are safeguarded (Klievink *et al.* 2018). This balance is critical to unlocking land administration's potential for economic development while addressing social and environmental concerns (Parnell and Walawege 2011). This strategy aligns closely with the SDGs, fostering shared prosperity and equitable opportunities. By nurturing collaborative frameworks between the public and private sectors and embedding development initiatives in a broader commitment to social and environmental sustainability, Bosaso can set a model for sustainable urban growth and improved public service delivery across Somalia and other countries approaching innovative systems of land administration.

6. Conclusion

Most fit-for-purpose projects primarily assess whether an organization can quickly and effectively implement a system with its ready-available resources. Considering requirements for maintenance and upgrades is more complex and highly contextual. With its long experience in local governance Bosaso is a good example of challenges and opportunities of sustaining this implementation over a longer period and across different land administration services with a FFP approach.

However, the path for land administration scale-up can be different, and differentiating the role and capabilities of the municipality in terms of these different paths and in relation to the other governance conditions is essential. Comparative case studies from a wider range of geographical areas within and beyond the country are essential to advance knowledge on FFPLA adoption, maintenance and scale up and to generalize lessons from this study. As FFPLA and digitalization in government and administration evolve for Somali cities, sustained reflection, integration of external and local expertise, as well as responsible design iterations remain crucial. Therefore, continued investments in land governance together with local commitment matter to gain sustained benefits from fit-for-purpose land administration in the longer run.

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Note on contributors

Francesco Tonnarelli is an urban planner and architect with broad experience working with intergovernmental organizations, multinational and design firms across Europe, South Asia and East Africa. He has managed and supported projects for different agencies of the United Nations, concentrating on technical and policy advice to national and local governments with specific focus on capacity building and innovation as an enabling tool for sustainable urban projects. As a doctoral student, his research focuses on governance mechanisms of digital transition and their impact on land administration and urban planning in the Global South and small urban contexts.

Sophos Sophianos has been working with UN-Habitat in Somalia for nearly ten years with a focus on urban regulations and land governance, planning, affordable housing and solutions to internal displacement. Together with Francesco Tonnarelli he produced urban profiles for secondary cities in Somalia and developed concepts for spatial strategic plans and visioning exercises in Mogadishu and Hargeisa. Previously, he had been deployed to municipal land, housing and planning offices in Ethiopia, Malawi and Nepal under GIZ programmes for subnational governance and decentralization. Before graduating as Urban and Regional Planner from Berlin Technical University, he managed tenant services and public relations for a non-for-profit housing trust in Leipzig.

Supplemental data

Supplemental data for this article can be accessed online at https://doi.org/10.1080/00396265.2025.2455369.

Notes

1. See for example Target 1.4 and Indicator 1.4.2, 'Proportion of total adult population with secure tenure rights to land, (a) with legally recognized documentation, and (b) who perceive their rights to land as secure'
2. The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) is

a body that coordinates and oversees global geospatial information management efforts, aiming to enhance the availability and quality of geospatial data and its integration into public policy and decision-making processes. It is one of the nine expert groups of the United Nations Economic and Social Council (ECOSOC).
3. Bosaso moved from a small centre of about 25,000 inhabitants in 1985 to the third city in Somalia, with more than 600,000 citizens. As a consequence the urban built-up area grew by 1100% in the same period.
4. It is worth noting that the most significant local source of revenue are customs fees, accounting for 47% of total OSR. This is showing the importance of the port for the economy of the city. Land-based revenue constitutes 36% of non-port related OSR.

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References

Ahsan, M.S., *et al.*, 2023. Assessing the status and challenges of urban land administration systems using framework for effective land administration (FELA): a case study in Pakistan. *Land*, *12*(8), 1560. doi:10.3390/land12081560.

Antonio, D., *et al.*, 2021. Transforming land administration practices through the application of fit-for-purpose technologies: country case studies in Africa. *Land*, 10 (5), 538. doi:10.3390/land10050538.

Arko-Adjei, A., and Akrof, E.O. 2019. *Customary land tenure security: tools and approaches in Sub-Saharan Africa (a synthesis report)*. UN-Habitat.

Augustinus, C., and Tempra, O., 2021. Fit-for-purpose land administration in violent conflict settings. *Land*, 10 (2), 139. doi:10.3390/land10020139.

Bakonyi, J., Chonka, P., and Stuvøy, K., 2019. War and city-making in Somalia: property, power and disposable lives. *Political geography*, 73, 82–91. doi:10.1016/j.polgeo.2019.05.009.

Balas, M., Carrilho, J., and Lemmen, C., 2021. The fit for purpose land administration approach-connecting people, processes and technology in Mozambique. *Land*, 10 (8), 818. doi:10.3390/land10080818.

Barry, M., 2018. Fit-for-purpose land administration – administration that suits local circumstances or management bumper sticker? *Survey review*, 50 (362), 383–385. doi:10.1080/00396265.2018.1501130.

Bennett, R.M., *et al.*, 2021. Land administration maintenance: a review of the persistent problem and emerging Fit-for-purpose solutions. *Land*, 10 (5), 509. doi:10.3390/land10050509.

Bennett, R.M., and Alemie, B.K., 2016. Fit-for-purpose land administration: lessons from urban and rural Ethiopia. *Survey review*, 48 (346), 11–20. doi:10.1080/00396265.2015.1097584.

Bharosa, N., 2022. The rise of GovTech: Trojan horse or blessing in disguise? A research agenda. *Government information quarterly*, 39 (3), 101692. doi:10.1016/j.giq.2022.101692.

Biraro, M., Bennett, R.H., and Lemmen, C., 2015. Accelerated land administration updates. *In*: J. Zevenbergen, W. De Vries, and R.M. Bennett, eds. *Advances in responsible land administration*. Boca Raton: CRC Press, 145–162.

Borgogno, O., and Colangelo, G., 2019. Data sharing and interoperability: fostering innovation and competition through APIs. *Computer law & security review*, 35 (5), 105314. doi:10.1016/j.clsr.2019.03.008.

Bresciani, S., Ferraris, A., and Del Giudice, M., 2018. The management of organizational ambidexterity through alliances in a new context of analysis: internet of things (IoT) smart city projects. *Technological forecasting and social change*, 136, 331–338. doi:10.1016/j.techfore.2017.03.002.

Bundgaard, L., and Borrás, S., 2021. City-wide scale-up of smart city pilot projects: governance conditions. *Technological forecasting and social change*, 172, 121014. doi:10.1016/j.techfore.2021.121014.

Calzada, I., 2017. The techno-politics of data and smart devolution in city-regions: comparing Glasgow, Bristol, Barcelona, and Bilbao. *Systems*, 5 (1), 11. doi:10.3390/systems5010018.

Chatterjee, S., and Kar, A.K. 2015, August 1. Smart cities in developing economies: a literature review and policy insights. *2015 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*.

Cordella, A., and Paletti, A., 2019. Government as a platform, orchestration, and public value creation: The Italian case. *Government information quarterly*, 36 (4), 101409. doi:10.1016/j.giq.2019.101409.

Curran, D., and Smart, A., 2021. Data-driven governance, smart urbanism and risk-class inequalities: security and social credit in China. *Urban studies*, 58 (3), 487–506. doi:10.1177/0042098020927855.

Delbridge, V., *et al.* 2022. *Enhancing the financial position of cities: Evidence from Kampala* (Financing Sustainable Urban Development, Issue. I. G. Centre).

de Zeeuw, K., *et al.* 2020. The proposed United Nations framework for effective land administration (FELA): Progress, pathways and prospects. *Proceedings of the Land and Poverty Conference*.

Dua, J., Warsame, A., and Shire, A., 2020. *Bosaso and the Gulf of Aden: changing dynamics of a land-sea network*. London/Nairobi: Rift Valley Institute.

Enemark, S., *et al.* 2014a. Building fit-for-purpose land administration systems. XXV FIG Congress 2014: Engaging the Challenges, Enhancing the Relevance.

Enemark, S., *et al.*, 2014b. *Fit-for-purpose land administration*. Copenhagen: International Federation of Surveyors.

Engin, Z., *et al.*, 2020. Data-driven urban management: mapping the landscape. *Journal of urban management*, 9 (2), 140–150. doi:10.1016/j.jum.2019.12.001.

Ercan, O., 2023. Evolution of the cadastre renewal understanding in Türkiye: A fit-for-purpose renewal model proposal. *Land Use policy*, 131, 106755. doi:10.1016/j.landusepol.2023.106755.

Fayyad, M., and Al-Sinnawi, A.R., 2023. Challenges of sporadic land registration in Palestine. *Land Use policy*, 131, 106723. doi:10.1016/j.landusepol.2023.106723.

German, L., Schoneveld, G., and Mwangi, E., 2011. *Contemporary processes of largescale land acquisition by investors: case studies from sub-Saharan Africa*, Vol. 68. Bogor Barat: CIFOR.

Gioia, D.A., Corley, K.G., and Hamilton, A.L., 2012. Seeking qualitative rigor in inductive research: notes on the Gioia methodology. *Organizational research methods*, 16 (1), 15–31. doi:10.1177/1094428112452151.

Goodfellow, T., *et al.* 2024. Land and connectivity: Domain report. *African Cities Research Consortium Working paper* (12).

Haas, A., 2017. *An overview of municipal finance in Hargeisa, Somaliland*. London: International Growth Centre.

Hagmann, T., *et al.*, 2020. *Commodified cities*. Nairobi: Rift Valley Institute.

Hendriks, B., *et al.*, 2019. Pro-poor land administration: towards practical, coordinated, and scalable recording systems for all. *Land use policy*, 81, 21–38. doi:10.1016/j.landusepol.2018.09.033.

Ho, S., *et al.*, 2018. Needs assessment in land administration: the potential of the nominal group technique. *Land*, 7 (3), 87. doi:10.3390/land7030087.

Hoehne, M.V., 2015. *Between Somaliland and Puntland: marginalization, militarization and conflicting political visions*. Nairobi: Rift Valley Institute.

Hull, S., and Whittal, J. 2016. Towards a framework for assessing the impact of cadastral development on land rights-holders. *Proceedings of the FIG Working Week*.

Johnson, M.C., and Smaker, M., 2014. State building in de facto states: Somaliland and Puntland compared. *Africa today*, 60 (4), 3–23. doi:10.2979/africatoday.60.4.3.

Kelm, K., Antos, S., and Mclaren, R., 2021. Applying the FFP approach to wider land management functions. *Land*, 10 (7), 723. doi:10.3390/land10070723.

Klievink, B., Bharosa, N., and Tan, Y.-H., 2016. The collaborative realization of public values and business goals: governance and infrastructure of public–private information platforms. *Government information quarterly*, 33 (1), 67–79. doi:10.1016/j.giq.2015.12.002.

Klievink, B., van der Voort, H., and Veeneman, W., 2018. Creating value through data collaboratives. *Information polity*, 23, 379–397. doi:10.3233/IP-180070.

Koeva, M., *et al.*, 2017. Towards innovative geospatial tools for fit-for-purpose land rights mapping. *The international archives of the photogrammetry, remote sensing and spatial information sciences*, XLII-2/W7, 37–43. doi:10.5194/isprs-archives-xlii-2-w7-37-2017.

Koeva, M., *et al.*, 2020. Innovative remote sensing methodologies for Kenyan land tenure mapping. *Remote sensing*, 12 (2), 273. doi:10.3390/rs12020273.

Langley, A., *et al.*, 2013. Process studies of change in organization and management: unveiling temporality, activity, and flow. *Academy of management journal*, 56 (1), 1–13. doi:10.5465/amj.2013.4001.

Magis, M., and Zevenbergen, J. 2014, 16–21 June 2014. *Towards sustainable land administration systems: designing for long-term value creation FIG Congress 2014*. Kuala Lumpur, Malaysia.

Markakis, J., 2004. *Pastoralism on the margin*. London: Minority Rights Group International.

Metaferia, M.T., *et al.*, 2023. Fit-for-purpose land administration and the framework for effective land administration: synthesis of contemporary experiences. *Land*, 12 (1).

Milindi Rugema, D., Birhanu, T.A., and Shibeshi, G.B., 2022. Spatial aspect of fit-for-purpose land administration for emerging land administration systems: a conceptual framework for evaluation approach. *Survey review*, 54 (382), 79–92. doi:10.1080/00396265.2021.1881230.

Muse, N.M., Tayfur, G., and Safari, M.J., 2023. Meteorological drought assessment and trend analysis in Puntland Region of Somalia. *Sustainability*, 15 (13). 10652. doi:https://doi.org/10.3390/su151310652.

Owusu, G., 2009. Internal boundaries and district administration: a challenge to decentralization and district development in Ghana. *Geografiska annaler: series B, human geography*, 91 (1), 57–71. doi:10.1111/j.1468-0467.2009.00306.x.

Palmer, D., Fricska, S., and Wehrmann, B. 2009. *Towards improved land governance* (Land Tenure Working Paper, Issue 11).

Parnell, S., and Pieterse, E., 2014. *Africa's urban revolution*. 1st ed. London: Zed Books. doi:10.5040/9781350218246.

Parnell, S., and Walawege, R., 2011. Sub-Saharan African urbanisation and global environmental change. *Global environmental change*, 21, S12–S20. doi:10.1016/j.gloenvcha.2011.09.014.

Rahmatizadeh, S., *et al.*, 2018. A framework for selecting a fit-for-purpose data collection method in land administration. *Land Use policy*, 70, 162–171. doi:10.1016/j.landusepol.2017.10.034.

Ranchod, R., 2020. The data-technology nexus in South African secondary cities: The challenges to smart governance. *Urban studies*, 57 (16), 3281–3298. doi:10.1177/0042098019896974.

Safo, L.K.A., *et al.*, 2024. Civic administrative centres in the northern and southern cities of Ghana: assessing their state and locational distribution and the implications for urban growth and land demand. *Land Use policy*, 143, 107199. doi:10.1016/j.landusepol.2024.107199.

Skjott Linneberg, M., and Korsgaard, S., 2019. Coding qualitative data: a synthesis guiding the novice. *Qualitative research journal*, 19 (3), 259–270. doi:10.1108/QRJ-12-2018-0012.

Tahir, A.I., 2023. Post-conflict statecraft, land governance and exclusion in Hargeisa, Somaliland. *Environment and urbanization*, 35 (2), 508–526. doi:10.1177/09562478231190283.

Tan, E., *et al.*, 2021. A capacity assessment framework for the fit-for-purpose land administration systems: The use of unmanned aerial vehicle (UAV) in Rwanda and Kenya. *Land Use policy*, 102, 105244. doi:10.1016/j.landusepol.2020.105244.

Toulmin, C., 2009. Securing land and property rights in sub-Saharan Africa: The role of local institutions. *Land Use policy*, 26 (1), 10–19. doi:10.1016/j.landusepol.2008.07.006.

Unger, E.-M., *et al.* 2023. Fit-for-purpose land administration and the framework for effective land administration in Chad. FIG Working Week 2023: Protecting our world, conquering new frontiers.

UN-GGIM. 2020. *Framework for effective land administration*.

UN-Habitat. 2015. *Harmonization of the legal systems resolving land disputes in Somaliland and Puntland*. https://unhabitat.org/harmonization-of-the-legal-systems-resolving-land-disputes-in-somaliland-and-puntland.

UN-Habitat. 2016. *Fit-for-purpose land administration - guiding principles for country implementation*. https://gltn.net/download/fit-for-purpose-land-administration-guiding-principles-for-country-implementation/.

UN-Habitat. 2024. *Bosaso city strategy*.

van der Molen, P., 2002. The dynamic aspect of land administration: an often-forgotten component in system design. *Computers, environment and urban systems*, 26 (5), 361–381. doi:10.1016/S0198-9715(02)00009-1.

Ven, A., 2007. *Engaged scholarship: A guide for organizational and social research*. Oxford: Oxford University Press.

Yeboah, I.E.A., Codjoe, S.N.A., and Maingi, J.K., 2013. Producing an urban system for the spatial development of Ghana: lessons for sub-Saharan Africa. *African geographical review*, 32 (2), 140–156. doi:10.1080/19376812.2013.776893.

Zevenbergen, J., de Vries, W., and Bennett, R.M., Eds. 2016. *Advances in responsible land administration*. Boca Raton: CRC Press. doi:10.1201/b18988.

Appendices

Appendix 1: Data sources

Author	Title	Year	Source
	City plans and strategies		
UN-Habitat – Bosaso Municipality	Bosaso – First steps towards strategic urban Planning	2008	UN-Habitat Website
Bosaso Municipality	District Development Framework 2010–2014	2012	Municipality
UN-Habitat – Bosaso Municipality	Bosaso City Extension Plan	2016	Municipality
Bosaso Municipality	District Development Framework 2018–2022	2018	Municipality
Bosaso Municipality	District Development Framework 2023–2027	2023	Municipality
UN-Habitat – Bosaso Municipality	Bosaso City Strategy	2024	Government Website
	Laws and regulations		
Puntland State of Somalia	State Government Law No. 7/2003 Law No.7 of 18th /09/2003 on the Laws of the District Councils of the Puntland State of Somalia (and amendment)	2003 (2020)	Government Website
Puntland Inter-Ministerial Committee on Local Government	Puntland Decentralization Policy 2013–2020	2013	Government Website
Puntland State of Somalia	Urban Regulatory Framework	2015	Government Website
Puntland Ministry of Interior, Federal affairs and Democracy	District Participatory Planning and Finance Guide (DPFG)	2016	UNDP website
Puntland Ministry of Finance	Fiscal Decentralisation Strategy for Local Service Delivery	2018	UN-Habitat archive
Puntland State of Somalia	Urban Land Management Law	2020	UN-Habitat archive
Puntland Ministry of Interior, Federal affairs and Democracy	Land Dispute Tribunal (LDT) Regulation	2023	UN-Habitat archive
	Project Documents, Reports and Presentations		
JPLG consortium	Joint Programme for Local Governance and Decentralised Service Delivery – Project Document	2008	UN-Habitat archive
JPLG consortium	Joint Programme for Local Governance and Decentralised Service Delivery – Final Report Document	2012	UN-Habitat archive
JPLG consortium	Joint Programme for Local Governance and Decentralised Service Delivery II – Project Document	2012	UN MPTF Website
JPLG consortium	Joint Programme for Local Governance and Decentralised Service Delivery II – Final Report Document	2018	UN MPTF Website
JPLG consortium	Joint Programme for Local Governance and Decentralised Service Delivery III – Project Document	2018	UN MPTF Website
JPLG consortium	Joint Programme for Local Governance and Decentralised Service Delivery III – Annual Progress report	2018–2023	UN MPTF Website
Saamyenta consortium	Saamyenta Programme – Project Document	2020	UN MPTF Website
JPLG consortium	Joint Programme for Local Governance and Decentralised Service Delivery III – Final Report Document	2023	UN MPTF Website
UN-Habitat	Land and property tax revenues for service delivery, reconstruction, citizenship building and sustaining peace in fragile states – Project document	2020	UN-Habitat Website
Bosaso Municipality	Bosaso Municipality Statistical Abstract 2018–2020	2022	UNFPA Website
Puntland Ministry of Public Works, Transport and Housing	Property Valuation Methods	2022	UN-Habitat Website
TADAT – UNCDF	Bosaso District Local Government – Performance Assessment Rerport	2022	UNCDF Website
Somali Public Agenda	Decentralizing Taxation and Public Services To Local Governments in Somalia – Findings from Puntland, Galmudug, and Benadir	2023	SPA Website
Heritage Institute	Somalia Land Governance Review	2023	HI Website
Puntland Ministry of Public Works, Transport and Housing	Urban Land Management Law Progress report: Strategy and implementation for Bosaso	2022	Public presentation
Saamyenta consortium	Joint assessment report on the pre-Saameynta Programme implementations in Bossaso district	2023	
UN-Habitat	Land and property tax revenues for service delivery, reconstruction, citizenship building and sustaining peace in fragile states – Final Project report	2023	UN-Habitat website
IOM	Saameynta baseline local reintegration assessment (LORA) in Bosaso, Puntland State of Somalia – Findings report	2023	UN-Habitat Archive
	Technical Documentation		
UN-Habitat	Somaliland – Puntland: The Land Legal Framework	2008	UN-Habitat website

(*Continued*)

Continued.

Author	Title	Year	Source
UN-Habitat – NRC	Land, Property and Housing in Somalia	2008	UN-Habitat website
UN-Habitat – GLTN	Advancing women's land and property Rights in the Somali region – Training Guide	2022	UN-Habitat website
UN-Habitat	Land and property taxation in fragile states	2023	UN-Habitat website
	News Article and Online presentations		
UN-Habitat	Protection, Reintegration, and Resettlement of IDPs (Bossaso)	2008	website
UN-Habitat	Strengthening Local Governance and Municipal Finance through Property Taxation	2016	News bulletin
UN-Habitat	Bossaso releases first urban development plan for city extension	2016	website
UNCDF	Fiscal Decentralization Policy for Somalia	2016	website
UNCDF	UNCDF supports Somali local governments on revenue mobilization		News bulletin
UN-Habitat	Bossaso road project breathes new life into port area	2016	website
UN-Habitat	UN-Habitat organises workshop to discuss urban land management law in Puntland	2017	website
UN-Habitat	New Urban Land Management Law to guide land issues in Puntland, Somalia	2020	website
UN-Habitat – GLTN	Learning series on leveraging land for Delivery of services, building the social contract and Promoting peace and security – Session 4	2021	Online report
UN-Habitat	Mobile taxation expanded to four districts of Somalia after a successful pilot	2021	website
UNCDF	Local Government Rising: Somalia's fiscal decentralisation success story	2022	website
UNCDF	Local Development Fund: Somalia's Fiscal Decentralisation Success Story	2022	website

Appendix 2: List of interviews and interviewees' characteristics

ID	Background	Role	Affiliation	Involvement in the projects unders study
INT.01	Civil engineering	Manager	Private company	Y
INT.02	Civil engineering	Manager/dean	Private company/East Africa University	N
INT.03	Urban Planning GIS	Manager	Bosaso Municipality	Y
INT.04	Land Administration	Manager	Bosaso Municipality	Y
INT.04	Land Administration	Technical officer	Bosaso Municipality	Y
INT.05	Urban Finance	Technical officer	Bosaso Municipality	Y
INT.06	Urban Planning	Technical officer	MoPW	Y
INT.07	Urban Planning	Technical officer	MoPW	Y
INT.08		Manager	Private developer	N
INT.09		Manager	Private developer	N
INT.10	Local Governance	Technical officer	UNDP	Y
INT.11	Local Governance	Technical officer	UNICEF	Y
INT.12	Urban Planning	Technical officer	UN-Habitat	Y
INT.13	Urban Finance	Manager	UN-Habitat	N
INT.14	Urban Finance	Manager	UN-Habitat	Y
INT.15	GIS	Manager	UN-Habitat	N
INT.16	Urban Planning	Manager	UN-Habitat	Y
INT.17	Urban planning	Technical officer	UN-Habitat	Y

Appendix 5

Publication V

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Responsible AI for Cities: A Case Study of GeoAI in African Informal Settlements

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ABSTRACT
Geospatial Artificial Intelligence (GeoAI) systems are increasingly used by local governments to manage urban planning activities. However, there is a lack of clear guidelines for responsible artificial intelligence (AI) implementation. We address this gap by applying the task-data-user-technology fit theory. First, we create a conceptual framework that translates ethical AI principles into practical system requirements. Second, we apply this framework through a case study analysis. We examine the geospatial AI system that the city of eThekwini, South Africa, has deployed to monitor their informal settlements. Based on expert interviews, our analysis highlights the ethical trade-offs inherent in the interactions between fits, data, tasks, users, and AI interactions, especially in an inherently localized and multi-stakeholder field such as urban planning. Additionally, we show how these fits are interconnected and cross-dependent. For example, the technical skills and resources of users can influence all other fits. Our study also reveals how task reconfiguration, user adaptability, and data improvement can enhance or hinder alignment with technology. From these insights, we introduce practical and theoretical recommendations for responsible AI development, adoption, and use.

KEYWORDS
artificial intelligence (AI); Geospatial Artificial Intelligence (GeoAI); ethics of technology; responsible AI; urban governance

Introduction

Urban planning has reached a new evolutionary stage with Geospatial Artificial Intelligence (GeoAI) systems, which refer to the integration of artificial intelligence (AI), particularly machine learning and deep learning techniques, with Geographic Information Systems (GIS) and spatial data analysis (De Sabbata et al., 2023). GeoAI claim several benefits over traditional methods, such as greater geographic coverage, reduced data bias, enhanced accuracy and time efficiency (Marasinghe et al., 2024). These advantages have been demonstrated in various urban applications, for example high-resolution urban pattern monitoring, land and property mapping, and planning decision-making support (Son et al., 2023).

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However, advancing the integration of these technologies to enhance city management and benefit citizens requires an understanding and respect for local conditions (Pereira and Prokopiuk, 2024): urban planning and governance systems should not only be more powerful, time and cost-effective, but also easy to implement and inclusive (Zevenbergen et al., 2016). In this regard, concerns persist about the ability of cities to manage the deployment, maintenance, and enhancement of these technologies (Yigitcanlar et al., 2021). The responsible use of AI in urban planning involves addressing three interlinked aspects: (1) the technical and administrative requirements of urban planning practices; (2) the ethical, social, and legal requirements of technology adoption; and (3) the specific needs of urban areas, their users, and their administrators (Peng et al., 2023). Unfortunately, current academic debates offer only abstract ethical principles, lacking in practical guidance for ethical decision-making and trade-offs (Morley et al., 2020). This absence hinders the responsible design and implementation of AI systems in the urban planning domain.

Against this background, our research addresses the following research questions:

- How can we translate responsible AI principles into practical requirements for urban planning systems?
- How do these requirements affect the development, adoption, and use of AI technology?

Our study makes a threefold contribution. First, we expand the academic discourse on responsible AI by structuring a conceptual framework that operationalizes broad ethical principles in urban planning. Leveraging task-user-technology fit theory (Jiang et al., 2020), this framework aligns ethical considerations with GeoAI system development, urban planning tasks, data, and user characteristics. Second, we apply this framework to a case study of an AI-based land-monitoring system in eThekwini, South Africa. Third, we build on the insights from the case study to offer both theoretical considerations and practical recommendations for the development of GeoAI systems.

The remainder of this article is organized as follows. The next section provides an overview of responsible AI research in urban planning and land administration, and it introduces our conceptual framework. After that, we describe our case study and the methodology that we used to conduct the analysis. Then we detail the findings of the study and follow that with a discussion of their theoretical and practical implications. That section is also instrumental in exploring the limitations of our study and providing recommendations for future research.

Literature Review

Responsible as Useful: Translating Ethical AI Principles into Task-Data-User-AI Fits

The surge in research, development, and deployment of AI systems has sparked significant ethical discussions in academic, governmental, and industrial contexts (Hagendorff, 2020). As a result of these debates, several ethical guidelines have been introduced in recent years. These guidelines, together with research on technology ethics (Jobin et al., 2019; Royakkers et al., 2018), demonstrate that the theoretical perspectives on "responsible AI" (Yigitcanlar et al., 2021: 6), converge around a set of recurring themes, including transparency, responsibility, accountability, privacy, safety, human dignity, and trust. Research by Floridi and Cowls (2019) have distilled these themes into five main principles: *beneficence* (being beneficial to and respectful of both people and the environment); *non-maleficence* (ensuring robustness, privacy, and security); *autonomy* (upholding and respecting human values and agency); *justice* (maintaining fairness and diversity, avoiding bias); and *explicability* (being explainable, accountable, understandable).

However, Morley et al. (2020) highlight a gap in practical guidance for implementing these principles. Existing studies only focus on AI specifics, such as research on fair and transparent AI (Miller, 2019), or they attempt to address implementation from a more strategic perspective rather than introducing practical guidance (Sturm and Peters, 2020; Traumer et al., 2017). More specific to the geospatial domain and urban planning applications, recent studies have attempted to identify responsible practices (Marasinghe et al., 2024), and exposed challenges in public perceptions and adoption (Son et al., 2023;

Yigitcanlar et al., 2020), as well as broader issues of urban AI governance (Cugurullo et al., 2023), but without sufficient details on technical aspects or other practical strategies.

To enhance our understanding of responsible AI in urban planning, we revisit the notion of *responsible* as traditionally portrayed in this domain (de Vries et al., 2021). For urban areas, this concept translates into the need for urban planning systems that are faster, more cost-efficient, straightforward to implement, and broadly inclusive. Consequently, when assessing AI technologies in urban planning, it is crucial to evaluate both their task performance efficacy and their appropriateness for the target user groups. In essence, this necessitates a proper alignment between the task requirements and the technology used, known as task-technology fit (TTF).

TTF theory is particularly useful for understanding how the interaction between tasks and technologies influences technology use and its impact on performance (Goodhue and Thompson, 1995). This theory emphasizes that the effectiveness of a technology is closely tied to how well it aligns with the specific tasks it is meant to address. Moreover, it highlights the importance of the contexts in which technologies are deployed (Howard and Rose, 2019).

TTF theory has been widely applied in research areas related to AI. Various studies, such as those by Chang (2010) and Wongpinunwatana et al. (2000), have validated the relevance of this theoretical perspective in assessing the performance, capabilities, and intention to use intelligent agents and expert systems at individual, group, and organizational levels. Additionally, TTF theory has also been instrumental in examining data usage practices (Karimi et al., 2004) including data analytics (Ghasemaghaei et al., 2017) and big data analytics (Muchenje and Seppänen, 2023). These studies have expanded the TTF theory by introducing a new dimension called *data-technology fit*. This dimension focuses on the compatibility between analytical tools and the data they process, which is crucial for effective and accurate data analysis (Ghasemaghaei et al., 2017).

TTF theory has been further developed with recent studies on decision support systems and planning support systems. Parkes (2013) found that in decision support systems, TTF positively influences outcomes when there is a match between technology features, employee skills, and their preferences for technological tools. Similarly, Pelzer (2017) showed that in planning support systems, success is not just about matching technology features with planning tasks, but also about aligning the capabilities of users with the functionalities of the technology. This connection is referred to as *user-technology fit*, which underscores the usability and applicability of a technology (Jiang et al., 2020; Russo et al., 2018).

However, the unique attributes of AI, such as broader learning capacities, autonomy, and inscrutability, require expanding these studies and the contribution they offer, by introducing new definitions and research perspectives (Baird and Maruping, 2021). Accordingly, in the following sections we examine the key characteristics of AI systems, data, urban planning tasks, and users, and we extend upon the traditional theoretical constructs of technology-fit in urban planning, incorporating AI-specific aspects (Rzepka and Berger, 2018; Sturm and Peters, 2020). This theoretical development will help us translate the ethical principles of AI into practical system requirements, emphasizing the criticality of matching tasks, data, and user characteristics for effective implementation.

AI Characteristics

The performance of AI systems is significantly influenced by computational time, which depends on model complexity, hardware efficiency, and the volume and complexity of the data being processed (Carter et al., 2020). GeoAI systems can be task-specific, that is, optimized for performing specific functions, or task-agnostic, designed to handle a wide range of tasks (Rolf et al., 2021). The latter, typically trained on large-scale datasets (Mai et al., 2022), requires substantial data processing and computation power (Cowls et al., 2023).

Another notable feature is the level of automation. The literature typically interprets humans as either in-, on-, or out-of-the-loop entities, emphasizing their decreasing level of involvement (Traumer et al., 2017). Different interaction levels can either obstruct or boost AI efficiency (Grønsund and Aanestad, 2020).

The explainability of AI algorithms, or how understandable their decision-making processes are, is also crucial. Machine learning systems rely on data patterns rather than human-defined rules, leading to the perception of AI as a black box (Burrell, 2016). Current efforts in Explainable AI (XAI) aim to build-in features to clarify AI decision-making processes and analyses (Rudin, 2019), but usually require statistical and coding knowledge to be interpreted (Meske et al., 2022).

This challenge emphasizes the importance of considering user interfaces and the experience of users (Haque et al., 2023). For example, Automated Machine Learning (AutoML) approaches allow AI-model development with minimal coding knowledge (Li and Chau, 2022) but can be associated with a low level of transparency and control over algorithm design (Dwivedi et al., 2023).

Data Characteristics

AI algorithms are trained on existing data to create models that capture underlying patterns. These models are then used on new data to perform specific tasks. Therefore, the functionality of AI tools and the algorithms they apply are influenced by the characteristics of the data used to train them (Danks and London, 2017), including aspects such as quantity and variety (Agrawal et al., 2017). This means that it is crucial to consider not just the availability and accessibility of data, but also issues like data ownership and privacy (Janssen et al., 2020). In this regard, the growing ability to use GeoAI systems to collect personal data for completing planning tasks, like socioeconomic information and geolocations, introduces challenges for responsible AI use. These include ensuring harm is not caused and respecting individual autonomy (Micheli et al., 2022). If data collection occurs automatically, without involving or informing people, it can lead to ethical concerns about justice, beneficence, and autonomy (Janowicz et al., 2022).

Data flows, from collection to application, assist in the implementation and maintenance of AI-based systems, as they continue to process data after their initial training phase (Jöhnk et al., 2021). However, data quality is the ultimate determinant of outcomes (Janssen et al., 2020). In geospatial data analysis, for instance, changing geographies, environmental conditions, and the heterogeneity of sensing instruments make it hard to select representative training data (Lunga et al., 2021). This could lead to computational biases in AI systems, especially if the datasets used for training are poor, limited, or biased. For example, in data-poor urban contexts, AI systems designed for land-use characterization may produce inaccurate results if they are not validated with local expertise and knowledge (Kim et al., 2021).

Task Characteristics

In the field of GeoAI, a task is the specific objective of using AI to predict or estimate a variable or feature, for example characterize land use or population densities from satellite imagery (Rolf et al., 2021). The complexity of tasks varies, depending on the level of cognitive resources and skills needed to implement it (Campbell, 1988). Some tasks are simple, leading directly to an outcome, whereas others may have multiple paths and numerous possible outcomes. The interaction between these paths and outcomes, such as balancing quality and quantity, along with the level of uncertainty and unpredictability, affect complexity. Moreover, tasks with varying complexities also differ in their automation potential, which is associated with concerns over transparency and fairness (Vimalkumar et al., 2021).

Roth et al. (2023) highlights the importance of integrating values and principles into these tasks, as reflected in legal norms. Factors such as time constraints, participant involvement, and political sensitivities, which are influenced by planning and policy processes, are crucial in this context (Geertman, 2006; Jiang et al., 2020). Furthermore, these tasks have various accountability implications—political, legal, organizational, and professional—in the context of modern urban planning, which also have wide-reaching societal effects (Bovens, 2007).

In this sense, in the deployment of AI for urban public services, openness and transparency can be features built around AI system rather than built in the system itself. This can be in the form of documentation and communication tools: for example, in Amsterdam and Helsinki public algorithm registers offered insight into algorithms being used in urban services (Floridi, 2020). Additionally, in New South Wales, Australia, co-design practices allowed participation in the early stages of the decision processes and addressed accountability more explicitly (Rittenbruch et al., 2022).

Users Characteristics

Indicators of digital divide highlight several AI-specific sensitivities (Carter et al., 2020). The need for increased computing power for AI tools poses a significant financial challenge, making access to digital technology difficult not only for underprivileged communities and developing countries but also for developed ones (Cowls et al., 2023).

Furthermore, even when access is available, factors like literacy, language barriers, and digital skills can hinder effective utilization of the technology (Bélanger and Carter, 2009). Specialized skills required by many innovative geospatial technologies (Ball et al., 2017) are often lacking in governments where such technologies are most needed (Haack and Ryerson, 2016). In this "capability divide" (Wei et al., 2011: 170) the perceptions and beliefs of individuals become increasingly significant in the AI context (Yigitcanlar et al., 2020). Risk perception is notably high with AI, driven by widespread concerns over malicious applications in areas like surveillance and the black-box nature of many AI systems. This apprehension decreases the willingness of individuals to use AI systems, thereby widening the AI divide (Carter et al., 2020). Moreover, a lack of "AI awareness" (Jöhnk et al., 2021:11) can result in interpretation biases; users may not fully comprehend the intended use of an AI system or may misinterpret its capabilities (Danks and London, 2017). On the other hand, the current hype surrounding AI could result in excessive reliance and premature adoption of untested or inappropriate tools (Vered et al., 2023), diverting resources and attention from more suitable solutions (Gevaert et al., 2021).

Task, Data, and User-AI Fit in Urban Planning

By combining the different characteristics of AI for urban planning tasks, we extrapolated a set of indicators to assess the fit and effectiveness of an AI systems for specific tasks and application contexts (Koumetio Tekouabou et al., 2022; Yigitcanlar et al., 2020). The indicators are listed in Figure 1 and discussed in the following paragraphs. Additionally, this integration prompts critical discussions on the responsible deployment of AI in urban planning (See Table 1).

Generalizability refers to the performance of the AI model across different datasets and tasks, beyond the ones it was initially trained on (Mai et al., 2022; Rolf et al., 2021). It is a measure of both task-AI and data-AI fit (Sturm and Peters, 2020), which is necessary to avoid concerns about transfer-context biases (Danks and London, 2017).

Reliability focuses on the quality and timeliness of AI output, as well as the expert control required to train the system. Inadequate understanding of the local context can lead to the exclusion or misrepresentation of data used for urban planning purposes (Burke et al., 2021), limiting their effectiveness and usability (Gevaert et al., 2021). Simultaneously, if AI tools fail to perform their tasks in the required timeframes, the outputs they generate may become irrelevant or unusable (Sturm and Peters, 2020).

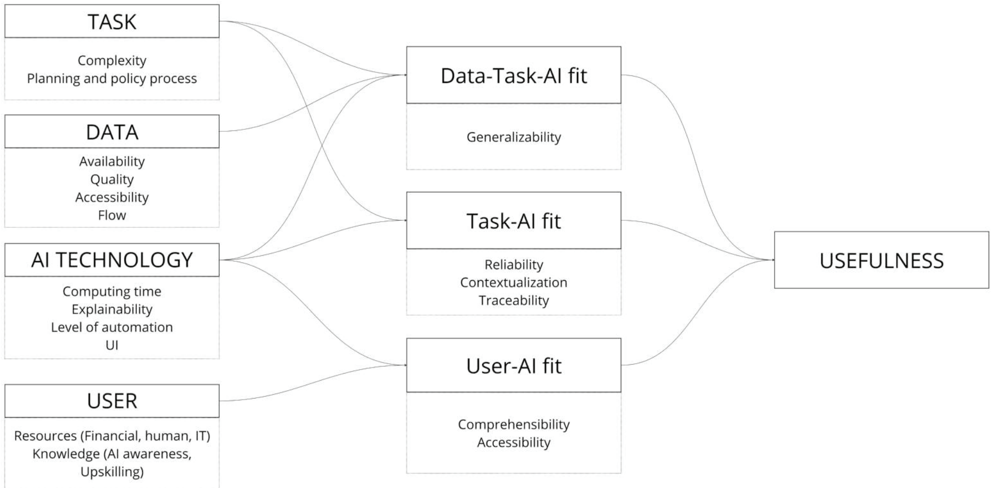

Figure 1. Indicators of Task, Data, and User-AI fit in urban planning

Contextualization refers to how sensitive an AI system is to its operational environment. It emphasizes the importance of designing AI in collaboration with its users, understanding their needs, methods of coordination, and the impacts of interventions (Floridi et al., 2020). By combining bottom-up perspectives with AI systems, urban planning is expected to become more inclusive, equitable, and responsive to the needs and priorities of diverse communities. Therefore, *contextualization* promotes justice and avoids perpetuating algorithmic and non-algorithmic biases in urban communities (Mitchell et al., 2021; Räz, 2024).

Traceability involves transparency and accountability of an AI system. Therefore, it is affected by factors like the approach adopted by decision-makers to document procedures and responsibilities (Sanchez et al., 2022).

Table 1: Task-Data-User-AI fit indicators (authors' elaboration based on Carter et al., 2020; Morley et al., 2020; Peng et al., 2023, Rzepka and Berger, 2018, and Sturm and Peters, 2020)

Indicator	Description	AI Concepts	Ethical Principle
Generalizability	Input data of the tool are valid and appropriate to the selected task	Training data bias, algorithmic processing bias, transfer context bias, explainability	Justice; Beneficence; Non-Maleficence
Reliability	Output data of the tool are accurate, usable, and timely	Meaningful human control AI latency	Justice; Autonomy; Explicability
Contextualization	Process and outcome are sensitive to contexts	Bottom-up perspective privacy protection data subject consent	Justice; Beneficence; Non-Maleficence, Explicability
Traceability	The process is transparent and accountable	Algorithmic accountability	Justice, Beneficence; Non-Maleficence, Explicability
Comprehensibility	The tool, its functioning, and its output intelligible and utilizable	Interpretation bias	Explicability
Accessibility	Attainable, affordable, upgradable	AI divide	Justice, Autonomy; Beneficence; Non-Maleficence

Comprehensibility concerns the trust and validation of the AI system's output (Berente et al., 2021; Sturm et al., 2023), which is influenced by the level of information available on how the AI system functions. This information is crucial to support effective adoption while preventing interpretation and automation biases (Vered et al., 2023).

Lastly, *accessibility* considers the human, financial, and technical resources needed to deploy and operate AI systems (Rolf et al., 2021). This indicator assesses whether an organization can quickly and effectively implement an AI system with its available resources. It also considers the requirements for ongoing operation and maintenance, as well as the potential for future improvements.

Research Methods

Case Description

We applied our conceptual framework to a single-case study (Yin, 2009), focusing on eThekwini Municipality and the implementation of the Building and Establishment Automated Mapper (BEAM) Project. Established in 2000, the eThekwini Municipality is a metropolitan authority that encompasses Durban, the third-most populous city of South Africa, and a major African port. Since its foundation, eThekwini has emphasized digital technology in its long-term development strategy (Odendaal, 2011) and has now developed a well-established policy that links digital innovation to a comprehensive political agenda for urban sustainability enhancement (Söderström et al., 2021). However, the municipality struggles with rapid and informal urbanization; 314,000 reside across 580 urban informal settlements[1], defined as "an unplanned settlement on land which has not been surveyed or proclaimed as residential, consisting mainly of informal dwellings."[2] Residents of these informal settlements are among the most vulnerable, facing significant risks from climate change, particularly increased flooding (Williams et al., 2019). To address these challenges, accurate data on the number, locations, and environmental hazards associated with informal structures is crucial. In response, the eThekwini Municipality initiated the Informal Settlement Information Management Solution (ISIMS) in 2018, supported by the UK Prosperity Fund.[3] This initiative is part of a larger effort to promote city-wide, evidence-based urban planning, with the objective of establishing a comprehensive system of processes and technologies that enhance informed decision-making within the city.[4]

As part of these efforts, in 2021 eThekwini responded to a call for proposals seeking innovative technological solutions for urban issues. The call was launched by the United Nations Innovation Technology Accelerator for Cities (UNITAC), which is jointly managed by the United Nations Human Settlements Programme (UN-Habitat), the United Nations Office for Information and Communication Technologies (UN-OICT), and HafenCity University. The Human Settlement Unit of eThekwini, dedicated to the planning and management of informal settlements, proposed developing a system to automatically identify informal settlements from aerial images, aiming to replace the labor-intensive manual marking process with GIS tools. This improvement was expected to eliminate a time-consuming workflow that was limiting the capacity of the city to address needs efficiently.

The response of UNITAC to this request led to the development of BEAM, a deep-learning algorithm designed for image segmentation that can detect building footprints in digital imagery.[5] When applied to aerial images collected annually by eThekwini, this GeoAI system promised continuously updated records of informal settlements.

Since 2022, the integration and testing of BEAM within the city's infrastructure are ongoing. Therefore, the AI system has not yet reached its full operational state, and the results and impact of the project are not fully measurable at this stage. However, its analysis allows for the evaluation of task-user-fit requirements through the stages of algorithmic development—use case development, design, training, and deployment—offering valuable insights into process dynamics, pitfalls, and challenges (Morley et al., 2020).

Data Collection and Analysis

Our primary data collection included interviews with 13 project managers and technical officers from the eThekwini Municipality and UNITAC. When selecting interviewees, we aimed for a diverse representation across various organizational levels, from senior management to frontline staff, and balanced between participants directly involved in the BEAM project and those with an external viewpoint. Therefore, our sample includes project team members with technical expertise and a comprehensive understanding of the AI system's development and implementation, as well as officials knowledgeable in urban planning processes, innovation dynamics, and data management within eThekwini. We adopted a snowball sampling approach (Johnson and Onwuegbuzie, 2004) and stopped adding participants when interviews began to repetitively reflect previously gathered data, indicating that data saturation was reached (See Appendix A).[6]

Interview transcripts were analyzed using a thematic-coding approach inspired by Gioia et al. (2012). This involved assigning codes to sections of the interview transcripts to identify core concepts and patterns in the qualitative data (Gerli et al., 2022). Our analysis began by pinpointing first-order concepts in these excerpts, covering areas like planning tasks, data, AI, and user characteristics. From these, we derived second-order themes concerning the interplay of task-data-user-AI characteristics. We then iteratively examined how these first- and second-order categories interconnected, grouping them into theoretical dimensions that aligned with the task-data-user-AI fit indicators of our conceptual framework (See Table 2). Appendix B presents some of the most representative quotes extracted during the coding process.

To supplement and corroborate our findings from the interviews, we gathered secondary data (Johansson, 2007) from policy documents like eThekwini's integrated development plans, its city-wide strategy for incremental upgrading of informal settlements, and various official documents and reports on the development of ISIMS and BEAM. We also reviewed user manuals, news articles, and online presentations related to these two projects. Appendix C presents the sources of the secondary data used in our study.

Findings

Generalizability

Owing to the limited bandwidth of eThekwini's broadband network, data for AI model training took a prolonged time to reach UNITAC, which is based in Hamburg, Germany.

Table 2: Data Structure

Concept *First-order coding*	Theme *Second-order coding*	Theoretical Dimension *Third-order coding*
Data accessibility and flow	Training	Generalizability
Data quality		
Variable project contributors	Task definition	
Dynamic requirement		
Expert validation and local knowledge integration	Accuracy	Reliability
Output quality		
Automation Potential	Production timeliness	
Computing time		
Complexity Bottom-up perspective	Transparent purpose	Contextualization
Data detail Community engagement	Privacy protection and data subject consent	
Interface for image analysis	User-friendliness	Comprehensibility
Interface for model retraining		
Developer-user dialogue	Expectations	
AI awareness		
Existing practices and fora Digital infrastructure	Accountability	Traceability
	Transparency	
Digital infrastructure	Using the tool	Accessibility
Capacity for operating the tool		
Capacity for retraining	Maintaining the tool	
Editability and continued support	Improving the tool	
Scale up and new features		

Initial samples were shared via a third party to begin development of the tool, but the bulk of the database for a single year of imagery (approximately 200GB) had to be physically transported on a hard drive. Although the model achieved 94 percent accuracy for the year 2019, it soon became apparent that the data-task-AI fit was very limited in terms of *generalizability*. The images were affected by atmospheric conditions, seasons, and time of flight. Additionally, the quality was affected by the sensor used for image capture, as the company managing the collection process operates over a three-year contract, and every third year a LiDAR scan is performed instead of normal photography. Therefore, image sets vary significantly from year to year. As a result, the images collected in 2020 had already a significantly lower tool performance and required retraining of the model. One of the use cases envisioned by the Human Settlement Unit was running BEAM through decades-wide historical aerials in the municipality's archives. However, this solution would have required lengthy manual labeling and training for each image set. Project development on the eThekwini side also moved from the Human Settlement Unit to Corporate GIS Unit, the City's centralized spatial data storage unit. This handover was meant to provide better technical expertise and was aligned with the city's data management rationalization. However, it shifted the focus of the tool from informal settlements to the entire city: a building footprint layer is "foundational" (INT.05) because it provides the basis for accurate city-wide analytics, population studies, and resource allocation strategies. However, the handover altered the task definition without a corresponding retraining of the tool. This resulted in an algorithmic focus bias, where the model trained on informal dwellings struggled to identify different shapes and larger buildings in eThekwini's formal neighborhoods and industrial areas, altering the task-data-AI fit.

Reliability

Training on the tool required only a few instances of validation by local experts to distinguish between formal and informal settlements and to identify structures and objects to exclude from mapping, such as buses, tents, and other objects that could be mistaken for informal buildings. However, the detail of the output was low, for example, shapes were not contoured into angular shapes or realigned to nearby polygons as would have been done manually.

The task-AI fit in this case was very much dependent on the specific use case to which BEAM would be applied. In the originally intended use of detailed service planning delivery and household-level calculations "more detailed analysis can be undertaken" (INT.10). Due to its limitations, the application of BEAM proved more suitable when swiftness was prevalent instead of accuracy; for a wholesome estimation "what you're getting from an AI process is good enough" (INT.02).

Production timeliness was, in fact, highlighted in all interviews. Improving the efficiency and speed of workflows was, by inception, the very reason for launching the project and was imperative to keep pace with the rapid urbanization of the city. On the part of UNITAC, in our interviews and during public events and presentations, emphasis was on a total processing time of approximately 72 hours for the entire city, or rather 80 seconds for each of the approximately 3,000 tiles covering the city, assuming a hardware meeting certain technical expectation, as discussed below. The computation time was comparable to state-of-the-art approaches (INT.07). However, the fit had to be estimated against the available hardware and working routines in eThekwini. Considering working hours, network slowdowns, possible power outages—common in eThekwini and South Africa—and other factors, the entire process could be completed "within three or four weeks" (INT.05).

Contextualization

Most interviewees did not see the need to involve the communities of the settlements being mapped as the end receivers of the intervention. The tool was described as "relatively basic" (INT.01) and conceived for a straightforward task, with no *contextualization* needed in terms of transparency of purpose or inclusion of a bottom-up perspective. Some level of community engagement was maintained through public presentations, but as one of the interviewees pointed out, "We didn't feel that it was particularly useful to bring community members in to discuss this piece of technology, which is assisting us to do a function that we're already doing, but just in a much more expensive and time-consuming way" (INT.04). Additionally, the high-altitude perspective of aerial imagery made it difficult to identify individual personal data during analysis, thus avoiding ethical concerns (INT.05).

Traceability

UNITAC raised some concerns about the potential use of the AI tool to target illegally occupied areas and use the information to enforce evictions, although this issue is already regulated by South African laws.[7] Existing rules, practices, and processes at the local and national levels were also highlighted to guarantee the *traceability* of the task regardless of the tool. Urban planning, as an inherently political process, is "entrenched" in the organizational structure of the municipality, and "it's difficult to remove the people" from the accountability chain of a decision-making process" (INT.06).

Comprehensibility

Rather than delving into the workings of the algorithm, people were more interested in understanding the confidence level of a prediction and the overall quality of the result. However, there is a clear difference between expectations at the managerial level of eThekwini and a grounded understanding at the technical level. The former created the concept but found "limited" (INT.10) and "annoying" (INT.09) the need to retrain models for new contexts and different images. The latter were more aware of the challenges and opportunities offered by machine learning algorithms and were conscious of being part of an ongoing development process (INT.12) and that a more capable tool would "depend on a lot of time and resources" (INT.05). They praised the tool for having a very simple and straightforward user interface (UI) for image analysis but lamented the lack of an embedded function or module for retraining the model, which now requires programming skills. Some noted BEAM's lack of integration with and limited advantage over GIS tools in use in the municipality, such as ESRI's products, which also incorporate similar but more customizable AI tools.

Accessibility

eThekwini proved to have personnel with the necessary skills to operate the tool and to engage in dialogue with UNITAC developers, establishing a positive feedback mechanism. The move from Human Settlements to Corporate GIS, as the main counterpart of the municipality, was instrumental in achieving this goal. The importance of continued AI development expertise through all phases of algorithmic development emerged strongly when the project had a monthslong stop, as UNITAC's data scientist changed twice. Furthermore, like most projects led by an international organization, BEAM is tied to specific donor funding, and its development and maintenance will cease with that revenue stream. UNITAC plans to publish the code under an open-source license to enable eThekwini to further develop the tool through a third-party contractor or future in-house expertise that may develop along its innovation pathways.

However, the entire municipality lacked a computer with the minimum requirements to run BEAM, and they had to procure one for this specific purpose. UNITAC found this revelation "a little bit surprising" (INT.01); from their perspective, these technical requirements appeared ordinary. Conversely, eThekwini found these higher specifications "a big limitation" to using the tool (INT.04) and had expected at least "a discussion to understand whether the city had the capacity to immediately run it" (INT.06). Given the protracted procurement process of the municipality, the computer was transferred from Human Settlement to Corporate GIS upon project takeover. However, relying on a single machine to operate the tool will affect its sustainability. The city must secure a steady and appropriate influx of resources for tool dissemination. Online options have already been discarded due to the limited bandwidth at the city's disposal, but even the offline tool that was developed did not immediately fit the resources of its intended user in terms of *accessibility*.

Discussion and Conclusion

The implementation of responsible AI requires value-based decisions and ethical considerations, an activity that implies trade-offs (Morley et al., 2020). Our study shows how these trade-offs reside implicitly in the data, task, user, and AI interactions and fits. Additionally, our findings reveal that these fits are interconnected and cross-dependent. This means that choosing a particular AI application involves balancing different tasks, users, and data characteristics, which extend beyond the specific features of a technology (Sturm and Peters, 2020). Specifically, as evidenced by our analysis, the technical abilities and resources of users can influence all other fits (Jöhnk et al., 2021). Inadequate infrastructure and insufficient skills not only make it challenging to set up and operate AI systems but also influence their *accessibility* and long-term sustainability. Dependence on resources can impede performance assessment and upgrade potential, thereby affecting *reliability*. These limitations also affect the development of AI tools before their deployment. Data accessibility and quality are crucially influenced by users; limited access to initial datasets and poor ongoing data flows can hinder the training and testing of the model, affecting its *generalizability*. Additionally, the nature of the task influences data sensitivities, which, in turn, determine the necessary level of *contextualization* and *traceability*.

Our study also highlights how task reconfiguration, user adaptability, and data improvement can either enhance or hinder alignment with technological systems. We observed that changes in the scope of eThekwini led to a redefinition of the task, which in turn negatively affected *generalizability*. Consequently, the application area of the AI system was modified in response to its low *reliability*. This indicates that not only can AI technologies be refined for better outcomes and bias mitigation but tasks and user resources can also be adapted to the characteristics of AI. Effective communication among decision-makers, developers, and users is crucial for this adaptation process, which often occurs under tight deadlines and involves people with varying levels of technological expertise (Sturm et al., 2023).

Berente et al. (2021) stress the importance of tailoring tool explanations to the understanding level of the receiver, considering their familiarity with the technology and how it aligns with their beliefs, objectives, and values. This approach is essential, especially given that while there is a general focus on making AI approaches more explainable, most non-experts find even transparent (white-box) models difficult to comprehend (Miller, 2019). In the case of eThekwini, we found three types of receivers: city leaders and managers, local government employees, and the community. The disproportionate expectations of city managers resulted in low *comprehensibility*, which caused misunderstandings between the city and UNITAC (Riveiro and Thill, 2021). For local officers, *comprehensibility* was sufficient, as a general understanding of the algorithm was believed to support developers at UNITAC and the deployment of the tool. However, the re-training of the model was not possible without coding skills, affecting *reliability*, *generalizability*, and *accessibility*. A new user interface could have simplified AI training, enhanced the overall quality of the result, and facilitated the daily use of AI models (Li and Chau, 2022). For communities, the focus should be on *contextualization* and *traceability* for an accurate understanding of the potential risks of the outcomes of the technology being deployed, rather than on explaining the nature and behavior of the AI model (Floridi et al., 2020).

Based on these insights, we reflected on the contribution of these indicators to research on responsible AI principles for urban planning, and we elaborated on how they can offer practical guidance for designing, implementing, and adopting AI systems.

Theoretical Implications

Our study shows how moving beyond the generic notion of responsible AI helps translating principles into more practical requirements. First, it advances our theoretical understanding of AI ethics within the specific task and application domain of urban planning. The fit indicators outlined in our model clarify the types of urban planning tasks involved and consider the rules and practices of the planning processes into which the task is integrated. Through this, it is possible to identify the ethical risks associated with using GeoAI for these tasks and determine what checks and balances should be exercised over them. This does not suggest that certain AI tools can simply fit within pre-existing frameworks of well-tested and reliable urban governance guidelines (Floridi, 2020). Instead, AI ethics cannot function in isolation and must be integrated with existing regulations and policies that address individual and systemic risks in cities. This underscores that the endeavor to operationalize responsible AI should not focus solely on AI developers with little knowledge of the problem domain (Athey, 2017). Urban planning professionals, city leaders, and communities also play pivotal roles in what should be understood as a collective effort.

In connection to this, our study also offers insights into how responsible AI must situate algorithms and their tasks in the specific local cultural and socioeconomic contexts of their users. This is particularly important in an inherently localized and multi-stakeholder field such as urban planning. However, just as AI systems advance, urban planning evolves and user's resources, needs and challenges change dynamically. It derives that AI-fit is not fixed (Muchenje and Seppänen, 2023) but should be evaluated through the stages of algorithmic development (Morley et al., 2020). Responsible AI should consider evolving institutional structures and processes; cities, in turn, must understand AI as a technology and derive the right ambition for potential applications along their digitalization journey (Jöhnk et al., 2021).

Finally, in line with recent literature (Rzepka and Berger, 2018; Sturm and Peters, 2020), our study contributes to TTF theory by adapting it to the unique technical characteristics of AI. In doing so, we included *user-* and *data-technology fit* (Ghasemaghaei et al., 2017; Jiang et al., 2020;Russo et al., 2018) in evaluating relevance and usefulness of GeoAI systems. Our results confirm these as crucial fit dimensions, at least in the context studied. Data availability, accessibility, and quality largely determine AI's suitability for given tasks. User characteristics affect task- and data-AI fit, especially as they affect data flow and planning processes. In addition, we identified the most relevant indicator for each construct. Future research could more systematically develop dimensions for the task-user-data-AI fit constructs.

Practical Implications

The framework employed in this study can help policymakers, AI developers, and urban planning practitioners harmonize technical functionalities with the environment in which they are embedded.

For example, the development of ever larger AI models, trained on vast datasets, promises to deliver both highly sophisticated (reliable) and highly adaptable (generalizable) outputs (Mai et al., 2022). For GeoAI, these models may not only be task-agnostic, but also able to work with images of different spatial or spectral resolutions, across a variety of environmental conditions and landscape structures, and aware of spatiotemporal variations (Li and Hsu, 2022). However, these models require major resource-intensive enterprise, making them increasingly unattainable (Ball et al., 2017). This accessibility gap is mostly addressed by focusing on the characteristics of AI, for example reducing the need for specialized computational resources (Rolf et al., 2021) and improving diffusion through cloud-based service solutions (Lins et al., 2021). By defining *accessibility* as fit indicator, we point to the importance of also considering users' characteristics and needs. As seen in eThekwini, available infrastructure, network speed and bandwidth can be a limiting factor. Responsible AI should consider costs, but also technical resources for development and deployment, and processes for upkeep, upgrades, and scale up. For example, standalone custom software like BEAM may integrate less effectively within an existing corporate structure and be less upgradable compared to open-source GIS plug-ins, such as QGIS tools developed in Toulouse and Kumasi (Chen et al., 2024; Touati et al., 2020). Accessibility also entails fostering AI skills and readiness (Jöhnk et al., 2021), and further research could specifically explore ways to improve capabilities in data preparation, data processing, and quality assurance in local governments (Engin et al., 2020).

Beyond purely technical progress towards *generalizability* and *reliability,* responsible AI must be flexible and responsive to the planning and policy processes of its application context. Expert reviews, community feedback loops, and validation with ground-based data collection support the *contextualization* of a tool (Blumenstock, 2018). For example, in Accra in situ observations and interviews with experts from local institutions integrated local knowledge and user requirements in geospatial analysis, addressing their impact on mapped communities (Owusu et al., 2021). Adopting inclusive approaches, collaboration and local ownership throughout the development and deployment stages of AI-systems ensures appropriate *traceability* and *comprehensibility* of a model for all stakeholders (Micheli et al., 2022).

Limitations and Future Research

The BEAM project was not finalized at the time of the study; therefore, user perspectives post-tool completion could reveal additional adoption barriers and enablers. This tool was also designed for straightforward tasks. Future research using our framework should address advanced AI applications, supporting problem-solving and decision-making, which involve a wider range of users and stakeholders, and raise deeper concerns about ethics and their eventual societal desirability.

Additionally, our research relies on a single case study, and remarks some specific challenges and barriers associated with AI adoption in African cities, including infrastructure limitations, poor data availability, inadequate technical expertise and poor institutional readiness (Arun, 2020). As for many other digital technologies, portrayed as "leapfrogging" conventional development patterns, AI promises to fix some of Africa's chronic problems through efficiency and optimal use of resources (Mengesha et al., 2024). By deploying models developed elsewhere and trained on data from different contexts, it also threatens to exacerbate existing vulnerabilities and disproportionately echo historical disadvantages (Ade-Ibijola and Okonkwo, 2023). Therefore, responsible AI in Africa deserves dedicated technical and ethical considerations for overcoming design, development, and implementation challenges (Eke et al., 2023) and our research offers contributions to this still emerging research stream.

While these challenges may vary in scale and urgency, they are not unique to African cities (Randolph and Storper, 2022). Examining how AI adoption challenges interact in different contexts can reveal ethical and policy issues that span cities globally and context-specific problems arising from the interplay of global urbanization forces and local factors. Comparative case studies from a wider range of geographical areas are essential to advance knowledge on AI adoption in urban planning and to generalize lessons from our study.

Notes

1. eThekwini Municipality, *eThekwini Integrated Development Plan 2020-2021*, (eThekwini: eThekwini Municipality, 2020) < https://www.durban.gov.za/storage/Documents/Integrated%20Development%20Plans%20IDP%20-%20eThekwini%20Municipality/eThekwini%20Integrated%20Development%20Plan%20IDP%202020%20-%202021.pdf > Accessed August 7, 2024
2. Page 9 of Statistics South Africa, *Census 2001: Concepts and Definitions. Report no. 03-02-26 (2001)* (Pretoria: Statistics South Africa, 2003) http://www.statssa.gov.za/census/census_2001/concepts_definitions/concepts_definitions.pdf(Accessed August 7, 2024).
3. eThekwini Municipality, *Improved Data Integration, Collection and Analysis to Facilitate Informal Settlement Action* (eThekwini: eThekwini Municipality, 2021) https://www.globalfuturecities.org/sites/default/files/2021-11/ISIMS%20City%20to%20City%20exchange%20Nov%202021%20%28002%29%20small.pdf(Accessed August 7, 2024).
4. The eThekwini Municipality is driving this transition through the development of an integrated data platform, the Strat Hub, https://strathub.durban.gov.za (Accessed July 22, 2024).
5. UNITAC, *Using AI to Map Informal Settlements in* eThekwini (2022) https://unitac.un.org/news/unitac-x-ethekwini-using-ai-map-informal-settlements-ethekwini-south-africa (Accessed August 7, 2024).
6. In the article, when discussing our findings (Section 4), direct quotations extracted from our 12 interviews are referenced with a code that links each of the 13 interviewees (two experts were interviewed together). The codes are from INT.01 to INT.13. These codes are also used in Appendix A, which compares interviewees' characteristics, and in Appendix B, which provides a sample of the most significant coded passages. Verbal consent to reuse these data for publication purposes was obtained from all participants and recorded during the interviews.
7. For example, through the Prevention of Illegal Eviction and Unlawful Occupation of Land Act 19 of 1998.

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References

A. Ade-Ibijola and C. Okonkwo, "Artificial Intelligence in Africa: Emerging Challenges," in D.O. Eke, K. Wakunuma and S. Akintoye, ed., *Responsible AI in Africa: Challenges and Opportunities* (Cham: Springer International Publishing, 2023) 101–117.

A. Agrawal, J. S. Gans, and A. Goldfarb, "What to Expect From Artificial Intelligence," *MIT Sloan Management Review* 58: 3 (2017) 22–26.

C. Arun, "AI and the Global South: Designing for Other Worlds," in M. D. Dubber, F. Pasquale and S. Das, ed., *The Oxford Handbook of Ethics of AI* (Oxford: Oxford University Press, 2020) 588–606.

S. Athey, "Beyond Prediction: Using Big Data for Policy Problems," *Science* 355: 6324 (2017) 483–485.

A. Baird and L.M. Maruping, "The Next Generation of Research on IS Use: A Theoretical Framework of Delegation to and from Agentic IS Artifacts," *MIS Quarterly* 45: 1b (2021) 315–341.

J.E. Ball, D. T. Anderson, and C.S. Chan, "A Comprehensive Survey of Deep Learning in Remote Sensing: Theories, Tools and Challenges for the Community," *Journal of Applied Remote Sensing* 11: 4 (2017) 042609.

F. Bélanger and L. Carter, "The Impact of the Digital Divide on E-Government Use," *Communications of the ACM* 52: 4 (2009) 132–135.

N. Berente, B. Gu, J. Recker, and R. Santhanam, "Managing Artificial Intelligence," *MIS Quarterly* 45: 3 (2021) 1433–1450.

J. Blumenstock, "Don't Forget People in the Use of Big Data for Development," *Nature* 561 (2018) 170–172.

M. Bovens, "Analysing and Assessing Accountability: A Conceptual Framework," *European Law Journal* 13: 4 (2007) 447–468.

M. Burke, A. Driscoll, D.B. Lobell, and S. Ermon, "Using Satellite Imagery to Understand and Promote Sustainable Development," *Science* 371: 6535 (2021) eabe8628.

J. Burrell, "How the Machine 'Thinks': Understanding Opacity in Machine Learning Algorithms," *Big Data and Society* 3: 1 (2016) 2053951715622512.
D.J. Campbell, "Task Complexity: A Review and Analysis," *Academy of Management Review* 13: 1 (1988) 40–52,
L. Carter, D. Liu, and C. Cantrell, "Exploring the Intersection of the Digital Divide and Artificial Intelligence: A Hermeneutic Literature Review," *AIS Transactions on Human-Computer Interaction* 12: 4 (2020) 253–275,
H.H. Chang, "Task-Technology Fit and User Acceptance of Online Auction," *International Journal of Human-Computer Studies* 68: 1 (2010) 69–89.
C. Chen, Z. Guo, and J. Judge, "A QGIS Plugin for GIS-based Multicriteria Decision Analysis: an Application of Developing Alternative Future Land-Use Scenarios in Ghana," *Applied Spatial Analysis and Policy* 17: 2 (2024) 779–797.
J. Cowls, A. Tsamados, M. Taddeo, and L. Floridi, "The AI Gambit: Leveraging Artificial Intelligence to Combat Climate Change—Opportunities, Challenges, and Recommendations," AI AND SOCIETY 38: 1 (2023) 283–307.
F. Cugurullo, S. Barns, V.J. Del Casino, N.M. Gulsrud, T. Yigitcanlar, and X. Zhang, "Editorial: The Governance of Artificial Intelligence in the 'Autonomous City'," *Frontiers in Sustainable Cities* 5 (2023) 1285175.
D. Danks and A.J. London, "Algorithmic Bias in Autonomous Systems," paper presented at IJCAI (Melbourne, Australia, August 19–25, 2017).
S. De Sabbata, A. Ballatore, H.J. Miller, R. Sieber, I. Tyukin, and G. Yeboah, "GeoAI in Urban Analytics," *International Journal of Geographical Information Science* 37: 12 (2023) 2455–2463.
W.T. de Vries, J. Bugri, and F. Mandhu, "Advancing Responsible and Smart Land Management," in W.T. de Vries, J. Bugri and F. Mandhu, ed., *Responsible and Smart Land Management Interventions - An African Context* (Boca Raton: CRC Press, 2021) 279–286.
R. Dwivedi, D. Dave, H. Naik, S. Singhal, R. Omer, P. Patel, B. Qian, Z. Wen, T. Shah, G. Morgan, and R. Ranjan, "Explainable AI (XAI): Core Ideas, Techniques, and Solutions," *ACM Comput.: Surv.* 55: 9 (2023) 194.
D.O. Eke, S. S. Chintu, and K. Wakunuma, "Towards Shaping the Future of Responsible AI in Africa," in D.O. Eke, K. Wakunuma and S. Akintoye, ed., *Responsible AI in Africa: Challenges and Opportunities* (Cham: Springer International Publishing, 2023) 169–193.
Z. Engin, J. van Dijk, T. Lan, P. A. Longley, P. Treleaven, M. Batty, and A. Penn, "Data-Driven Urban Management: Mapping the Landscape," *Journal of Urban Management* 9: 2 (2020) 140–150.
L. Floridi, "Artificial Intelligence as a Public Service: Learning from Amsterdam and Helsinki," *Philosophy and Technology* 33: 4 (2020) 541–546.
L. Floridi and J. Cowls, "A Unified Framework of Five Principles for AI in Society," *Harvard Data Science Review* 1: 1 (2019) 2–15.
L. Floridi, J. Cowls, T.C. King, and M. Taddeo, "How to Design AI for Social Good: Seven Essential Factors," *Science and Engineering Ethics* 26: 3 (2020) 1771–1796.
S. Geertman, "Potentials for Planning Support: A Planning-Conceptual Approach," *Environ. Plan. B* 33: 6 (2006) 863–880.
P. Gerli, J. Clement, G. Esposito, L. Mora, and N. Crutzen, "The Hidden Power of Emotions: How Psychological Factors Influence Skill Development in Smart Technology Adoption," *Technological Forecasting and Social Change* 180 (2022) 121721.
C.M. Gevaert, M. Carman, B. Rosman, Y. Georgiadou, and R. Soden, "Fairness and Accountability of AI in Disaster Risk Management: Opportunities and Challenges," *Patterns* 2: 11 (2021) 100363.
M. Ghasemaghaei, K. Hassanein, and O. Turel, "Increasing Firm Agility Through the Use of Data Analytics: The Role of it," *Decision Support Systems* 101 (2017) 95–105.
D.A. Gioia, K.G. Corley, and A.L. Hamilton, "Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology," *Organizational Research Methods* 16: 1 (2012) 15–31.
D.L. Goodhue and R.L. Thompson, "Task-Technology Fit and Individual Performance," *MIS Quarterly* 19: 2 (1995) 213–236.

T. Grønsund and M. Aanestad, "Augmenting the Algorithm: Emerging Human-in-the-Loop Work Configurations," *The Journal of Strategic Information Systems* 29: 2 (2020) 101614.

B. Haack and R. Ryerson, "Improving Remote Sensing Research and Education in Developing Countries: Approaches and Recommendations," *International Journal of Applied Earth Observation and Geoinformation* 45 (2016) 77–83.

T. Hagendorff, "The Ethics of AI Ethics: An Evaluation of Guidelines," *Minds and Machines* 30: 1 (2020) 99–120.

A.B. Haque, A.N. Islam, and P. Mikalef, "Explainable Artificial Intelligence (XAI) from a User Perspective: A Synthesis of Prior Literature and Problematizing Avenues for Future Research," *Technological Forecasting and Social Change* 186 (2023) 122120.

M.C. Howard and J.C. Rose, "Refining and Extending Task–Technology Fit Theory: Creation of Two Task–Technology Fit Scales and Empirical Clarification of the Construct," *Information and Management* 56: 6 (2019) 103134.

K. Janowicz, R. Sieber, and J. Crampton, "GeoAI, Counter-AI, and Human Geography: A Conversation," *Dialogues in Human Geography* 12: 3 (2022) 446–458.

M. Janssen, P. Brous, E. Estevez, L.S. Barbosa, and T. Janowski, "Data Governance: Organizing Data for Trustworthy Artificial Intelligence," *Government Information Quarterly* 37: 3 (2020) 101493.

H. Jiang, S. Geertman, and P. Witte, "Ignorance is Bliss? An Empirical Analysis of the Determinants of PSS Usefulness in Practice," *Computers, Environment and Urban Systems* 83 (2020) 101505.

A. Jobin, M. Ienca, and E. Vayena, "The Global Landscape of AI Ethics Guidelines," *Nature Machine Intelligence* 1: 9 (2019) 389–399.

R. Johansson, "On Case Study Methodology," *Open House International* 32: 3 (2007) 48–54

J. Jöhnk, M. Weißert, and K. Wyrtki, "Ready or Not, AI Comes—An Interview Study of Organizational AI Readiness Factors," *Business and Information Systems Engineering* 63: 1 (2021) 5–20.

R.B. Johnson and A.J. Onwuegbuzie, "Mixed Methods Research: A Research Paradigm Whose Time Has Come," *Educational Researcher* 33: 7 (2004) 14–26.

J. Karimi, T.M. Somers, and Y.P. Gupta, "Impact of Environmental Uncertainty and Task Characteristics on User Satisfaction with Data," *Information Systems Research* 15: 2 (2004) 175–193.

D.-H. Kim, G. López, D. Kiedanski, I. Maduako, B. Ríos, A. Descoins, N. Zurutuza, S. Arora, and C. Fabian, "Bias in Deep Neural Networks in Land Use Characterization for International Development," *Remote Sensing* 13: 15 (2021) 2908.

S.C. Koumetio Tekouabou, E. B. Diop, R. Azmi, R. Jaligot, and J. Chenal, "Reviewing the Application of Machine Learning Methods to Model Urban Form Indicators in Planning Decision Support Systems: Potential, Issues and Challenges," *Journal of King Saud University - Computer and Information Sciences* 34: 8, Part B (2022) 5943–5967.

R.Y. M. Li and K.W. Chau, "Predicting Housing Prices in Hong Kong Based on AI Interpreted Sentiment in Social Media, Health and Sustainability Factors: A White-box AutoML Research Agenda," in R.Y M. Li, K.W. Chau and D.C.W. Ho, ed., *Current State of Art in Artificial Intelligence and Ubiquitous Cities* (Singapore: Springer Nature, 2022) 135–154.

W. Li and C.-Y. Hsu, "GeoAI for Large-Scale Image Analysis and Machine Vision: Recent Progress of Artificial Intelligence in Geography," *ISPRS International Journal of Geo-Information* 11: 7 (2022) 1–44.

S. Lins, K.D. Pandl, H. Teigeler, S. Thiebes, C. Bayer, and A. Sunyaev, "Artificial Intelligence as a Service," *Business and Information Systems Engineering* 63: 4 (2021) 441–456.

D. Lunga, J. Arndt, J. Gerrand, and R. Stewart, "ReSFlow: A Remote Sensing Imagery Data-Flow for Improved Model Generalization," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 14 (2021) 10468–10483.

G. Mai, C. Cundy, K. Choi, Y. Hu, N. Lao, and S. Ermon, "Towards a Foundation Model for Geospatial Artificial Intelligence (vision paper)," paper presented at ACM SIGSPATIAL 2022 (Seattle, Washington, November 1–4, 2022).

R. Marasinghe, T. Yigitcanlar, S. Mayere, T. Washington, and M. Limb, “Towards Responsible Urban Geospatial AI: Insights From the White and Grey Literatures,” *Journal of Geovisualization and Spatial Analysis* 8: 2 (2024) 24.

G.H. Mengesha, E.G. Belay, and R. Adams, “Technical Considerations for Designing, Developing, and Implementing AI Systems in Africa,” in L.G.A. Amoah, ed., *Examining the Rapid Advance of Digital Technology in Africa* (Hershey, PA, USA: IGI Global, 2024) 86–104.

C. Meske, E. Bunde, J. Schneider, and M. Gersch, “Explainable Artificial Intelligence: Objectives, Stakeholders, and Future Research Opportunities,” *Information Systems Management* 39: 1 (2022) 53–63.

M. Micheli, C. M. Gevaert, M. Carman, M. Craglia, E. Daemen, R. E. Ibrahim, A. Kotsev, Z. Mohamed-Ghouse, S. Schade, I. Schneider, L. A. Shanley, A. Tartaro, and M. Vespe, “AI Ethics and Data Governance in the Geospatial Domain of Digital Earth,” *Big Data and Society* 9: 2 (2022) 1–5.

T. Miller, “Explanation in Artificial Intelligence: Insights from the Social Dciences,” *Artificial Intelligence* 267 (2019) 1-38.

S. Mitchell, E. Potash, S. Barocas, A. D’Amour, and K. Lum, “Algorithmic Fairness: Choices, Assumptions, and Definitions,” *Annual Review of Statistics and its Application* 8: 1 (2021) 141–163.

J. Morley, L. Floridi, L. Kinsey, and A. Elhalal, “From What to How: An Initial Review of Publicly Available AI Ethics Tools, Methods and Research to Translate Principles into Practices,” *Science and Engineering Ethics* 26: 4 (2020) 2141–2168.

G. Muchenje and M. Seppänen, “Unpacking Task-Technology Fit to Explore the Business Value of Big Data Analytics,” *International Journal of Information Management* 69 (2023) 102619.

N. Odendaal, “Splintering Urbanism or Split Agendas? Examining the Spatial Distribution of Technology Access in Relation to ICT Policy in Durban, South Africa,” *Urban Studies* 48: 11 (2011) 2375–2397.

M. Owusu, M. Kuffer, M. Belgiu, T. Grippa, M. Lennert, S. Georganos, and S. Vanhuysse, “Towards User-Driven Earth Observation-Based Slum Mapping,” *Computers, Environment and Urban Systems* 89 (2021) 101681.

A. Parkes, “The Effect of Task–Individual–Technology Fit on User Attitude and Performance: An Experimental Investigation,” *Decision Support Systems* 54: 2 (2013) 997–1009.

P. Pelzer, “Usefulness of Planning Support Systems: A Conceptual Framework and an Empirical Illustration,” *Transportation Research Part A* 104 (2017) 84–95.

Z.-R. Peng, K.-F. Lu, Y. Liu, and W. Zhai, “The Pathway of Urban Planning AI: From Planning Support to Plan-Making,” *Journal of Planning Education and Research* 44: 4 (2024) 2263–2279.

A.P. Pereira and M. Prokopiuk, “Informational Modeling of Cities: Method and Challenges for Institutional Implementation,” *Journal of Urban Technology* 31: 2 (2024) 97–115.

G.F. Randolph and M. Storper, “Is Urbanisation in the Global South Fundamentally Different? Comparative Global Urban Analysis for the 21st Century,” *Urban Studies* 60: 1s (2023) 3–25, 004209802110679.

T. Räz, “Gerrymandering Individual Fairness,” *Artificial Intelligence* 326 (2024) 104035.

M. Rittenbruch, M. Foth, P. Mitchell, R. Chitrakar, B. Christensen, and C. Pettit, “Co-Designing Planning Support Systems in Urban Science: The Questions They Answer and the Questions They Raise,” *Journal of Urban Technology* 29: 2 (2022) 7–32.

M. Riveiro and S. Thill, ““That’s (Not) the Output I Expected!” On the Role of End User Expectations in Creating Explanations of AI Dystems,” *Artificial Intelligence* 298 (2021) 103507.

E. Rolf, J. Proctor, T. Carleton, I. Bolliger, V. Shankar, M. Ishihara, B. Recht, and S. Hsiang, “A Generalizable and Accessible Approach to Machine Learning with Global Satellite Imagery,” *Nature Communications* 12: 1 (2021) 4392.

T. Roth, A. Stohr, J. Amend, G. Fridgen, and A. Rieger, “Blockchain as a Driving Force for Federalism: A Theory of Cross-Organizational Task-Technology Fit,” *International Journal of Information Management* 68 (2023) 102476.

L. Royakkers, J. Timmer, L. Kool, and R. van Est, “Societal and Ethical Issues of Digitization,” *Ethics and Information Technology* 20: 2 (2018) 127–142.

C. Rudin, “Stop Explaining Black Box Machine Learning Models for High Stakes Decisions and Use Interpretable Models Instead,” *Nature Machine Intelligence* 1: 5 (2019) 206–215.

P. Russo, R. Lanzilotti, M. F. Costabile, and C. J. Pettit, “Towards Satisfying Practitioners in Using Planning Support Systems,” *Computers, Environment and Urban Systems* 67 (2018) 9–20.

C. Rzepka and B. Berger, “User Interaction with AI-enabled Systems: A Systematic Review of IS Research,” paper presented at ICIS (San Francisco, USA, December 13–16, 2018).

T.W. Sanchez, H. Shumway, T. Gordner, and T. Lim, “The Prospects of Artificial Intelligence in Urban Planning,” *International Journal of Urban Sciences* 27: 2 (2022) 179–194.

O. Söderström, E. Blake, and N. Odendaal, “More-Than-Local, More-Than-Mobile: The Smart City Effect in South Africa,” *Geoforum* 122 (2021) 103–117.

T.H. Son, Z. Weedon, T. Yigitcanlar, T. Sanchez, J. M. Corchado, and R. Mehmood, “Algorithmic Urban Planning for Smart and Sustainable Development: Systematic Review of the Literature,” *Sustainable Cities and Society* 94 (2023) 104562

T. Sturm and F. Peters, “The Impact of Artificial Intelligence on Individual Performance: Exploring the Fit between Task, Data, and Technology,” paper presented at ECIS (Marrakech, Morocco, June 15–17, 2020).

T. Sturm, L. Pumplun, J. P. Gerlach, M. Kowalczyk, and P. Buxmann, “Machine Learning Advice in Managerial Decision-Making: The Overlooked Role of Decision Makers’ Advice Utilization,” *Journal of Strategic Information Systems* 32: 4 (2023) 101790.

N. Touati, T. Gardes, and J. Hidalgo, “A GIS Plugin to Model the Near Surface Air Temperature from Urban Meteorological Networks,” *Urban Climate* 34 (2020) 100692.

F. Traumer, S. Oeste-Reiß, and J. M. Leimeister, “Towards a Future Reallocation of Work between Humans and Machines – Taxonomy of Tasks and Interaction Types in the Context of Machine Learning,” paper presented at ICIS (Seoul, South Corea, December 10–13, 2017).

M. Vered, T. Livni, P. D. L. Howe, T. Miller, and L. Sonenberg, “The Effects of Explanations on Automation Bias,” *Artificial Intelligence* 322 (2023) 103952.

M. Vimalkumar, A. Gupta, D. Sharma, and Y. Dwivedi, “Understanding the Effect that Task Complexity has on Automation Potential and Opacity: Implications for Algorithmic Fairness,” *AIS Transactions on Human-Computer Interaction* 13:1 (2021) 104–129.

K.-K. Wei, H.-H. Teo, H.C. Chan, and B.C.Y. Tan, “Conceptualizing and Testing a Social Cognitive Model of the Digital Divide,” *Information Systems Research* 22:1 (2011) 170–187.

D.S. Williams, M. Máñez Costa, C. Sutherland, L. Celliers, and J. Scheffran, “Vulnerability of Informal Settlements in the Context of Rapid Urbanization and Climate Change,” *Environment and Urbanization* 31:1 (2019) 157–176.

N. Wongpinunwatana, C. Ferguson, and P. Bowen, “An Experimental Investigation of the Effects of Artificial Intelligence Systems on the Training of Novice Auditors,” *Managerial Auditing Journal* 15: 6 (2000) 306–318.

T. Yigitcanlar, J.M. Corchado, R. Mehmood, R.Y.M. Li, K. Mossberger, and K. Desouza, “Responsible Urban Innovation with Local Government Artificial Intelligence (AI): A Conceptual Framework and Research Agenda,” *Journal of Open Innovation: Technology, Market, and Complexity* 7: 1 (2021) 71.

T. Yigitcanlar, N. Kankanamge, M. Regona, A. Ruiz Maldonado, B. Rowan, A. Ryu, K.C. Desouza, J.M. Corchado, R. Mehmood, and R.Y.M. Li, “Artificial Intelligence Technologies and Related Urban Planning and Development Concepts: How Are They Perceived and Utilized in Australia?,” *Journal of Open Innovation: Technology, Market, and Complexity* 6: 4 (2020) 187.

R. K. Yin, *Case Study Research: Design and Methods* (London: Sage,2009)

J. Zevenbergen, W.: de Vries, and R.M. Bennett, ed., *Advances in Responsible Land Administration* (Boca Raton: CRC Press, 2016).

Appendix A

Table A1: List of interviews and interviewees' characteristics

ID	Background	Role	Affiliation	Municipality Unit	Direct project involvement	Date
INT.01	Urban Planning	Manager	UNITAC	-	Y	28 March 2023
INT.02	Urban Planning	Technical officer	eThekwini Municipality	Spatial Planning	N	3 April 2023
INT.03	Data Science	Technical officer	UNITAC	-	Y	4 April 2023
INT.04	Geography	Manager	eThekwini Municipality	Human Settlement	Y	6 April 2023
INT.05	GIS	Technical officer	eThekwini Municipality	Corporate GIS	Y	13 April 2023
INT.06	GIS	Technical officer	eThekwini Municipality	Corporate GIS	Y	13 April 2023
INT.07	Technology	Manager	eThekwini Municipality	Economic Development	N	14 April 2023
INT.08	Data Science	Technical officer	UNITAC	-	Y	26 April 2023
INT.09	Urban Planning	Technical officer	UNITAC	-	N	10 May 2023
INT.10	Urban Planning	Manager	eThekwini Municipality	Data, Research and Policy Advocacy	Y	1 August 2023
INT.11	Urban Planning	Manager	eThekwini Municipality	Human Settlement Unit	N	3 August 2023
INT.12	GIS	Technical officer	eThekwini Municipality	Human Settlement	Y	10 August 2023
INT.13	GIS	Technical officer	eThekwini Municipality	Corporate GIS	Y	14 August 2023

Appendix B

Table B1: Sample of the most significant coded passages

Concept *First-Order Coding*	*Representative Quotations*
Data accessibility and flow	The most important thing in the beginning, of course, was to get some data to understand what we could work with in the first place. Problem was that the city had terabytes of data, but the issue was that according to them, due to Internet connectivity it was not possible to upload this data anywhere so that we could access it. So for months we were in talks of getting a hard drive that would be shipped to Europe from eThekwini. (INT.03) Some of the file size of the imagery was too big for us to send via email or via a cloud service, the upload time would have been quite long and with the issues of load shedding in South Africa it would not have sufficed. (INT.12)
Data quality	The idea that we worked based off of was that the images would be like the ones that we were given to train on, that that would be the type of image that it would later be run on. But we weren't told what and how the other images that this should also work on were, what their resolution was or so on. (INT.03) Durban has been flying the whole city boundary since the 1990s. Obviously the resolution has changed over time. So, we do understand that it might not be able to go back to say the 1995 aerial imagery or the 1990 aerial imagery, it might not be high enough resolution. (INT.04) The issue that we faced was that the image quality and the resolution of those images were far more different than the resolution of the 2021 and now the 2022 images. So they trained them on a lower resolution imagery and then we got higher resolution imagery after that. So that's where most issues came about. It was mostly logistical issues of sending the data, but you know also a delay on actually finalizing processing. (INT.12)
Variable project contributors	Our corporate GIS section has actually taken over from us in running the partnership from eThekwini side, so they're able to make more technical input

(*Continued*)

Table B1: Continued.

Concept *First-Order Coding*	*Representative Quotations*
	than I could. But at the same time, the scope of the tool and the user journeys seem to have changed a little bit since they've taken over. (INT.04)
	I think there was mention of some shape files for formal areas that we could have done the testing on, but again we haven't really done anything systematic. We didn't really have time because I was focused on the handover and putting everything together for the person taking over. (INT.03)
Dynamic requirement	It was trained to pick up small structures, informal settlement structures, and now it's being trained to pick up all structures. So, it's moved out of the specific informal settlement focus. (INT.04)
	In commercial areas like our central business district, it does a poor job. Again, it's understandable that it was trained on the informal settlements, and it understands them well and it may not understand all the other different types of classifications. (INT.13)
Expert validation and local knowledge integration	Even with AI you need to use it by deduction, you need to take a human eye or a human assessment to look at it because you see in something that's normal or abnormal in it and you have concerns about it.(INT.02)
	What I think still needs to happen to ensure that data is reliable is to train the model further with our help. As you are aware, there's quite a lot of structures or phenomena that the tool picks which may not really be building structures. In some instances, it just picks up a big piece on the side of the road based on the shade, as an example. In some instances, it picks up buses, in some instances it will pick up many buses. (INT.13)
Output quality	To inform your decision making you need additional investigation, additional research. Or sometimes you'll be satisfied. Sometimes you don't need that detail. Sometimes what you're getting from an AI process is good enough. Depending on what you need to use it for. (INT.02)
	If you're looking at 300 and 14, 300 and 15,000 structures, if there is a 1% change higher or lower, that's acceptable, because once a project is selected or a settlement is selected and you zoom into it, that's when more detailed analysis can be undertaken. (INT.11)
	It's mostly going to be used for quantitative purposes. I'm not so much qualitative but more for as you said in numeration, entities and all those things. (INT.12)
	There may be issues in terms of reliability and confidence. People may have more confidence in what we've generated using a manual process because it gives out much more refined, much more accurate building footprints. (INT.13)
Automation potential	I do not see us running that manual process of extracting building footprints using the LIDAR data with a few QA process that could take us one and a half year just to release a comprehensive data. (INT.06)
	I think officers were more than willing to use [the tool] because the current methodologies have proven to be time consuming and to some extent rather inaccurate at times. (INT.12)
	What we've been able to get out using different processes is of great quality, but we should also note and not forget that it's actually a very manual process and it takes extensive number of hours and human effort, while what we get out of beam is something that's quite quicker to get out and it doesn't really require that much human intervention in terms of generating the footprints. (INT.13)
Computing time	We are able to map all informal settlements in the city of eThekwini within 72 hours, so this is something that otherwise would take months and a huge team because they have been doing the whole mapping process manually beforehand. (INT.01)
	Obviously, we were then responsible to do all the technical and practical testing to prove that statement correct. One, we have to consider how many working hours we are here for during the day. Two, you had to consider other IT factors such as network speed etcetera, but I think roughly we're able to achieve that full process within three weeks or four weeks. (INT.05)
	This number comes from the 72 hours. Or actually I like the other number, which is 80 to 90 seconds per image depending on the complexity of the image. This is for the whole city. (INT.08)
Complexity	It's a very straightforward task and we can fulfill this task. (INT.01)

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Table B1: Continued.

Concept *First-Order Coding*	*Representative Quotations*
	I would say from a technical perspective it's not super complicated because this is a pioneer project, and the idea of segmentation or buildings is there since a long time. (INT.08)
Bottom-up perspective	At broad strategic level when you gather information for purposes of determining your overall backlog for determining funding at a high level, the actual accuracy down to getting it to 100% perfection is not going to happen in any case. So, it's only when, for example, a project becomes a reality, when people actually go on the ground to capture information from households that you would get a good idea of the exact number of people living there, because at the end of the day, that's what it boils down to: people and families as opposed to an account of the structures. (INT.11)
	Given the extent of the municipal boundary, given the magnitude of the backlog that we have, it would be impossible to have somebody on the ground, and covering such a large area and effectively over a short space of time. So, the best we can do is use such technology to assist us and to make very broad and informed assumptions based on maybe pilots or sample cases to determine the number of people or households or families residing in informal settlements and capture the growth that's occurring. (INT.12)
Data detail	It is assumed that when using a plane so many meters above the earth, privacy sensitivity cannot be breached. But if you're going to look at things like drone imagery, for example, a drone can fly very close. Yeah. Then I think that's only when we can have such conversations. (INT.05)
	It's a pretty transparent kind of data. It's transparent information. It's just an image, we're sure that the images were not manipulated or something. (INT.08)
Community engagement	We didn't feel that it was particularly useful to bring community members in to discuss this piece of technology, which is assisting us to do a function that we're already doing, but just in a much more expensive and time-consuming way. (INT.04)
	Generally, when you're doing something like this, you also need to go to the ground and actually speak to those you think you will be assisting. It's no good just developing a model at this level and just assuming that it's basic function will be achieved right at the bottom. So, there was that need for that engagement, and it was done. (INT.06)
	The communities should be informed, I think this also helps with the understanding where data gaps could be. As an example, if you are running a AI model to pick up building footprints and some buildings are not picked up in the process and you're making decisions out of that, the communities need to be aware that there is that margin of error in the data that is generated. (INT.13)
Interface for image analysis	What [UNITAC] was able to deliver was a completely user-friendly solution. It's a literally a step one to three, once you've done all your prerequisites of downloading the different pieces of software that need to be there and installed the tool properly, running it very simple. (INT.05)
	It's definitely easy to use, so with that you have more people that will be able to use it because you have sort of guided process, a three-step process for you to run the tool. (INT.13)
Interface for model retraining	I don't currently have the understanding to do that. What we were hoping, and I'm not quite sure if it's gone that way, is that there would be a simple interface where when you load your aerial imagery, you can tell it whether it's just to analyze or whether it's to train. And then you could retrain the machine for each set ourselves. But I don't think that it's at that level. (INT.04)
	Retraining is not something that's been automatically included in the process. It's something that happens in the back end. So that's the challenge I foresee with the tool, it's retraining it to use new assets of data. (INT.07)
	The difference [with corporate products] stays that you get something that is AI driven and much more simplified in terms of training your model, building your model, and running your model. (INT.13)
Developer-user dialogue	I can only tell you my feeling because I don't know what happened behind the scenes on their end. It did seem like most people had their main projects and this was kind of a side thing on top of their current work. It was always a bit like last minute and seemed a bit improvised. This was my main task. So I was, I felt

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Table B1: Continued.

Concept *First-Order Coding*	*Representative Quotations*
	much more invested in it than my counterparts because I could tell that this was just one of many things they had on their plate. (INT.03)
	I'm not an IT specialist. The concept came from us, but I wasn't able to contribute towards the actual technological development, and I don't think UNITAC wanted that from us. I think they're had that best and the University of Hamburg. (INT.04)
	Without a doubt between the municipality and the team in Hamburg this issue should have been resolved when the project was handed over. But obviously that didn't happen. (INT.07)
	A planning tool needs to have a very deep internal component of people internally developing it and ensuring that it talks to the existing systems. (INT.10)
	We had some feedback loop from the corporate GIS because they obviously know better than us. They're the experts on the city. (INT.08)
Trust in technology	The opportunity that exists for African cities, particularly the big metros, is that they have a possibility of leapfrogging a lot of cities in the world because of the tools that are available. (INT.10)
	If we can demonstrate to city officials the benefits of this tool … it would be key in in winning over officials to accept it. (INT.11)
AI awareness	AI being Something that's new and growing, and we're definitely at the South of Africa, so everything tends to reach us last. Even the perceptions won't be the same. In an organization you'll have your technical staff right at the bottom, and then you'll have your senior management staff at the top. Your interactions technically are not the same, therefore perceptions will not be the same. And when new concepts like AI come across people can get excited and make assumptions about what it can do. But the technicals of it is something else. The science of it is something else. (INT.05)
	You either live with the option to consistently retrain for every single year, or you strengthen the algorithms and the development of the tool by familiarizing it more and more each time so that you wanted to automatically detect over years or you have the option to retrain every year. That depends now on a lot of time and resources. (INT.06)
	I feel that the tool has been oversold to those outside the city while the reality is that it doesn't really function or do what it had promised to do. (INT.10)
Legal and policy framework	UN-Habitat has an MOU with eThekwini in place that this data can only be used for planning and not for eviction. It's really sensitive data now, if you provide data on informal settlement growing So it's actually data to see how our informal settlements growing, where they are densifying and where they need to go specifically with their upgrading measures and programs. (INT.01)
	We were told that in South Africa [evictions] wouldn't be possible. There are certain safeguards for people that have to be relocated from informal settlements and so on. So, I wonder, you know, how people when you tell them that the city now wants to automatically map their buildings from the sky, how they would feel about, it if they would even want to participate, if they would want to help. (INT.03)
	There are decision making structures, ten levels of decisions, that's how the reporting is done. Testing for approval. The reporting on the progress is unchanged, the decision making is entrenched in these systems and processes, so it's difficult to remove the people. This is how the structure works and how the accountability in the system is allocated. (INT.07)
Existing practices and fora	The more effective way of bringing community closer to mapping is to do what we call enumeration or community-based mapping and profiling. We do that through other organizations like the Community Organization Resource Center. They have a lot of expertise in community-based mapping, enumeration processes, and we called them in the reference group for the BEAM. (INT.04)
	On algorithms and using algorithms for decision making and predicting certain things, we also have to be very transparent with that, because that creates a lot of challenges because it creates issues of exclusion. You exclude certain people if you are just using algorithms and trusting algorithms that they would pick up the differences and categories of people in certain ways. So I think for me that's

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Table B1: Continued.

Concept *First-Order Coding*	*Representative Quotations*
	extremely, extremely important that we look at how those processes are done. (INT.10)
	We did have a launch last year for the tool and we invited various stakeholders to participate at the top level management and counselors as well to see how the tool works and you know to see how it was developed, how it was done. So there has been quite a few stakeholders involved that represents the citizens of eThekwini municipality (INT.12)
Digital infrastructure	Hardware procurement was a little bit difficult …) we just wanted them to procure one computer with higher resolution. For us it was a little bit surprising because it was not that much RAM and so on, and it was difficult to procure. (INT.01)
	Remember, we're sitting here in a third world country, so IT availability, fee, resources capacity, availability for funding might not be what you're used to. (INT.04)
	The team in Hamburg at least should have had in the discussion to understand whether the city had the capacity to immediately run [the tool]. You can also imagine that adding the cost of one computer in this project which would be able to run the tool would have just ensured that it's successful in terms of implementation. (INT.07)
	As we speak, we're trying to make use of the tool, but the city actually does not have in its possession a computer which is meeting the minimum requirements to be able to run that tool. Because the AI would require a machine with a very large GPU. So, you start to realize that on the technology infrastructure we are not as advanced. And also, the way the city is geared up it's not able to quickly respond to owning that tool. It means we have to now look for budget, we have to motivate for budget to be able to purchase a computer which is going to be able to run the tool. (INT.07)
Capacity for operating the tool	I think in terms of staff they have human resources, like with the corporate GIS and their Innovate Durban and so on, they have a lot of human resources. (INT.01)
	That was one of the reasons that I actually had it transferred to corporate GIS because I knew that I personally don't have the technical skill to interact with the tool at that level for maintenance or anything. But I'm hoping that our corporate GIS staff will be able to continue to refine and work with the tool given what's been set up so far by the UNITAC team. (INT.04)
Capacity for retraining	We have the whole focusing on capacity building and knowledge transfer and there to enable people in antiquity or in other South African cities to train the modules themselves. For providing them with notebooks and training sessions. So, it's more like really tech driven capacity building to […] train the models themselves for when they have new images, if they want to go back in time, if they want to train it for, for example, different use cases. (INT.01)
	Our GIS technicians are fairly competent … but I'm not sure that they have highly got the capacity to retrain or do anything like that. Some people would probably be able to work with the source code, but even then, I'd be hesitant to just let him loose on it, unless we had somebody from UNITAC holding his hand. (INT.04)
	For training this model, unfortunately, eThekwini doesn't have that capacity. The idea that we came up with in the end is that maybe each year they would have to hire a freelancing or a very limited capacity of a data scientist or an expert to retrain the model for those images and then they can use it. (INT.08)
	There were still issues of training the model, whether the model could be trained using the new data without the intervention from UNITAC ambushing that process, where as a city we are able to utilize the whole data to be able to train the tool. (INT.10)
	Code had to be rewritten to train the model. So the skill is not really a skill that is easily available within the council at the moment. So in terms of training data sets, in terms of adjusting the tool in the back end, definitely the tool need either training of staff or identification and hiring of people that already possess those skills. (INT.13)
Editability and continued support	UNITAC will not employ this project for a longer period, so we hand over the tool, hand over the code. (INT.01)

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Table B1: Continued.

Concept *First-Order Coding*	*Representative Quotations*
	If they've developed a tool, it is fine for them to hand over everything to us. Or do we just get the user version where we are just able to operate on the interface? Or are we able to go on the back end and do our own sort of inhouse development where we tweak and adjust one or two things, so they knew you bringing those conversations into play, so that just makes everything more complex. (INT.05)
	We like the fact that this tool is being developed on an open-source platform where we're not really requiring a lot of funding for us to purchase licenses and other things. The challenge with that is that the municipality is so used to proprietary software, and it hasn't really focused on ensuring that the skills to work with open-source software. (INT.13)
Scale up and new features	The idea was to have one work package "Enhancing the beam tool", training the model for different use cases and typologies in eThekwini, so that the model that we to have a good Output as well on on And the CBD area and so on. And then we had geographical upscaling in South Africa, and I think that's important. (INT.01)
	There's a common question that does come up, it's the identification of objects. Whether the BEAM tool would now be able to automatically tag certain objects and identify them. The answer is no, we're not at that level yet. Well, I think we they still much more scope here in just the training of the data and making sure that the AI model does as best it can just to identify primary buildings as initial objects, so we're not at that level. (INT.05)
	There's new data or can it then predict and we don't have to prepare training data all the time? because of course that's frankly annoying when you're retraining the model each year. (INT.10)
	Those skills may not be skills that are present internally whether we make use of proprietary or open source, but in terms of the fuel chain what's more secure in the way I see it would be to make use of proprietary. We are exploring the AI capabilities within ArcGIS pro. (INT.13)

Appendix C

Table C1: Secondary data sources

Author	Title	Year	Source
	City Plans and Strategies		
eThekwini Municipality	eThekwini Integrated Development Plan (IDP) 2017/18 to 2021/22. 2020–2021 Review	2020	Government Website
eThekwini Municipality	*Informal Settlement Incremental Upgrading City-Wide Strategy and Programme Description*	2022	Government Website
eThekwini Municipality	eThekwini Integrated Development Plan (IDP) 2023/24 to 2027/28. 2023–2024 Review	2023	Government Website
	Reports and Presentations		
eThekwini Municipality	Improved Data Integration, Collection and Analysis to Facilitate Informal Settlement Action	2021	Project Document
UN-Habitat	Durban City Context Report	2019	Project Document
Future Cities South Africa	Consolidated Principles for Data Management in the eThekwini Municipality	2020	Project Document
	Technical Documentation		
UNITAC	BEAM User Manual	2022	UNITAC Knowledge Hub
	News Article and Online Presentations		
UNITAC	Building Smart Tools for Sustainable Cities: UNITAC Hamburg Projects	2022	Youtube
UNITAC	Using AI to Map Informal Settlements in eThekwini	2022	UNITAC
UNITAC	Building and Establishment Automated Mapper (BEAM)	2023	Youtube
Urban AI	Enabling Safe and Inclusive Cities in Africa—UN-Habitat-Mapping Urban AI Series	2023	Youtube

Curriculum Vitae

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2008–2013	Università degli Studi di Ferrara, MSC
2002–2007	Liceo Scientifico Galileo Galilei, High school

Language competence

Italian	Native
English	Fluent
Spanish	Fluent
French	Intermediate

Professional employment

2025–present	Joint Research Center, European Commission
2022-2025	FinEst Centre for Smart Cities, Tallinn University of Technology
2022-2024	United Nations Human Settlements Programme
2021-2022	UNHCR (United Nations High Commissioner for Refugees)
2016-2021	UN-Habitat (United Nations Human Settlements Programme)
2015-2016	Sauerbruch Hutton Architekten
2013-2014	INOUT Architettura

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Keelteoskus

Itaalia keel	Emakeel
Inglise keel	kõrgtase
Hispaania keel	kõrgtase
Prantsuse keel	kesktasemel

Teenistuskäik

2025–present	Joint Research Center, European Commission
2022-2025	FinEst Targa Linna Tippkeskus, Tallinna Tehnikaülikool
2022-2024	United Nations Human Settlements Programme
2021-2022	United Nations High Commissioner for Refugees
2016-2021	United Nations Human Settlements Programme
2015-2016	Sauerbruch Hutton Architekten
2013-2014	INOUT Architettura

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