Rethinking Smart Urbanism

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Rethinking Smart Urbanism

City-Making and the Spread of Digital Infrastructures in Nairobi

Het heroverwegen van Smart Urbanisme:
Stad-maken en de verspreiding van de digitale infrastructuur in Nairobi
(met een samenvatting in het Nederlands)

PROEFSCHRIFT

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INTRODUCTION

1.1 Background and Problem Outline

The capacities of conventional infrastructure networks in African cities are stretched by the complex and adverse effects of rapid urbanization (UN-Habitat 2010, 2013, 2008, 2016; Mutisya and Yarime, 2011). In academia and the policy world particularly, urban water and energy systems are often cited as domains that reveal varying degrees of deficiency that limit their capacity to provide adequate basic services to all citizens (see Kariuki et al., 2003). Urban populations have to navigate everyday consequences of sporadic power blackouts (Byrd and Matthewman, 2014) and rationed water services (Wamuchiru, 2017). Here, patchwork and in-situ incremental and self-organized mechanisms—that often lie outside the defined laws and are sometimes at loggerheads with urban planning—become the go-to alternatives (Monstadt and Schramm, 2017; Jaglin, 2014; Lawhon et al., 2018; Hailu et al., 2011). For energy supply, these sources include firewood and charcoal, paraffin stoves, repurposed car batteries, diesel-powered generators, solar energy and home systems, biogas and biomass stoves, and agricultural wastes (Silver, 2014; Silver and Marvin, 2017; Butera et al., 2015). For water supply, auxiliary schemes comprise of overhead reservoirs such as storage tanks, underground systems like drilled boreholes and shared public standpipes, and fetching water from neighbouring places by foot, hand-push carts, tanker trucks or motorbikes locally known as tuk-tuks or boda-bodas (Kyessi, 2003; Smiley, 2013). Other sources include concentrated supply chains of vending that are dependent on strategic clusters of informal power and water distributors that self-connect from central grids and networks (Akallah, 2019; Wamuchiru, 2017). Although these infrastructural engagements are prevalent in both rich and poor areas, they are more common in poor urban neighbourhoods. They are acknowledged for their ability to meet some of the most immediate household needs and demands and for filling the gaps in the conventional service (Jaglin, 2014). At the same time however, they reveal the inevitable limits of networked infrastructure systems in urban Africa (Gandy, 2006; UN-Habitat, 2016; Güneralp et al., 2017; Pieterse and Parnell, 2014).

However, there have been far-reaching expectations concerning the role and impact of digital technologies in enhancing the ability of infrastructure systems to supply basic services (see e.g. GSMA, 2016; Nique and Opala, 2014). For example, the last two or so decades have seen urban water and energy providers in African cities invest heavily in digital technologies as tools with the potential to expand the reach of centrally planned water and electricity networks amidst structural conditions and socio-spatial disparities of urban splintering. Utility providers have employed digital technologies (Foster et al., 2012; Baptista, 2015; Ndaw, 2015; Nique, 2013) to push heterogeneous service constellations out of the market and to expand and universalize their networks. These technologies have predominantly taken the form of mobile phone text-based services and applications that providers use to interface with their users, and particularly for allowing their users to purchase services, make payments and settle their bills (Ndaw, 2015; Nique, 2013; TEIU, 2014). The Kenyan mobile payments and banking service M-Pesa is an example of such technology (Mbiti and Weil, 2015). M-Pesa provides baseline infrastructure for a wide range of unique and innovative mobile phone-based transfer and payment services that rely on texts and short codes (Hughes and Lonie, 2007; Jack and Suri, 2011). M-Pesa's rise in Kenya has led to the emergence of numerous spinoffs, with other communication and telecommunication companies adopting a similar infrastructural logic. In the turn of the new millennium, technologies such as M-Pesa have reconfigured urban infrastructures, engineering new socio-technical developments and attaining a critical role in the provision of utility services in Africa's cities. They have enabled automated service provision where users are able to buy or rent-to-own water and power meters and products, self-manage and control their own meters, recharge phone or power bundles and pay outstanding bills, query utility providers, and sell and provide services.

A variety of researchers, practitioners and policymakers have widely advocated for greater engagement with digital technologies as catalysts for enhancing infrastructure supply in the pursuit of the Sustainable Development Goals (SDGs) ratified during the UN General Assembly in September 2015 (e.g. Osburg and Lohrmann, 2017; United Nations, 2015; UN-Habitat, 2016; Güneralp et al., 2017). The SDGs promote digital technologies for their ability to enable service provision and access, as well as potential to make cities smarter and more sustainable. For example, digital technologies are acknowledged by SDG 9 on industry, innovation and infrastructure, which cites the broad application of digital technologies as critical for building resilient infrastructure and fostering innovation (United Nations, 2015). They are also reflected in SDG 6 on clean water and sanitation (e.g. through smart pipes, smart meters, consumption control apps and e-billing), SDG 7 on affordable and clean

energy (e.g. smart grids, smart appliances, energy consumption monitoring, detection technologies, smart sensors, predictive analytics and demand response technology) and SDG 17, which identifies technology as a significant "means of implementation" (ibid.). However, beyond this recognition of the complex and dynamic interface between digital technologies, infrastructure development and urbanization in Southern contexts, further substantial conceptual and empirical research is required.

This dissertation highlights the need for a greater understanding of the interactions between the digital technologies and contemporary large-scale infrastructure systems, and the interface between these interacting domains and the city. Viewing the city as a site of infrastructure development and digitalization processes amidst countervailing processes and rationalities, this dissertation, drawing from the case of Kenya's capital, Nairobi, examines the multiple ways in which cities and infrastructures are constructed and reconstructed through ICT innovation and appropriation. The dissertation explains existing infrastructure constellations through countervailing processes and rationalities in the context of sustained and large-scale urban fragmentation. This context fits the description of what urban scholars and researchers today commonly understand by "splintered urbanism", a description rooted in Graham and Marvin's (2001) "splintering urbanism": a thesis to infrastructural landscapes that radically challenge established assumptions that have underpinned integrated networks and cities. In response to this thesis, different scholars have argued that many Southern cities, rather than splintering, are *already* splintered (Kooy and Bakker, 2008; Coutard, 2008). These scholars argue the splintered character is not primarily due to the commercialization of infrastructures undermining a 'modern infrastructural ideal', as originally agued by Graham and Marvin (2001). Rather, it is because this ideal of a ubiquitous and equal supply of infrastructure services has never been realized and, as a result, residents and communities have initiated own mechanisms of co-provision at their own expense, to counter states' failure, neglect, or inability to meet citizens' infrastructure needs. This, scholars argue, leads to the splintered character of infrastructures (i.e. water and electricity) that become both "enacted from 'below', as well as from 'above'" (Kooy and Bakker, 2008: 1855). Accordingly, the following section sets out the merits and demerits of extant theoretical and empirical advances to research on digital technologies and infrastructure provision and access, in the context of splintered urbanism. I draw from the postcolonial critique of urban theory, postcolonial science and technology studies, urban infrastructure studies in the global South, debates of ICT-driven water and energy infrastructures in Africa, and the wider research on smart urbanism. In so doing, I substantiate the need for a more balanced, pragmatic and situated understanding of urban and infrastructure landscapes in the digital age.

1.2 State of Research

1.2.1 Postcolonial critique of urban theory

While urban theory has for a long time concentrated almost exclusively on cities in the global North, urban scholars are increasingly shifting the epistemological debates of urban theory and practice to the global South (McFarlane, 2008; Robinson and Parnell, 2011; Parnell and Oldfield, 2014). Over the years, Southern cities have gradually become sites of scholarly debate in urban research (Robinson and Parnell, 2011; Parnell and Oldfield, 2014). Urban scholars have emphasized that Southern thinking or theory making from Southern cases can open up new avenues and ways of thinking creatively about cities and urban theory in general (Myers, 2020; Lawhon, 2020; Lawhon and Truelove, 2020). These scholars have examined Southern cities as spaces with the potential to generate rich knowledge and analyses of urban conditions (Lawhon, 2020). This new focus transcends negative and shadowy characterizations in which Africa is portrayed as revealing a dark side, constituting a "black hole of the information economy" (Castells, 2010: n.p.), and obstructing tropes of modernity. These images are not only symbolic of the hegemonic and colonizing discourses underpinning their disconnection, but also signifiers of specific hierarchies in which the African region is linked to the wider global world (De Boeck et al., 2010; Mbembé and Nuttall, 2004). Hence, this focus takes note of the creativity and heterogeneity that make African cities work, and understands "how this has the potential to change the way the space functions and is read" (O'Shaughnessy, 2008: 6). This engagement brings to bear the postcolonial critique of urban theory.

By definition, the postcolonial critique of urban theory challenges the longstanding hegemony of Western theorizing of cities. It instigates a conversation about the relationships between cities in the North and South in urban theory (see, e.g. Robinson, 2004, 2005, 2006). Urban scholars have been instrumental in highlighting the problem with developing urban theory from a narrow set of Southern cities (Roy, 2015; Robinson, 2006), a tendency that not only leads to universalisation of theory but also "fails to adequately explain global urban diversity and specifically cities in the global south" (Lawhon and Truelove, 2020: 5). These scholars have called for a critical understanding and representation of novel forms of urbanism in postcolonial settings that exceed the modernity of the West (Robinson, 2006; Robinson and Roy, 2016; King, 2009; Sheppard et al., 2013). Hence, the postcolonial critique of urban theory opens up space for developing other ways of thinking as alternatives to "Western-derived imaginaries" (Harrison, 2009: 320). It encourages alternative understandings of urbanity in Southern contexts (see e.g. Roy, 2005; Robinson, 2006; Myers, 2011)

while enriching thinking and practice across the globe (Harrison, 2009). According to Roy (2015), the postcolonial critique exposes fundamental defects in the notion of a single, universalized theoretical framework (see also De Satgé and Watson, 2018). It heeds Robinson's (2006) call for scholarship to view Southern cities as "ordinary" and pays better attention to their diversity and peculiarity. Simone and Pieterse, who remind us of the need to "avoid any kind of overarching theoretical story about urbanization processes", further reinforce this call (2017: 185). They invite us instead to work with the "molecular *details* of everyday life" (ibid: 59).

Thus, the postcolonial critique of urban theory highlights the concern of Southern urban scholars regarding the extent to which contemporary planning theory remains almost entirely centred on Northern intellectual traditions and institutional contexts. For example, while pointing to the relevance of these Northern planning theories in Africa, Watson (2014, 2009, 2003) questions their validity in other contexts. She draws attention to the danger in normatively applying these theories and practices to diversified African settings. Other urban theorists have sought to rethink urban planning theory in general, and questioning its practicality in settings characterized by "stubborn realities" (Yiftachel, 2006: 2013) both material and discursive (Watson, 2012).

Harrison (2006), for instance, has argued for the need to bring a critical engagement with the epistemologies and traditions of non-Northern contexts. Such an engagement would provide a conceptual opening for discerning urban and infrastructure planning theories and processes within the age of digital technologies, in particular concerning the different and conflicting rationalities in postcolonial urban settings. Promoted by Watson (2003, 2009), "conflicting rationalities" provides a way of seeing and a making sense of the agency, the values and the motivations of multiple actors in the realisation of plans and development initiatives within a particular place (ibid.). According to de Satgé and Watson (2018), the concern about conflicting rationalities encapsulates the deep differences and logics that serve to legitimise a course of action of different individuals and groups that intersect in planning and development processes of Southern cities. It draws us to a better understanding of conflicts that may arise when tensions emerge and persist at the interface of different individuals, groups of individuals and institutions in practice. Conflicting rationalities offers a valuable frame for understanding different kinds of urban environments and dynamics in which many actors in the global South operate. It draws attention to the often-uneven power relations and close linkages of urban residents with political decision-makers within a specific space. As such, it provides the much needed angle of

engagement in postcolonial urban theory that is concise and critical of the socioeconomic, micro-political, and governance complexities of urban and infrastructure planning in the global South and elsewhere.

Yet, this critical engagement with Northern planning theory – but also, more generally, the call in postcolonial urban studies for paying attention to the differences and idiosyncrasies of Southern urbanism – has been heavily criticised. For example, Storper and Scott (2016: 1121) have criticised postcolonial urban theory's "exaggerated complaints regarding Euro-American epistemological bias in contemporary urban analysis" as well as its inherent tension between its call for a worlding of urban analysis and the affirmation of a North-South binary (ibid.: 1120). Accordingly, they call for more generalized theoretical concepts of the urban, and what they refer to as "a limitless urban theory" that would allow us to "contribute to the investigation of cities by providing us with pointers that facilitate the crucial task of demarcating the inner logic of urbanization from other social processes" (ibid. 2015: 3-4, see also, Mould 2016). This critique is particularly important because it critically engages the distinct epistemologies of postcolonial urban debates. However, the idea that a single, universal or dominant theoretical frame will suffice everywhere has been strongly countered by urban studies scholars (Roy 2015; de Satgé and Watson 2018). These posit that the postcolonial critique can reveal serious flaws, particularly where cities are either expected to conform to universality, or explicitly disparaged as failed when they do not conform. Therefore, the postcolonial frame brings attention to the differences of positions between the South and North and provokes further debate about the discourse on the city and the urban condition in the global context.

1.2.2 STS and its relation with urban studies and postcolonial thought

Simply defined, science and technology studies, or science, technology and society studies (STS) provides a foundational framework for the study of how society, politics, and culture affect scientific and technology innovation, and how these, in turn, affect social, cultural and political contexts (Hackett et al., 2008). As such, STS offers an integrative understanding of the multiple entanglements of science (e.g., knowledge and the social institutions and practices that produce them) and technology (e.g., materials, techniques and routines directed towards producing intended results) (Bijker, 2001) and their transformative power in arranging and rearranging contemporary societies (Felt et al., 2017). Thus, the paradigm challenges conventional accounts of science, technology and politics as separate domains, and establishes that there are no pre-determined boundaries for what constitutes these domains. Instead, they are rather linked and interconnected (Harding, 1998: 56). Within urban

studies, STS has been said to have the potential for broadening our understanding of the contingent nature and dynamics "of technological change in the context of urban design and development" (Coutard and Guy, 2007: 715). For example, it is imperative for revealing the diversity of actors engaged in controlling, negotiating, and tampering or interfering with technological change (Bijker and Law, 1992). Moreover, it is important for illuminating the ambivalences inherent in the construal, contestation and resistance of technology that may lead some technological artefacts or infrastructures to get reformed, revised or even trashed or discarded for new ones to forcibly or ostensibly emerge—or old ones to reappear (Harding, 2011).

During the last two decades or so, scholars have increasingly related STS with postcolonial thought (Anderson, 2009; Harding, 2008, 2016). This has led to the prominence of a modest but growing subfield referred to as 'postcolonial STS' (Harding, 2009; Law and Lin, 2017). Postcolonial STS bridges theoretical and methodological dissonance between postcolonial studies and STS, develops a critique of the Western hegemony in science studies, and proposes new ways of studying the shifting political economies of science and technology in the global context (Sarathchandra, 2018). Moreover, it demonstrates "the locality of science and technology, and the consequent conflicts and other relations between localized science and technology" (Sismondo, 2010: 196). According to Irani et al. (2010: 1316-1317), postcolonial STS provokes a revisiting of science and technology with an eye on "the highly local and contingent practices that we see at work in different specific sites of technology design and use, while at the same time recognizing the ways that those localisms are conditioned and embedded within global and historical flows of material, people, capital, knowledge, and technology". As such, it promotes a real and important advance that recognizes the locatedness or spatial dimension of "modern Western sciences" taking into account their political, contextual, institutional, cultural and cognitive dimensions (Harding, 2011: 3; Hinterberger, 2013: 620). Therefore, engagement with postcolonial STS is imperative for opening and broadening our view of the urban practices, processes and dynamics that underpin largescale infrastructure deployments and appropriation—as well as the politics that surround them.

Of particular note to the STS debate, in relation with urban and postcolonial studies, is the call for a comprehensive and encompassing perspective to technological innovation in contexts of the global South. This is particularly important for purposes of transcending the diffusionist model (Arnold 2006; Rogers 2003) which in portraying a simplistic linear transfer of technology and knowledge from the global North to the global South (Monstadt and Schramm, 2017) fails to describe the novelty and

creativity of situated contexts (Bar, et al., 2016). The STS perspective offers a more nuanced and inclusive angle to innovation processes. This perspective goes beyond mere adoption and spread of technological models and pays better consideration of actual processes of use and appropriation. It examines innovation processes not just from the point of view of both established professionals such as experts and system builders, but also from 'those at the "receiving" end' (Edwards et al., 2009: 371) who are constantly reinventing technologies sometimes in ways that defy the professionals themselves (Graham and Thrift, 2007: 5). As such, it adds more nuance and differentiation to processes of technology transfer (Jackson, 2014), highlights the innovation and creativity in translating new technologies and models to new contexts (Monstadt and Schramm, 2017) and allows for a better understanding of the social shaping and appropriation of technologies within situated settings (Jamison and Hård, 2003).

1.2.3 Evolving debates of urban infrastructure in the global South

Usage of the term "infrastructure" has gradually evolved since taking on its contemporary meaning in the English language in 1951 (Carse, 2017). Its understanding has evolved from the conventional view—i.e. as "the physical components of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions" (Fulmer, 2009: 30-32)—to one where the term is used to describe not just the material structures or physical artefacts (Carse, 2017: 28), but also the socio-political and cultural processes. In urban studies for instance, infrastructure has provided a focal point for understanding, analysing and theorising the city. Over the years, ensuing studies have examined the multiple social dimensions of infrastructure, focusing not only on the provision of services to urban populations, but also distributions of political power with regard to specific components of infrastructure (Larkin, 2013; Rutherford, 2020). In these studies, infrastructure is framed as a coupling of the social and the technical – thus as a sociotechnical rather than merely technical reality. As sociotechnical systems, infrastructures are framed as "a key political site through which urban futures are negotiated and forged" (Rutherford, 2020: 3, see also, McFarlane and Rutherford, 2008).

This framing is particularly evident in studies linked by their dedication to urban contexts. Here, contemporary infrastructure debates have focused on the networked character of cities, and how infrastructures shape and are shaped by the material flows and processes that constitute urban life in the city (Graham 2000; Amin and Thrift 2017). In these studies, the "'modern infrastructure ideal' of spatially and socially ubiquitous centrally-governed infrastructures providing exclusive, homogeneous services over extensive areas" has been critiqued as the standard of reference for the

providing basic essential services, such as water and energy supply (Graham, 2010; Coutard and Rutherford, 2015). Part of this critique has to do with the idea that the realisation of this ideal requires a highly integrated socio-spatial context in terms of wider social, political, institutional and demographic conditions (Coutard and Rutherford, 2015). Scholars who have studied cases in urban contexts where informality and fragmentation are the norm rather than the exception have questioned the universal applicability of this ideal, while demonstrating broad differences, particularly but not entirely, between cities in the global North and global South (see e.g. Coutard, 2018).

Consequently, critical urban scholars have shown how this ideal becomes practically impossible to achieve, particularly in cities that constantly face economic and spatial disintegration (see, Coutard and Rutherford 2015; McFarlane 2010; McFarlane and Rutherford 2008; Graham 2010; Graham and Marvin 2001). This work examines urban infrastructure beyond what Graham and Marvin (2001) termed the "modern infrastructure ideal" (Kooy and Bakker 2008; Jaglin 2014; Coutard and Rutherford 2015; Monstadt and Schramm 2017; Lawhon et al. 2018; Smiley, 2020). This work demonstrates how hybrid and heterogeneous infrastructures create new modes for access and city-making. It examines what Coutard and Rutherford (2012) have referred to as the "post-networked city", a notion that describes the multiplicity of urban infrastructure configurations beyond and complementary to centralized networks. Other studies build on Simone's (2004) view of 'people as infrastructure' (e.g. Silver 2014 and 2015), a view which provokes a way of thinking that directs attention to the infrastructural practices of users who seek to compensate for the splintered nature of networked infrastructures (Simone, 2004; see also, Graham and Thrift 2007, De Boeck 2013). Fundamentally, this work draws attention to the bounds and limits of universal and standardized coverage by a single, homogeneous network. It demonstrates how while city plans and policies in the global South are still strongly guided by this ideal, services are still barely delivered within the framework of a uniform, ubiquitous system (Jaglin, 2014).

In this scholarship, urban water and energy infrastructures have provided important analytical entry points for questioning the universal coverage of infrastructure networks (see Coutard, 2008; Coutard and Rutherford, 2015; McFarlane and Rutherford, 2008). For urban water systems, scholars have demonstrated the failure of water networks to provide equal or universal services, showing instead how they historically reproduced wider patterns of socio-spatial differentiation in Southern cities (Gandy, 2008; Jaglin, 2008; Furlong, 2014; Kooy and Bakker, 2008; Monstadt

and Schramm, 2017; Smiley, 2020). For energy, scholars have demonstrated how centrally planned electricity grids face innumerable challenges (de Bercegol and Monstadt, 2018; Smith, 2018; Jaglin, 2008; Silver, 2014), such as the fracturing of systems (de Bercegol and Monstadt, 2018) whereby electricity services increasingly disintegrate from the modern infrastructure ideal, "towards more fragmented forms of service or infrastructure delivery" (Smith, 2018: 3). These studies show that urban residents draw from additional sources that are hybrid (Furlong 2014; Jaglin, 2016; Monstadt and Schramm, 2017), heterogeneous (Lawhon et al., 2014; Jaglin, 2014; Smiley, 2020) and incremental (Silver, 2014). These sources characterise the plurality of service modalities that as Jaglin (2014: 436) argues, "is related to the main characteristics of urbanisation in the South". In doing so, they contribute to academic and policy debates surrounding broader questions of citizenship and socio-political life on how urban infrastructure projects are produced and reproduced over time.

One common theme in the evolving debates of urban infrastructure in the global South concerns the politics of infrastructure, or what has been referred to, from an anthropological perspective, as technopolitics (Edwards and Hecht, 2010). Technopolitics can be defined as "hybrids of technical systems and political practices that produce new forms of power and agency" (ibid.: 619) whereby political action is expressed through technological design and tinkering rather than through explicit political debates in the 'traditional' political sphere (von Schnitzler, 2016). As a dynamic approach to the study of infrastructure, technopolitics reveals "forms of political rationality that underlie technological projects and which give rise to an apparatus of governmentality" (Larkin, 2013: 328). It demonstrates how politics are inscribed into technological devices, and how they may work toward, or against urban socio-spatial cohesion in contexts of the global South. As such, it is important for explaining how a wide range of countervailing actors and dynamics shape sociotechnical infrastructures in the global South. In sum, technopolitics is important to examine technology and politics as co-constitutive and to understand the politics and power dynamics of technology that are necessarily embedded in infrastructure development.

1.2.4 Emergent studies of ICT-driven water and energy infrastructures in urban Africa

Information and communication technologies (ICTs) in Africa have attracted a growing interest among scholars in the social sciences. Over the years, an increasing amount of critical studies of digital technologies focusing on African contexts has surfaced. These studies are part of a broad range of academic fields including science

and technology, urban and development studies. For example, the earliest accounts brought to attention the path-breaking role of ICTs for enhancing the speed and proficiency of organizational processes of service delivery (e.g. Oyedemi, 2004, 2009; Foster and Briceño-Garmendia, 2009). These studies, in addition to bearing resemblance to "ICT for development" approaches, see technology as a modernizing force to be introduced into underdeveloped settings with an underlying assumption that there exists an intrinsic way in which ICTs foster development (Kamga and Cishahayo, 2013). They have been critiqued for placing significant prospects on the potential of ICTs for "leapfrogging" conventional development process (Etzo and Collender, 2010: 662), and for being "largely concerned with developmental objectives and technology diffusion" (Odendaal 2011; 2010: 41). These studies align with first generation of literature on ICTs that fail to provide a middle ground between the enthusiastic/celebratory and indifferent/dismissive accounts, and present utopian and deterministic views.

Other accounts have examined how service delivery, particularly in low-income urban areas is increasingly becoming shaped by mobile technologies. This research has focused on the growth and role of mobile payment systems in the water service sector (Foster et al., 2012; Hope, 2011; Amankwaa, et al., 2020) and the energy sector (Nique, 2013; Nique and Opala, 2014). These studies have investigated how these systems create automated and mobile payment modalities, citing business models, structural transformations and users' everyday practices (Wenner et al., 2018; Krolikowski, 2014; Hope et al., 2011; Foster et al., 2012). For Hope et al. (2011) for instance, the adoption of mobile payments is viewed as possessing the potential to overcome key barriers such as delayed reconciliation of billing systems, limited customer awareness, lack of physical proof of payment, high transaction tariffs and the convenience of alternative pay points. Thus, these studies have aroused far-reaching expectations concerning the advent and role of mobile payment technologies and the potential of these technologies to precipitate profound transformations in the service provision sector, namely higher cost-recovery and effective forms of load management between supply and demand. As work in this area has progressed, commentators have moved beyond studying mere uptake of digital technologies, towards understanding their opportunities, impacts and drawbacks amidst structural conditions synonymous with cities of the global South.

However, it is the prepaid systems that have provoked more scholarly interest as digital infrastructures in African cities— and other regions of the global South including India (Anand, 2014, 2020) and Brazil (Esteves, et al. 2016). Scholars have drawn on

a range of case studies within the energy sector (van Heusden, 2012; Baptista, 2015, 2016) and the water sector (von Schnitzler, 2008, 2013; Heymans et al., 2014). These studies have focused on particular market segments of urban populations, mostly in Mozambique (Baptista 2015, 2016) and South Africa (von Schnitzler, 2008, 2013; van Heusden, 2012). Scholars have drawn attention to the rapid expansion of these technologies in the electricity grid (Baptista, 2015, 2016; van Heusden, 2012) and piped water networks (Loftus, 2009; von Schnitzler, 2008, 2013), and to their role in increasing access to utility services especially for under-served populations. Contrary to earlier ICT-driven infrastructure studies, these studies are increasingly attentive to the situatedness of technology and the nature in which it is employed by diverse people in diverse locations, embedded in urban environments and shaped by different "ordinary" facets. Herein, they have gone beyond highlighting their motivations, workings, economics and diffusion (Tewari and Shah, 2003; Mwaura, 2012), towards exploring their material, spatial and political aspects in urban contexts (Baptista, 2015; von Schnitzler, 2008, 2013). In the process, these studies examine technology as an integral component for addressing multitudes of social, economic and environmental problems.

Most recent accounts have examined ICT-driven infrastructures as socio-technical constellations supported by international companies and social enterprises (Brill and Reboredo, 2018; Chambers, 2019; Chambers and Evans, 2020). Brill and Reboredo (2018) have pointed to how the development of these infrastructures in peripheral settings of many African cities demonstrate the speculative nature of private sector-led digital infrastructure projects through 'world-class city' aspirations, yet exacerbating existing problems such as spatial inequality and environmental degradation. Furthermore, Chambers and Evans (2020) have examined how and with what implications the growing proliferation of these technologies are being applied in heterogeneous urban areas. These studies highlight some of the limitations of digital infrastructures as 'technological fixes' as well as their tendency to further exacerbate inequalities in access. They provide some of the most pervasive characterizations of ICT-driven urbanism through the lens of infrastructure in the global South.

What this research has in common is that it reveals a particular set of rationalities premised upon the ubiquitous role and logics of digital technologies in shaping infrastructure landscapes. Moreover, by examining how urban water and energy infrastructure domains are being revitalized in the digital age, this research makes distinct contributions to the expansion of theorization of urban transitions in Africa drawing on ICTs' ability to reconfigure technical infrastructures and overcome urban

challenges of service provision. As such, it shapes an emergent discourse on how urban infrastructure systems are being mediated and reconstructed through digitalization processes. Nevertheless, this research is still in its infancy, and less matured than the scholarship on digital landscapes from parts of the Global North as well as other regions of the global South. Thus, while making significant contributions, there is still a need to generate a systemic empirical examination of crosscutting ICT applications in urban African settings. It is thus not only important to bring ICT developments to the table and show how considerably different they are from those commonly discussed in the global North, but also to discern their implications for urban life and the smart city agenda in postcolonial contexts.

1.2.5 The state of research on smart urbanism

Smart urbanism denotes a mode of urban development produced by the application of digital platforms, automated processes, and data-driven and central control responses to the management and supply of urban services and infrastructure for the improvement of urban life (Luque-Ayala and Marvin, 2015; Kitchin, 2015; Marvin et al., 2016). Implicit in its articulation are processes that involve technological aspirations to achieve smart and sustainable urban development and governance (Madsen, 2018). As an emerging discourse, smart urbanism has been stimulated by scholarship and engagement from the global North since the mid-1990s. Of particular note is Graham and Marvin's (1996) seminal *Telecommunications and the City* that aimed to shift "telecommunications from the margins to the centre of urban studies" (ibid: 75). Graham and Marvin (1996, 2001) illustrate how trends in the telecommunications sector contributed to the unequal development of cities and regions, particularly due to competition in the sector to supply telecommunications services and infrastructures to the most profitable areas, to the detriment of the less favoured ones. Since then, this discourse has grown with scholars exploring not just the effects of ICTs on the development of cities, but also broad relational aspects of these technologies within urban, regional and global spheres (e.g. Rutherford, 2004; Graham, 2004; Townsend, 2000; Batty, 1997; Castells, 1996). As is evident, these studies have mostly focused on North American, European and Asian cities, and less on African contexts.

Moreover, while certainly a critical model that adds to analytical frameworks for examining contemporary developments of the digital age, smart urbanism remains highly critiqued by some for its normative and seductive imaginaries and significations that depict hyper-networked aspirations (Madsen, 2018). This critique encapsulates claims that smart urbanism is no more than a branding exercise of utopian

and representational descriptions, labels, catchwords and storylines in the context of what Kitchin (2015) refers to as "technological utopianism". This view denotes a criticism by Allen et al. (2015: 2) of agendas of "taming processes that reduce complexity, homogenize and exclude in the name of progress and over-riding imperatives" and inadvertently silence "other ways of producing and learning the city". Inherent in this criticism is the concern that the discourse of smart urbanism is highly deterministic (e.g. Hollands, 2008) and aims to homogenize the different urban worlds through a singular, unitary language. Hajer and Dassen (2014) further elaborate this critique by encouraging us to evolve from the techno-driven views of smart urbanism to a broader view that encompasses different considerations such as persuasive storytelling about smart urban futures. This critique emphasises that smart urban projects are not always future proof or universally transferrable, neither do they universally conform to the logics of neoliberalism or apolitical and business-as-usual trajectories. As Shelton and Lodato (2019: 38) have demonstrated, this critique foregrounds the need to transcend "stereotypically top-down, neoliberal and repressive visions of the smart city" and to pay better attention to the context-dependent nature of urban infrastructure development in the smart digital age (see also, Datta, 2015; Luque-Ayala and Marvin, 2015).

Drawing on these critiques, there is a need of a more nuanced and contextualised understanding of smart urbanism. For example, Shelton et al. (2015) argues for greater attention to be paid to the "actually existing smart city", rather than the exceptional and sophisticated ideals promoted by business and policy experts. According to Shelton et al., there is need for "understanding the material effects of these policies in actual cities around the world, with a particular focus on how and from where these policies have arisen, and how they have unevenly impacted the places that have adopted them" (2015: 13). In the global South, for instance, a limited number of studies have begun to draw attention to smart city developments in cities in India (Datta, 2015, 2019) and in Africa (Odendaal, 2006, 2011, 2016; Watson, 2014, 2015; Backhouse, 2015; Manda and Backhouse, 2019). These studies meticulously examine universal visions and plans for the smart city (e.g. Datta, 2015, 2019; Watson, 2014; Backhouse, 2015; Manda and Backhouse, 2019) and the spiralling of top-down large-scale projects by public and private institutions (e.g. Watson, 2015; van Noorloos and Kloosterboer, 2018; van Noorloos et al., 2019). More broadly, these studies reflect that Southern cities in general and African cities in particular, are indeed gaining some traction within the larger discourse on smart urbanism.

However, the story that still remains largely untold in this context—and one that could potentially inform urban studies debates and even advance a more critical research agenda around smart urbanism—concerns the actual impact of smart city agendas on 1) urban infrastructures in the global South, and 2) the lived experiences of the smart city within ordinary urban settings that are synonymous with issues of marginalization and exclusion (see e.g. Slavova and Okwechine, 2016; McFarlane and Söderström, 2017). Research on smart urbanism in the global South has yet to examine the multiple ways through which infrastructures are being reconfigured in the digital age, and the actual implications of these developments on the ordinary facets of everyday life. A more nuanced and critical understanding of contemporary developments of smart urbanism in the global South is needed to bring African urban spaces into a more exhaustive discussion that considers the context-dependent nature of smart urbanism in postcolonial contexts. This is necessary to respond to longstanding calls to move beyond singular or binary ontological positions in urban studies (Roy, 2015, 2009) and to broaden our understanding of the discourse on smart urbanism. Taking these points of consideration, the next sub-section highlights the merits, demerits and opportunities for further research on rethinking smart urbanism, and in particular, the aspects of city-making and urban infrastructure development in a Southern city.

1.2.6 Merits, demerits and opportunities for further research

Thus far, I have critically highlighted theoretical and empirical advances around city-making and its co-evolution with infrastructure development and the digital age. Four key merits can be highlighted from the above state of research. Firstly, the current state of research leading to recent ICT-driven infrastructure studies in urban Africa provides a foundation upon which to build. It offers a great starting point for better understanding interactions between digital technologies and contemporary large-scale infrastructure systems, and the interface between these interacting domains in the city. Secondly, present research provides important insights for challenging the hegemony of Western theorizing of the cities and infrastructures. It opens up space for alternative conceptions (from the South) that illuminate how cities produce novel forms of urbanism that exceed the modernity of the West. Thirdly, this research provokes a more dynamic, open and relational view of ICTs, infrastructures and cities, especially one that not only foregrounds hegemonic and universal visions and plans, but also lived experiences or actual implications within situated urban localities. Finally, it highlights how infrastructure landscapes are being recasted in continuing efforts towards smart urbanism. The recasting of socio-technical arrangements of water and electricity provision through the deployment of digital technologies offers

an important extension to research of postcolonial cities and infrastructures in the global South and elsewhere.

Building upon this state of research, there is still need for more concrete data about how ICT and infrastructure constitute one another within a rapidly growing and highly fragmented city. Particularly, the state of research of ICT-driven water and energy infrastructures in urban Africa exposes a still limited and disjointed knowledge on the subject of ICT and infrastructure development—such as through the spatialities and politics of splintered urbanism in the global South. Accordingly, a sociotechnical approach that views ICT-driven plans and infrastructures not only as substrates for social operations, but also as terrains that underlie power dynamics and political interests, is key for examining the nature in which artefacts are embedded in their social, political, economic and demographic context. For example, a more nuanced and differentiated interpretation of the various actors and stakeholders involved, and how they enact contradictory visions in making sense of, deploying, adopting or rejecting new technologies is needed. In addition, a detailed ethnographic view of the rationalities of these actors and stakeholders within the context of a contested urban setting is necessary. Thus, more data is needed on the processes of sociotechnical tinkering as a useful entry point for better understanding of the innovation and appropriation of ICT-driven water and energy infrastructures. This data has the potential to reveal place-specific tensions and rationalities between different actors and stakeholders' visions of citizenship through an analysis of their particular ways of seeing and dealing with new technologies.

Likewise, there is a need to challenge techno-managerial approaches of city-making and planning in the digital age. There is further need for a more refined and elaborate empirical investigation that transcends restrictive diffusionist models of a linear transfer of technologies and planning models (Arnold 2006). First, such an investigation must do justice to the inherent complexity of the deployment of ICT-driven plans and the appropriation of infrastructure in the context of splintered urbanism. Second, this investigation needs to provide more nuanced empirical understanding of the nature of contestations of and resistance to urban and infrastructure landscapes in the digital age. Finally, it needs to draw on more elaborate engagement with postcolonial urban critique and STS in raising important questions about global circulations and local articulations of ICT-driven plans and technologies in the Southern city. This is important for purposes of further enriching these studies in a manner that runs contrary to technology determinism—i.e. the idea that technology develops independently of specific societal conditions (Woodhouse and Patton, 2004).

In summation, as the state of research on smart urbanism raises more questions about local articulations of smart city plans and technologies in the urban South, it is imperative to further rethink smart urbanism, with the aim of better situating the discourse. Here, empirical and real-world accounts (Karvonen et al., 2018) are important for providing evidence of how global smart city discourses and ideals are being translated and applied in situated contexts. Such an engagement entails going beyond the technocratic approaches and deterministic appeals that underlie narratives of the smart city as a universal, technocratic and top-down project. It requires us to draw attention to how cities and people in the global South can produce novel forms of smart urbanism beyond hegemonic designs. This means locating understandings of smart urbanism and drawing attention to how ICT-driven planning and infrastructure developments are produced not just through universal notions, but also by differentiated actors and stakeholders (including national and local governments, private and public institutions, international corporations, collective actors and urban residents) who within postcolonial settings reside in cities where socio-spatial inequalities are firmly entrenched.

1.3 Research Focus

The previous section raised the need for the study of urban planning and infrastructure development processes in the age of smart urbanism. First, it highlighted the critical role of digital technologies in service delivery in cities of the global South. Secondly, it recognized the current limits of research on ICT-driven urbanism in African cities as opposed to North American, European and Asian cities where smart urban projects have been meticulously studied. Thirdly, it underlined the need to focus on not only universal visions and plans for smart urbanism, but also on lived experiences, conflicting rationalities and technopolitics within its localities. Moreover, it indicated that in making these contributions, it is imperative to build on and add to emergent engagements of Southern urbanism that speak to dynamics of city-making and infrastructure development. Finally, it called for a more inclusive and situated understanding of these processes and practices to understand the nature and dynamics of urban and infrastructure landscapes in the age of smart urbanism. Such an understanding is vital to moving beyond a limited view of smart urbanism and opening up space for alternative conceptions that exceed the modernity of the West.

In view of the above, the main goal of this dissertation is:

> **To empirically explore and understand the multiple ways in which cities and infrastructures are constructed and reconstructed through ICT innovation and appropriation, and to explain existing infrastructure constellations through countervailing processes and rationalities in the context of splintered urbanism.**

To achieve this, my approach builds on the growing prominence of engagements with cities and infrastructures in the global South, particularly those inspired by smart urbanism, postcolonial critiques and STS. The scope of my analysis for this dissertation primarily regards infrastructures not as technical domains but as socio-technical systems that always relate to specific environments and populations. Secondly, it goes beyond a focus on individual domains to examine interfaces between digital technologies and infrastructure systems within urban areas. Thirdly, it views the Southern city not simply as a sphere of adaptation to technological ideals, but also as one of technology development and innovation. Lastly, it examines digital infrastructures as political domains that shape and are shaped by a wide range of actors and processes at stake. In light of this approach, a set of research aims and questions are outlined.

RQ 1: What is the relationship between urban plans and the ICT-driven development of technical infrastructures? And to what extent is the implementation of plans and policies contingent upon politicization, contestation and context-specific realities?

This question juxtaposes ICT-driven infrastructure development projects with urban planning processes (see chapter 2). It explores the extent to which infrastructure development in the digital age aligns with the governmental visions articulated through urban plans. In addressing this question, I draw on both STS and urban studies perspectives that challenge techno-managerial approaches to city-making as a technocratic and rational exercise. I do so with the aim to examine the city as an object of—not a backdrop to—science and technological inquiry. Accordingly, I provide alternative framings of ICT-driven urbanism that shift away from the study of futuristic scenarios, towards "actually existing" urban realities of the smart city in the making. I assume that the development of technical infrastructures in the age of smart urbanism is not isolated from but fundamentally entangled with context-specific

realities as well as politicization and contestation between state administrations, planning agencies and urban residents.

RQ 2: What are the place-based contexts shaping the deployment and appropriation of ICT-driven water and energy projects, and which technopolitical relations does the project implementation reveal?

This question attends to the complex and localized power dynamics that result from their attempt to implement digital metering projects in peripheral communities. The question is addressed in chapters 3 and 4. It is particularly imperative for examining the urban water and energy utilities' interests and motivations for increasing both cost recovery and the coverage of water networks, the strategies used in deploying them, and the urban population's responses and user practices in appropriating ICT-driven infrastructures. In answering this question, we provide a nuanced empirical examination of the visible ways in which political relations are inscribed and negotiated through infrastructure by different actors, including utility providers, the national government, donor agencies, slum residents and grassroots actors, such as the multifaceted informal power distributors. We assume that hybrid and dynamic infrastructure constellations emerge from the engagements of various interest groups, socio-political institutions and regulatory authorities, and that these engagements play out in ways in which actors creatively and continuously modify infrastructure development projects beyond their original plans and designs through processes that reveal countervailing rationalities between actors.

RQ 3: How and with what impact does the proliferation of ICTs in urban water and energy utilities facilitate utility providers' ambitions to universalize and homogenize service provision in the splintered city?

This question addresses the impact of ICTs in facilitating processes of service provision and access in the splintered city (see chapter 5). More specifically, I seek to better understand the ambitions and motivations of utility providers for investing in and promoting ICTs for water and energy service provision. In discerning this question, I examine the socio-spatial and micro-political dynamics and implications of ICT-driven deployments within the context of splintered urbanism. I assume that the development of ICTs in urban water and energy utilities is driven by the urge for extending and universalizing centrally planned networks, and realizing formal monopolies. I also assume that ICT innovation has the potential to lead to a multiplicity of private firms (in formerly monopolistic territories), to reshape urban

planning and service delivery arrangements, and to restructure the city's spatial structures and technological arrangements (in contexts of splintered urbanism).

RQ 4: What lessons can be drawn from ICT-driven urban and infrastructure development projects in present processes of city-making, and how could they more effectively contribute to the sustainability cities and infrastructures?

This question examines the potential of ICT-driven urban and infrastructure development processes in the context of a splintered city in the global South, for instigating new paradigms of urban planning and infrastructure development. Apart from those analyses, chapters 2-5 suggest policy recommendations. I postulate that perspectives developed from splintered urban contexts relating to processes and dynamics of ICT-driven infrastructure development if taken into account, have key implications for city-making practices and processes not only in the South (where urban heterogeneity and informality constitute the general form of order and development), but also cities in the North (where urban fragmentation and informality might not be as distinct as in the South but still apparent).

1.4 Study Area: City of Nairobi, Kenya

Nairobi lies at the southern end of the agricultural heartland of Kenya, East Africa. Nairobi's present administrative boundary covers an area of 696 square kilometres (Owuor and Mbatia, 2012). Nairobi constitutes one of the 47 county governments in Kenya provided by the 2010 Constitution of Kenya as the units of devolved government, and is one of the four counties within the wider Nairobi metropolitan region, which covers approximately 32,000 square kilometres (Mundia, 2017). In addition to being Kenya's political and economic hub, and a major commercial, diplomatic, technological and cultural centre, Nairobi is also the country's capital. According to the most recent national census, the city is home to more than 4.55 million inhabitants (Kenya National Bureau of Statistics, 2019). Nairobi continues to grow in tandem with rural-to-urban migration and a rise in informal settlement. For example, it is estimated that 60–70 per cent of the city's residents reside in low-income urban areas. These residents occupy only 5 per cent of the city's residential land (see, Olima, 2001). Moreover, much of Nairobi's urban footprint today is constituted of unplanned settlements and the meteoric proliferation of scattered settlements remains one of the most striking challenges faced by the postcolonial city (Mundia, 2017).

As in many urban postcolonial African contexts, service provision in Nairobi is splintered. Kenya Power and Nairobi City Water and Sewerage Company are the two leading providers of electricity and water respectively. Kenya Power is responsible for most of the electricity transmission and distribution system. It retails electricity in bulk from Kenya Electricity Generating Company Limited (KENGEN) and the Independent Power Producers (IPPs) to over 7.5 million customers (Kenya Power, 2020). The Government has a controlling stake at 50.1 percent of shareholding and the private investors at 49.9 percent (ibid.). The Nairobi City Water and Sewerage Company is responsible for providing, supplying and retailing water and sewerage services to residents of Nairobi (NCWSC, 2020). The water utility is a wholly owned subsidiary of Nairobi City County (ibid.). Unlike the electricity utility company that is a national utility service provider, the water and sewerage company only provides its services to the city county of Nairobi. Both companies face considerable challenge of inequitable, exclusive and ill-fitted service supply. They have also been notorious for providing predominantly 'premium' services for urban elites, 'with millions of poor people lacking basic services in the cities' (Nilsson, 2017: 481).

One of the main challenges is the difficulties that come with extending formal services to informal settlements where land tenure systems are not formally recognised within the state's legal system. Thus, a key challenge and barrier to access of reliable services has persisted. Historically, urban authorities in Kenya have acted not only to prohibit the construction and development of permanent structures (e.g., Schramm, 2017, in the case of Kibera), but also restricted the provision of infrastructural services to the community (Akoth, 2011; Owuor and Mbatia, 2012). As such, a large number of urban populations has remained either completely un-serviced or has at least faced sporadic difficulties concerning water and electricity access. This state of exception has come to constitute a rather more generalized mode of urbanization in the informal areas of the city.

It is partially because of these challenges, that urban water and electricity sectors have sought digital technological solutions. These solutions have become central to the operations of the utility providers in their desire to improve service delivery instruments and capacities in the planning of the splintered and heterogeneous city. Utility companies have deployed both sophisticated and incremental technological applications. The incremental applications include Short Message Service (SMS), and Online and Email that have been deployed for managing user records, improving accounting and customer service and management, complaint handling, documentation management, and service extension. Also, Unstructured Supplementary Service Data (or USSD) and

other mobile apps and platforms such as M-Pesa, Airtel Money, and Orange Money have been deployed to enable automated billing and payment processes, and crediting services to consumers. The sophisticated applications that have been deployed are concerned with facilitating automated vending and dispensing, metering, consumption tracking, and reporting and querying have also been integrated in the delivery of utility services in the city. In these cases, applications facilitate automated and self-service systems that particularly allow users in the underserved and unserved settlements of the city to read their meters, download their bills, recharge water and electricity credit cards and tokens, and purchase rent-to-own digital water meters and power products. In sum, these applications have sought to improve access to infrastructure services in the context of splintered urbanism.

In Nairobi, different actors, including city planners, other urban government authorities and utility companies, have opened their doors to the deployment of significant technological innovations. For example, these actors have been committed to the deployment of digital technologies with the aim of enabling a smoother infrastructure provision in the city. Here, digital technologies are presented as key means to achieving this goal. The Kenya Information and Communications Act (Ministry of Information Communications and Technology, 2013) and the national ICT Policy (Government of Kenya, 2016) are two of the policy documents that guide the development of the ICT industry in Nairobi. Moreover, the Nairobi Metro 2030—a spatial plan for the Nairobi metropolitan region, whose goal is to create a world-class African metropolis through the development of urban infrastructure—defines ICT development as its major thrust and building block (Ministry of Nairobi Metropolitan Development, 2008). In addition, Kenya's vision for 2030 is anchored in ICT as one of the key pillars critical to its realisation (Government of Kenya, 2007). The city authority has exerted significant influence on the growth and development of technological innovations partly through its ICT Transformation Roadmap of 2015–2020 (Nairobi City County, 2014). These innovations are directed towards achieving the automation of county services, and operational efficiency and effectiveness in urban planning, metering, finance and service delivery.

Similar developments can be witnessed in the private sector where a thriving industry of mobile technologies ranging from the SIM card will involve registration and subscription not only for communication services that include calling and SMS texting, but also for moving money through the encrypted SMS and USSD platforms. These services provide the baseline infrastructure for a wide range of different services that offer unique and innovative mobile-phone-based applications and systems, rely on

text and short code, and often— in some ways— fall within the category of mobile money and payment facilities. Mobile payments may even seem more suitable for services and goods in malls or arcades, stores and supermarkets, and pretty much for all utility bill payments such as electricity, gas, water, television subscriptions, fuelling at petrol stations, rent, and so on and so forth. In fact, it may almost seem plausible simply to inhabit the city with as little cash as possible if not for any other reason than security, safety and convenience.

Thus, the rationale for selecting Nairobi as a case study centres on its ICT innovations that have become widely appropriated, shaping the city and its infrastructures. Digital technologies and data-driven platforms have become one of the key signifiers of Nairobi's identity as a smart city in the making. Nairobi has become a centre of growth and development of mobile telephony in the region, and a hub of software development, ICT-driven infrastructure projects, and the mobile money market. As such, Nairobi has become a major cause for excitement among critics and media observers alike as Africa's city of and seedbed for unfettered technological innovation and socioeconomic development in the digital age (Macharia and Mutuku, 2014). It is often referred to as a model that fits the description of a 'smart' city (Backhouse, 2015; Kumar and Dahiya, 2017). It has been ranked as the "smartest city" in Africa by the Intelligent Community Forum (ICF) (Standard Media, 2017), and as the most "innovative city" (CNN, 2015) in 2015. Nairobi is portrayed as one of the world's top ten cities concerning the capacity to reinvent itself (Cities Research Centre, 2017). It is cited as the "next tech capital" (Tech Trends, 2013) and is often referred to as Africa's "Silicon Valley", and sometimes "Silicon Savannah" (Cities Research Centre, 2017).

Moreover, Nairobi constitutes a city where aspects of the "Silicon Savannah" coexist with largescale urban fragmentation and informality. Thus, while composed of highly modernist urban planning ideals and exemplary ICT-driven transformations, Nairobi is also associated with the spread of unplanned urban growth characterised by slums and low-income settlements. These parts of the city are associated with a general lack or deterioration of public utilities, including poor sanitation, inadequate drainage systems, and substandard water and electricity supplies.

Hence, it is important to study what can be gleaned from a city that is both a pioneer in ICT development and a fragmented city. I thus study Nairobi as an exemplar of the extent to which African and Southern cities are becoming synonymous with new sociotechnical formations caused in part by the emergent reliance on mobile media,

digital technologies and data-driven platforms in everyday urban life. As such, I seek a better understanding of the aggregations of digital technologies in such a city, the interactions between these technologies and contemporary large-scale infrastructure systems that materialise in the form of ICT-driven infrastructures, and the interface between ICT-driven infrastructures and the city. Of particular significance is the need to examine the situated complexities and nuances, urban politics and multiple rationalities of different actors and stakeholders involved. I provide empirical examination and contextual nuance of Nairobi's urban condition both as a smart city in the making, and as a (historically) fragmented and contested place. I examine the ways through which novel digital technologies and data-driven platforms have become increasingly prioritized at the city level. Here, I establish how these technologies and platforms have become leveraged by a wide range of actors for reorganizing urban spaces and service delivery in the splintered city.

Figure 1.1. Nairobi and the locations of Kibera and Soweto-Kayole

In this regard, I draw from specific subcases of Kibera (a slum) and Soweto-Kayole (a peri-urban settlement) (see, figure 1.1). These areas were selected for one primary reason: to reveal the deployment and appropriation of ICT-driven infrastructure developments beyond the wealthy, high-class, and planned urban environments; toward the poor, contested, and unplanned informal settlements of a splintered city.

Kibera and Soweto-Kayole thus constitute sites where new technologies have been employed or tried-out in overarching processes by private and public utility providers in their processes to extend centrally planned networks. In these settlements, digital technologies and data-driven platforms accompany new-targeted infrastructure deployments that seek to attain coherence, modernity and world-class status by formalizing infrastructure access through ICTs. As such, this dissertation is concerned with how new digital technologies and data-driven platforms for urban infrastructure provision are shaped by local practices, politics and rationalities of the different actors and stakeholders—including urban residents.

1.5 Data and Methodology

The methodological approach employed involved in-depth qualitative fieldwork primarily from four rounds of data collection for a combined period of seven months between October 2014 and March 2019, involving four phases of data collection in Nairobi. The first phase was a three-week pilot exploration conducted between March and April 2015. The second phase was three-month phase, which took place between February and April 2015. And the third phase took seven weeks between November 2016 and January 2017. The fourth and last phase took the period of one month between January and February 2019.

1.5.1 Research design

This dissertation applies a case study research design to enable profound contextual analysis specific to locations and across different contexts (Flyvbjerg, 2006). A case study allows in-depth exploration of an issue, where a more nuanced and contextualised understanding of an issue, such as infrastructure development, city-making, and smart urbanism within a particular location, is needed. As de Satgé and Watson argue, this approach has the potential to "provide rich portraits of the specifics of place" to provide a basis to speak back to theory and practice within global urban studies (2018: 64). As the construction and reconstruction of cities and infrastructures through ICT innovation are shaped by the situated complexities, urban politics and multiple rationalities of actors and stakeholders involved, this dissertation seeks a greater understanding of these articulations. It aims to add to and expand upon extant theoretical and empirical advances—drawing from postcolonial critiques, STS, infrastructure studies, and smart urbanism. These theoretical advances inspired my case study research design as well as my empirically situated approach directed towards learning from the case of Nairobi as a splintered city. The theoretical frameworks used were selected and applied for purposes of adding depth to my research

and stimulating other further research and studies. They were helpful for purposes of avoiding ad hoc, superficial and poor reporting of the data. For example, they played a key role in offering an alternative reading of the networked character of cities, and the ways through which infrastructure systems shape and are shaped urban contexts.

In order to enrich further my empirical and theoretical contribution, I went further to report on two "paradigmatic cases" from Nairobi. Paradigmatic cases are carefully selected examplars that reflect or reveal key elements of a larger phenomenon under study (Pavlich, 2010; Flyvbjerg 2001). For example, chapter 3 examines Soweto-Kayole, where a self-reading approach in digital metering for water access was deployed in May 2014, and chapter 4 examines Kibera, where the implementation of a prepaid-based approach to digital metering for electricity access has been ongoing since April 2009 (see, Figure 1.1) respectively. These cases were sought as emblematic examples that contain the most evidence, best descriptions, and extensive characteristics of smart urbanism in the context of splintered urbanism. They were chosen through the purposive sampling technique, which is a non-random sampling technique, where sites and informants are chosen deliberately due to their relevant qualities to the central phenomenon and research problem (Teddlie and Yu, 2007). For instance, during the research process, Nairobi City County officials frequently cited these two projects and described them as exemplary representations of the progress reached in realising a smart, modern and world-class city through ICT. These projects were often mentioned as integral elements for the city county in its processes of enhancing urban livelihoods and sustainability, as well as automating service delivery. Accordingly, my aim, rather than offering a comparative perspective across these projects, was mostly to understand them as independent and unique projects in their own right, with the aim to offer the empirical contributions and lessons from each case within its temporal and place-specific setting. Thus, I examined different periods, including before implementation (i.e. the planning phase) and after implementation (i.e. the appropriation).

In sum, the splintered nature of Nairobi's digital and infrastructure landscapes warranted a single case design. This single case study design was particularly beneficial for purposes of undertaking a comprehensive study, optimizing my understanding of the dissertation's research question, and engaging with the discourse on city-making and infrastructure development in the digital age. Thus, this design was important for speaking back to theory and into theoretical debates, as well as challenging the emergent practices and concepts of smart urbanism in the context of Nairobi's urban condition. To this end, I sought to offer a context-specific account, and better understand, explain and particularize extant articulations of smart urbanism in a splintered

and fragmented context in the global South. From an analytical and epistemological standpoint, Nairobi offers a *sui generis* reading of a smart city that is at the same time splintered and fragmented. From a practical viewpoint, Nairobi contributes to a better understanding of smart urbanism and infrastructure planning and development in the digital age. As such, it provides a nuanced, empirically rich, holistic account where essential concepts, concerns and applications could be distil and applied in in different contexts for urban scholars and researchers and policymakers. Thus, a future research and policy directions would be to study other case studies and examples similar to mine. My case could use my research and results as a reference.

1.5.2 Data collection methods

Triangulation, which is the use of different research methods and data sources (Denzin, 1978) was used for purposes of avoiding the limitations associated with the use of a single dataset, and enhancing validity the data collection, quality of coding, credibility of results, and rigour of the thematic analysis (Hennink, et al., 2011; Carter, et al., 2014). Data collection methods are categorised into two: primary methods and materials, including semi-structured interviews and ethnographic observation, and secondary methods and materials, including critical review and reflection of academic and grey literature.

Primary empirical material

Individual interviews. Qualitative semi-structured interviews included fieldwork and oral dialogues with two main categories of respondents. The first category constituted of key informants and executives. These were recruited based on purposive sampling interviews; selected through a systematic review of key actors in urban processes of city-making and planning in the digital age in Nairobi. Forty-seven key informants participated in the study. These include global development agents, comprising technical experts and communications staff within supranational and intergovernmental organisations including the World Bank and UN-Habitat and the Japan International Cooperation Agency (JICA) in Nairobi. They also included utility officials and staff from telecommunications (e.g. Safaricom Limited) and urban water and electricity utility providers (e.g. Nairobi City Water and Sewerage Company, and Kenya Power), including engineers, technicians and community development assistants. Other actors and stakeholders interviewed included consultants and scholars based in Nairobi and familiar with infrastructure development, urban planning and smart urbanism in Nairobi; infrastructure development experts and city planners and practitioners; and politicians and other county authorities. The interviews were conversational in style and semi-structured. This method was critical to the development of Chapters 2-5.

The second category was comprised of urban residents, community residents and intermediaries. These were recruited through snowball sampling, and were particularly imperative for providing a user perspective and well as supplementing the data from the key informants. They were mostly drawn from Kibera and Soweto-Kayole. They included interviews with consumers of basic urban services (e.g. 25 from each of the two urban areas, Kibera and Soweto-Kayole). Fifty interviews were conducted including residents, community representatives, and other kinds of intermediaries the multifaceted informal water and energy providers in low-income areas, and local recruits of Nairobi City Water and Sewerage Company and Kenya Power. The interviewees had a variety of occupations (for example teachers, a print shop owner, graphic designers, and stockbrokers) and represented a wide range of established social groups, including community groups, networks, or associations. These interviews were mostly non-structured and open-ended in style. The questions concerned the role and impact of urban planning in the development of ICT-driven infrastructures, the deployment and appropriation of ICT-driven infrastructures, and the tensions and conflicts of these processes in the context of urban inequality and splintered urbanism. Interviews were semi-structured, open-ended and non-structured in style. This method was critical to the development of Chapters 2-5.

Ethnographic observations. Detailed ethnographic observations were made through a collection of impressions and perceptions gained through direct field experience in Nairobi. This type of observation was mostly participatory in nature. For example, I observed sites where smart infrastructures were deployed. Here, I joined and followed Kenya Power and Nairobi City Water and Sewerage Company staff and agents during their day-to-day activities in the low-income areas of Kibera and Soweto-Kayole for a combined period of twelve weeks on specific days of the week during the period of my research in Nairobi. Furthermore, I participated in key activities of the smart infrastructure initiatives and processes. Here, I visited physical settings of some projects and initiatives, and attended city county events, such as meetings, gatherings, workshops and seminars as well as facilitation meetings. These methods fall within the realm of 'following the infrastructure' where my interest was not necessarily to achieve an appraisal or evaluation of the performance of the infrastructures, neither was it to assess the success and failure rate. Instead, I sought to offer modest and empirically grounded explication of manifestations of ICT-driven artefacts and platforms including digital meters and infrastructure in general within the context of Nairobi's built environment. This method was critical to the development of Chapters 3 and 4.

Secondary empirical material

Academic literature. Relevant literature on cities in the Global South, mobile technology, and urban water and energy systems and services was reviewed and deducted. Based on findings from the literature review, I introduced, defined and critiqued a range of broad theoretical approaches relevant to urban infrastructure transition to digital technologies and data-driven platforms. Of particular interest were urban theories and theories of everyday life, particularly those that transcend technologically deterministic understandings. This strategy was particularly important for recognising ICTs not as monolithic or placeless technologies, but rather as systems embedded in and shaped by urban environments; used by diverse people, in diverse real-world locations; and develop place-based styles in their development, delivery, use and technological layout. Based on this literature review, I introduced, defined and critiqued a range of broad theoretical approaches within smart urbanism, STS and postcolonial urban studies relevant to the study of urban infrastructure in the digital age. Starting from this literature, I was able to develop novel ways of looking at urban and infrastructure systems in the digital age within the context of splintered urbanism in the global South. This method was critical to the development of Chapters 2-5.

Grey literature. An analysis of grey literature covering a period from the 1990s to the 2010s was completed, with the aim of finding data sources pertaining urban infrastructure and technology development in urban Kenya, Nairobi in particular. These publicly available documents are of relevance to urban planning and policymaking, government, regional and international reports, websites, statistical data and figures pertaining infrastructure development, urban planning and city-making in Nairobi, with the key ones including Kenya's ICT policies, Vision 2030 Kenya and Nairobi Metro 2030. The other sources of information included official and unpublished reports such as project-related memos, minutes and presentations, from urban water, energy and telecommunications. These were largely pertaining to focal aspects of ICT deployments, and action and strategy plans. Additionally, I also collected and reviewed archival and documentary resources from Kenyan and other East African sources, including pieces of editorials from newspapers and magazines, brochures, regulatory plans, strategy reports, institutional materials, and websites. These documents were randomly sampled and approached as discursive materials. The data retrieved from them provided me with good insight into what has been written and reported about digital technologies and data-driven platforms in telecommunications and urban water and electricity sectors. This method was critical to the development of Chapters 2 and 5.

1.5.3 Data Analysis

Data was analysed qualitatively, using a thematic approach that focused on identifying themes from the research questions as well as from the narratives of research participants as well as field notes from the study. Analysis took the form of descriptive, exploratory and interpretive approaches. For Chapters 2–5, four main themes were identified: 1) visions and ideas of urban plans, policies and related documents toward urban infrastructure development, implementation and operationalization; 2) utility-based planning frameworks of ICT-driven provision of water and energy services, and utilities' interests in, motivations for, and strategies to the deployment of ICTs in water and energy utility providers were investigated; 3) the nature of development and character of socio-technical and socio-spatial characteristics of ICTs, and varieties of local practices and place-specific considerations in the appropriation of digital infrastructures in different urban livelihoods in the city; and 4) the lessons that can be drawn from ICT-driven urban and infrastructure development projects in present processes of city-making in the global South, and how these could more effectively contribute to the planning of sustainable cities and infrastructures. I generated further subthemes from the coding using MAXQDA, a qualitative analysis software. Through these subthemes, I was able to organize my content thematically and present prominent themes, quotes from the interviews, participant observations from field trips and photographs of digital urban infrastructure projects.

1.6 Summary of Contribution

1.6.1 Intellectual merit

This dissertation builds on and adds to the growing number of engagements with the urban South regarding technology, infrastructure and the city in the digital age, and speaks back to the disciplines of smart urbanism, postcolonial urbanism and STS. Thus, in addition to enhancing our understanding of the new possibilities of the digital age for service provision and access particularly in the context of an African city, it opens up inquiry to new socio-spatial dimensions—particularly regarding how ICT and urban infrastructures constitute one another in a rapidly growing, highly fragmented city. The dissertation makes this contribution in three ways. First, it provides a new understanding of wider calls in social and urban studies for new geographies of theory that are attentive to conditions in the global South, including Africa (Lawhon et al., 2016; McFarlane and Silver, 2017; Robinson, 2015). In doing so, the dissertation employs innovative views of a Southern city not simply as a sphere of adaptation to technological ideals, but also as one of technology development and innovation. Secondly, the dissertation contributes to a new understanding of smart urbanism,

and reveals urban development "as a set of potentials which contain unpredictable elements, as a result of the co-evolution of problems and solutions" (Amin and Thrift, 2017, 2002: 4). For example, it realizes the call for grounded and place-specific research for providing a new understanding of postcolonial African cities as creative and innovative domains as opposed to their view as chaotic, disorderly, disorganized and decaying. Finally, this dissertation transcends static and techno-centered descriptions and visions of the smart city, and pays better attention to the context-dependent nature of smart urbanism and infrastructure development in the digital age. For instance, by emphasising the nature of mundane technologies and low-income urban areas in an African city (as opposed to technological and aspirational articulations of hyper-networked urbanism), it opens up notions of smart urbanism to broader and more inclusive conceptions. Likewise, it extends urban representations and imaginaries of cities and systems through which "technology is constantly contested and renegotiated" (Coutard and Guy, 2007: 3). In so doing, it provides a more nuanced way of thinking about smart urbanism and smart digital infrastructure development beyond technologically deterministic frameworks that fail to describe the novelty and creativity of heterogeneous and splintered urban contexts in the South.

1.6.2 Societal relevance

The aims of this dissertation align with the goal of developing more effective and sustainable responses to current urban challenges and societal changes, in alignment with the United Nations' SDGs. First, it demonstrates the role of ICTs (SDG 17) in tackling societal challenges and enhancing water (SDG 6) and electricity (SDG 7) infrastructure service provision and access (United Nations, 2015). Since stark inequalities in access to water and energy have historically left poor communities marginalized and their residents struggling to survive (UN-Habitat, 2016; Güneralp et al., 2017), this dissertation presents insights on how targeted, small-scale ICT-driven initiatives can be employed to improve the quality of life of populations in low-income urban areas. Secondly, it highlights the role of different actors and stakeholders including urban planners, policymakers and technicians in tackling challenges and dilemmas of urbanisation (SDG 11) and infrastructure development (SDG 9) (Osburg and Lohrmann, 2017). For example, it shows that international donors and private and public utility providers together with city authorities play significant roles in the deployment of modest and mundane digital technologies and data-driven platforms, as well as within overcoming infrastructural challenges of lack of appropriate service delivery in low-income areas of the city. Thirdly, this dissertation is also relevant in the sense that it draws attention to the fact that challenges to urban and infrastructure development in the digital age call not just for engineering and technomanagerial solutions, but also

for socio-political and sociotechnical capacities. It suggests a non-technocratic and non-deterministic understanding of splintered and incremental responses (by urban populations) to standard infrastructures that are always bound to reflect infrastructure development and appropriation processes within splintered and contested urban settings of the global South.

1.7 Thesis Outline

This introduction outlined the problem and provided the background to the study. Chapter 2 draws on social studies on technology perspectives and observations, interviews, and policy analysis to juxtapose ambitious visions of emergent smart city-making plans with ordinary realities of ICT-driven infrastructure development in Nairobi. The chapter contrasts urban planners' approach and reliance on the modernizing power of technology with the actual realities infrastructure deployments in the city. It reveals that while processes of smart city-making are inclined towards technocratic and deterministic appeals, these processes are essentially politicized, contested and shaped by local practices and context-specific realties.

Chapter 3 draws on science and technology studies to illustrate how the deployment and appropriation of Jisomee Mita in Soweto-Kayole is shaped by place-based factors. The chapter highlights the nature of this project as a hybrid infrastructure designed to allow self-meter reading and mobile-phone-based billing, payment and querying systems in the settlement, to demonstrate how various actors continually reassemble technology beyond its original design in rather unforeseen and partly subversive ways.

Chapter 4 examines an electricity digital metering project, which allows prepayment and the use of mobile telephony for billing, payment, recharging and querying purposes. This chapter builds on scholarship on prepaid meters and debate on conflicting rationalities within urban studies to provide a more nuanced examination of the ways in which different actors contribute to the deployment, appropriation and use of prepaid systems in Kibera. The chapter considers the politicians, donors, residents of the slum Kibera and informal power distributors to show how these actors' different rationalities conflict within contexts in which actors have radically different understandings of an infrastructure development intervention in question.

Chapter 5 follows on the centralized water and electricity utility operators' deployment and appropriation of digital technologies in selected slum areas of Nairobi to

understand how and with what impact the proliferation of ICTs in urban water and energy utilities facilitate utility operators' ambitions to extend centrally planned networks in the splintered city. The chapter demonstrates how, in light of the city's splintering and fragmentation, service providers deployed services that strategically target the urban poor. It demonstrates how, while framed through narratives of spatial justice and pro-poor deployment, these deployments essentially demonstrate utility operators' desire to maximize returns on investment, scale centrally planned networks, expand market share and dominate or monopolize service provision.

The conclusion summarizes and reflects on the main empirical findings, responds to the key research questions, and offers critical and pragmatic proposals for Southern cities struggling to realize smart and sustainable service delivery.

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Table 1.1 Overview of Research Questions

Research Question	Chapter	Topic	Published in:
What is the relationship between urban plans and the ICT-driven development of technical infrastructures? And to what extent is the implementation of plans and policies contingent upon politicization, contestation and context-specific realities?	2	Smart city-making? The spread of ICT-driven plans and infrastructures in Nairobi.	Urban Geography (published, 2020)
What are the place-based contexts shaping the deployment and appropriation of ICT-driven water and energy projects, and which technopolitical relations does the project implementation reveal?	3	Hybrid constellations of water access in the digital age: The case of Jisomee Mita in Soweto-Kayole, Nairobi.	Water Alternatives (published, 2019)
	4	Post-, pre- and non-payment: conflicting rationalities of electricity access in Kibera, Nairobi.	(Submitted, 2020)
How and with what impact does the proliferation of ICTs in urban water and energy utilities facilitate utility providers' ambitions to universalize and homogenize service provision in the splintered city?	5	Smart urbanism? ICTs for water and electricity supply in Nairobi.	Urban Studies (published, 2019)
What lessons can be drawn from ICT-driven urban and infrastructure development projects in present processes of city-making, and how could they more effectively contribute to the sustainablity of cities and infrastructures?			
What are the multiple ways in which cities and infrastructures are constructed and reconstructed through ICT innovation and appropriation, and explain existing infrastructure constellations through countervailing processes and rationalities in the context of splintered urbanism?	6	Conclusion	N/A

CHAPTER 2

SMART CITY MAKING? THE SPREAD OF ICT-DRIVEN PLANS AND INFRASTRUCTURES IN NAIROBI

Abstract

Since the late 2000s, the city of Nairobi in Kenya has become a focal point of large-scale and ambitious technology-driven city-making processes and ambitions. In this study, we draw upon observations, interviews, and policy analysis to examine processes of city-making and the spread of ICT-driven infrastructures, juxtaposing ambitious visions of emergent plans with ordinary realities of the African city. We demonstrate that while processes of smart city making have strongly been inclined toward technocratic approaches and deterministic appeals, this inclination is highly deceptive. We argue that rather than being deterministic, these processes are essentially politicized, highly contested, and shaped by the role and impact of local practices and context-specific realties. In making this argument, we draw from a social studies of technology perspective which engages with the notion of technological determinism to make this contribution to the academic field of critical urbanism.

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2.1 Introduction

Since the late 2000s, Kenya's capital, the city of Nairobi, has witnessed renewed interest for large-scale master-planning and urban redevelopment processes featuring a strong role for digital technologies and technical infrastructures. The first of such ambitious processes is the Nairobi Metro 2030 Strategy which was launched in December 2008 as part of the national plan known as Kenya Vision 2030 (MNMD, 2008). The strategy sought to transform the Nairobi metropolitan region into a modern and world-class African metropolis by the year 2030. The second plan is the Nairobi Integrated Urban Development Master Plan (NIUPLAN) which provides the guiding framework integral for realising urban development in Nairobi and to operationalise the goals of Nairobi Metro 2030 Strategy (NCC, 2014). The third is the ICT Transformation Roadmap launched in September 2013 as one of NIUPLAN's flagship strategies that aims to operationalise the leading role of ICTs attached to future urban development (NCC, 2018). Altogether, these plans reflect the shared vision of developing the city of Nairobi into a modern, smart and world-class city through the rapid dissemination of ICTs and their innovative application in everyday life. As such, they embody a strong belief in the role of ICT as a modernising tool, governing force and precipitant for curing urban problems, boosting urban development and entrepreneurialism, and unlocking the potential to transform Nairobi into a "*Silicon Savannah*".

This paper interrogates these plans' approach and strong faith in the modernising power of technology. Our central premise is that inasmuch as these plans are designed, deployed, and marketed as approaches possessing deterministic appeals and transformative power, this inclination is highly deceptive. Hence, we argue that urban plans and processes of city-making are shaped by context-specific practices and politics. In making this argument, we juxtapose Nairobi's ICT-driven plans and actually existing technical infrastructures. By doing so, we demonstrate the ways in which technological visions and techno-centred strategies are detached from the ways the majority of urban residents in Nairobi interacts with ICTs.

Accordingly, we draw from science and technology studies (STS) and urban studies which challenge techno-managerial approaches to city-making as technocratic and rational exercise. Hereby, we examine the city as a relational context, not backdrop of science and technological inquiry, providing an alternative framing of ICT-driven urbanism that shifts away from the study of futuristic scenarios, toward the study the actually existing urban realities and relations of the digital city in the making.

Our methodological approach, which involved in-depth qualitative fieldwork for a combined period of six months between 2014 and 2017, is three-fold. First, we executed an in-depth content analysis. We reviewed the Nairobi Metro 2030 Strategy, the NIUPLAN and the ICT Transformation Roadmap as well as policy instruments and strategy-related documents relating to these plans such as the National ICT Policy (2016) and the National ICT Master Plan (2013). Other secondary materials examined include government, regional, and international reports, websites, statistical data and figures, pieces of news stories and editorials, as well as brochures pertaining to processes of urban planning and city-making in Nairobi. This data was analysed using thematic categories. Three main themes were identified: the visions and ideas of the plans, their ICT focus toward urban infrastructure development, and strategies for their implementation or operationalisation. Second, we interviewed experts and urban residents. 25 experts were interviewed including principal actors from Nairobi City County, global institutions including UN-Habitat, World Bank and the Japan International Cooperation Agency (JICA), private institutions including telecommunication companies like Safaricom and start-up firms like iHub. The other experts included scholars within the academia familiar with urban planning and city-making processes in Nairobi and beyond. These were selected through a systematic review of key actors in urban processes of city-making and planning in the digital age in Nairobi. These interviews were conversational in style and semi-structured. They were analysed qualitatively, using a thematic approach which focused on identifying themes from the research questions as well as from the narratives of research participants from the study. Finally, we employed ethnographic observations, drawing from structured city walks in and around Nairobi with the aim to analyse the urban imaginaries of the city plans and their development and materialisation through infrastructure projects.

The remainder of this paper is structured as follows: Section two is a conceptual delineation of the debate on city-making and the spread of digital infrastructures. Section three presents the geographical setting and historical reflection of the making of the city of Nairobi. Section four draws from processes of city-making in the digital age, highlighting dynamics and evolvement of ICT-driven urban plans and visions. Section five juxtaposes ICT-driven urban plans and the actualities of infrastructure development in Nairobi. We conclude that artefacts—including plans and technologies—cannot be understood without also understanding their embeddedness in context-specific realities and their shaping by human action.

2.2 Sketching the Debate

2.2.1 Re-viewing the spread of digital technologies in urban Africa

Since the early 1990s, Africa has witnessed a remarkably dynamic spread of digital technologies. This spread has attracted significant enthusiasm regarding the central role and positive impact of digital technologies—e.g. smart phones, mobile banking and payment, web tools, programming tools and/or software applications—in transforming African contexts and in "leapfrogging" to a digital age. A lot of this speculation has been based on the rising penetration of mobile telephony in the region. For instance, statistics and survey findings demonstrate that within just a few years, high-bandwidth undersea telecommunication networks were built, quickly followed by upgraded programs of many telecommunications providers that improved both fixed and wireless connectivity, which enabled rapid growth of digital technologies. By 2016, for instance, the share of 80.8 percent of Africans owned a mobile phone of some kind—a 10 percent jump from 71 percent in 2014 (ITU, 2016). Moreover, sub-Saharan Africa (SSA), a region of the continent of Africa that lies south of the Sahara, is projected to have the largest proliferation of mobile telephony, anticipating an increase of up to 8 percentage points between 2017 and 2025 (GSMA, 2018: 12). These figures are even higher for Africa's urban regions where digital technologies have become fundamental to everyday life. For example, significant markets for a wide range of smart technologies have developed, ranging from cheap Chinese smart phones to mobile-based applications, most of which were produced through collaborations with local mobile phone operators, tech hubs, and start-ups.

Through such digital technologies, Africa is portrayed as steadily "leapfrogging" from conventional development patterns that connect individual households with expensive fixed infrastructure networks "in ways that set it apart from other continents" (PWC 2016: 1). Low-cost, easy-to-use digital technologies (Etzo and Collender 2010: 662) have grown at a high speed, shaping the way people pay for services, relate with service providers, communicate with others, and organize their everyday lives. Once viewed through a dystopian lens as "the black hole of the information society" (Castells, 2000), SSA is now portrayed a "new digital actor" (de Bruijn et al., 2009). The spread of digital technologies in SSA has become described as a "remarkable phenomenon" (Vodafone, 2005), with some studies going so far as to claim that the digital age in Africa represents a "revolution" (PWC, 2016) or "renaissance" (Guardian, 2016). These descriptions serve as a vehicle for an interpretation of Africa as a "rising continent" (i.e. Ponelis and Holmner, 2015) or as continent being "disrupted" (PWC, 2016) through the spread of technology.

These accounts have become extremely appealing and seductive for researchers, practitioners, and experts alike who are keen to depict the nature of digitalisation processes in Africa and beyond. They are placed within a discourse that has become identified as ICT for development (ICT4D). However, while pertinent for examining the centrality and impact of ICT in fostering development, these accounts' most fundamental critique relates to their deterministic approach, which describes the correlation between ICT and development, but does not explain its construction within a situated context.

2.2.2 Studying ICT-driven urbanism in Southern cities

The discourse on ICT-driven urbanism in Southern cities has undergone significant evolution over the last decade (Odendaal, 2014). Following the increased penetration of ICTs and the spiralling of vast top-down large-scale projects by public and private institutions in the larger cities, focus has begun to shift with studies exploring these new urban formations in the global South (Watson, 2014; Odendaal, 2011; Datta, 2015). Southern cities in general, and African cities in particular are beginning to gain more traction. Within this literature, however, instead of seeing them as places of technological innovation and production, Southern cities are mostly portrayed as passive recipients for models and technologies from elsewhere. As such, the common predisposition in the study of technology diffusion takes for granted the limitations of Southern cities—mostly so, African cities—in producing and innovating technology. Instead these cities have mostly been viewed as fodder for ideals, plans, and technology developed in the global North; or in other words, as a homogeneous container space receptive of a unidirectional transfer of technologies. Indeed, Watson (2014: 216) has recognised this predisposition in which African cities have become viewed as the "last development frontier"' awaiting grand-scale foreign investments and urban re-development.

Addressing the phenomenon of "African urban fantasies," Watson cites "new city plans, satellite cities and large urban projects in sub-Saharan Africa" (2014: 222) that are currently being remodelled "in the rhetoric of 'smart cities'" (Watson, 2014: 215). Watson shows how these attempts promise to modernize cities and "turn them into gateways for international investors and showpieces for ambitious politicians" (ibid). These processes, Watson argues, reflect a new urbanism in place. Cain (2014: 561) maintains however that while a distinct phenomenon, "African urban fantasies [find] echoes in another era almost 50 years in the past." Indeed, as Cain argues, the new fantasies that Watson and others have examined are familiar with those that transpired during the post-independence era. For instance, they both originate from

foreign concepts and ideas of what a modern city should look like; they both initiate massive city development projects; and they both reflect development models prevalent at the time of their deployment.

In a similar vein, Datta (2015) has taken the case of Dholera as a "new utopia" in India, to examine the ways in which the city is being reshaped through ICT-driven planning. By so doing, Datta gives insight into a new phase of utopian urbanization in India, examining the linkages between global models and local histories, politics and laws. As Watson (2015) has argued, the analysis of Dholera rings true for African urban plans in the digital age. For instance, the use of a 'rhetoric of urgency' to address the problems of urbanisation and the urge to ignore the extant planning systems or any possibilities for public participation calls (Datta 2015: 5) are particularly synonymous with the tendency for ICT-driven urban plans in African cities to be top-down, biased, and generally rushed (Watson, 2015). Watson for instance draws our attention to the plans for Kigali in Rwanda, Kigamboni New City in Dar es Salaam, Tanzania, Tatu City and Konza Techno City in Nairobi, Kenya, and Hope City in Accra, Ghana. These cities' plans are also examined by van Noorloos and Kloosterboer (2018: 1223) as being representative of "new city making trajectories" in the urge to build eco, smart and satellite cities. According to Watson (2015) and van Noorloos and Kloosterboer (2018), these plans demonstrate how new and old urban centers in Africa are being driven by international developers, spread by global consultants, and financed by foreign investors in the digital age (also, van Noorloos, et al. 2019).

Studies on ICT-driven urbanism in Southern cities provoke a lively debate within geography and urban studies. Notwithstanding, some conceptual and empirical limitations in our understanding of this new and emergent urbanism can be highlighted, especially as they relate to African contexts. Although attention to key aspects of ICT-driven urbanism in African contexts is emerging (Odendaal 2016; Watson 2014), there is need to add a view of how ICT-driven urbanism plays out through distinct processes of city-making.

2.2.3 Framing city-making in the digital age

This paper complements the above debates by focusing on processes of city-making in the digital age which to date, has received limited attention. Moreover, it complements studies that respond to calls for empirical and situated accounts in the framing of city-making in the digital age. For instance, Karvonen, et al. (2018) provide real-world evidence of how the notion of the smart city ideal is being translated and applied in cities across the globe. Karvonen, et al. provide a great attempt at situating

smart city developments by grounding and contextualizing such developments within divergent contexts. This approach is further accompanied by Joss, et al. (2019) who examine the smart city "as global discourse," drawing from a wide range of different cases studies across the world in portraying the ideal as globally circulating best practice. This paper is thus a response to Karvonen, et al. and Joss, et al.'s appeal to empirically examine how the smart city evolves through combinations of both high- and low-profile initiatives, mundane and cutting-edge technologies, local and non-local consortia, public and non-public actors, and urban residents (Karvonen, et al. 2018: 2). In making this contribution, we take the case of Nairobi which has received relatively less attention in debates around smart city making. Conceptually, we draw from three distinct insights.

First, we employ the concept of smart city making as a conceptual category to infer a process through which digital technologies are constantly shaped and re-constructed by place-based urban geographies. By smart city making, we mean short- and long-term processes of urban development and planning which are shaped by the role and centrality of digital technologies. Our understanding of city-making is informed by the emerging discourse on "smart urbanism" which reiterates a particular set of rationalities premised on the ubiquitous role and logics of data, algorithms, and information technology in shaping cities (Kitchin, 2014; Luque-Ayala and Marvin, 2015). However, recognising that its preoccupation with technological underpinnings has rendered the discourse technocratic and deterministic (Kong and Woods, 2018), our framing critiques the inclination towards a technocratic and deterministic view of technology in processes of city-making. Viewing smart city making through a constructionist view of technology means that digital technology develops and function very differently across urban contexts. Contrary to what ambitious smart city plans often suggest, the transfer of digital technologies to urban places does not simply replace incumbent technologies in use with new ones, but usually adds to them and implies new forms of appropriation, interference and conflict (Edgerton, 2006). Instead, we argue similarly to Karvonen et al. (2018) that city-making processes in the digital age co-evolve with the local specifics of urban societies. In this regard, we point to the social embeddedness, relationality and urban co-construction of smart urbanism, drawing on its place-based realities and dynamics in the context of an African city.

Secondly, and building on the first point, our framing transcends elusory one-size-fits-all frames which tend towards a top-down approach to city-making. We contend that city-making is not necessarily a methodical process or practice developed and implemented in a holistic and systematic manner. City plans, even when

comprehensive, are hardly, if ever, homogeneously followed to the core—especially within contexts of urban fragmentation and informality. For instance, Cugurullo (2018: 74) invites us to transcend the idea that "there is a scientific approach to urbanisation, based on a holistic and rigorous plan of action which shapes the entire city, homogeneously, making it sustainable." We take Cugurulo's invitation to juxtapose visions or ambitions of the emergent plans with the realities and existing technological arrangements of ordinary African cities.

And last, but not least, we postulate that while urban plans do certainly play a role in the production of urban order in a practical sense, they do not always lead to compliance of all parties involved and to effective implementation. We contend that informal practices and "dealings" co-evolve with those from the planning authorities. While urban plans have the tendency to be more aspirational in their nature, sometimes compromising the conditions of urban inhabitants, the actual reality reflected on the ground tends to be different. We argue, as de Satgé and Watson (2018) for instance, that urban plans are not always as deterministic, mechanistic, and predictable as sometimes portrayed to be, but are always shaped by context-specific realities. Moreover, they co-evolve with the dynamics of informal urbanisation and everyday urban processes.

Therefore, our key argument is that while processes of smart city making have been strongly inclined toward technocratic approaches and deterministic appeals, these processes are highly contested and shaped by context specific politics and practices. Accordingly, the next section sets the context for this examination by offering a socio-spatial and historicised account of Nairobi as a city in the making.

2.3 Setting the Context: A Historical Geography of the Making of Nairobi

Nairobi, as currently defined, constitutes one of the 47 counties in Kenya, and of the 4 counties within the wider Nairobi metropolitan region which covers approximately 32,000 square kilometres. Nairobi is situated at the southern end of the agricultural heartland of Kenya. Nairobi City County (NCC) is successor to the defunct 'City Council of Nairobi.' It is one of the four counties that constitute the larger Nairobi metropolitan region (the others being Kiambu, Machakos and Kajiado) which extends over 32,000 square kilometres, contains a population size of 6.65 million (2009 Population and Housing Census), and generates about 50 percent of Kenya's gross domestic product. The administrative boundary of NCC covers an area of 696 square kilometres (Owuor and Mbatia, 2012: 120) and constitutes a population of

3,138,369 (2009 Population and Housing Census). It is governed by the County Government founded in 2013 (Constitution, 2010). It is currently under the leadership of a governor who is mandated with a service provision in tandem with the 2010 Kenyan Constitution and the Nairobi County Appropriation Bill 2017.

Historically, the physical development and layout of Nairobi was shaped by a British model intended to design a garden city. This model dates back to 1899 after Nairobi was established as a depot and settler outpost by British colonial authorities on the Mombasa-Kampala railway line (Obudho and Aduwo, 1992). The railway authorities had determined that the area's central location, flat landscape, and moderate climate were an ideal setting for a colonial administrative centre. Upon its establishment, Nairobi slowly grew into a small trading zone. Notwithstanding, it was in 1900 that Nairobi's boundary would become officially defined as constituting "the area within a radius of one and a half miles from the offices of the sub-commissioner of the then Ukamba Province" (Morgan, 1967: 102). In 1905, Nairobi assumed the necessary requirements for performing as the capital of the British East Africa Protectorate, becoming a municipality in 1935, and a fully-fledged city from 1950 onwards (Owuor and Mbatia, 2012). During this time, Nairobi has undergone a wide range of urban planning and re-planning to meet increased demands of an emergent city in transition. These efforts, are outlined in table 2.I below.

The above table outlines earlier urban plans and processes for Nairobi between 1898 to the late 2000s. In the table, we demonstrate that these plans, beyond guiding the development and setting development needs for service sectors in the city, also sought to accommodate growing populations, expand land for residence, and turn the city into a more attractive sphere for industrial investment.

In spite of the above plans, Nairobi city has evolved as a place susceptible to unplanned and incremental urban growth. Informality and formality have thus formed a continuum, co-evolving and shaping each other. In fact, much of Nairobi's urban footprint today is constituted of unplanned settlements (Mundia, 2017) and the meteoric proliferation of scattered settlements remains one of the most striking challenges faced by the postcolonial city. Over 180 slum settlements are identified within Nairobi County (UN-Habitat, 2010). 80 percent of the Nairobi's population inhabit high-density settlements that occupy less than 20 percent of the city's residential land area (UN-Habitat, 2006; Badiane, 2008: 7). And about 55 percent of the total urban population inhabit the spatially segregated informal settlements which constitute only five percent of Nairobi's residential area zoned for residential use (Badiane, 2008: 7).

Table 2.1 Earlier planning and city-making processes for Nairobi: from 1898 to the late 2000s

Plans	Year	Proponents	Population	Objective
First Plan of Nairobi	1898	Drawn by Arthur Frederick Church.	___	To prepare a town layout for the railway depot at "Nairobi."
Plan for a Settler Capital	1927	Drawn by F. Walton James. Planned by Eric Dutton.	11,000	To accommodate the growing population at the time; and expand land for urban residence.
Master Plan for a Colonial Capital	1948	Prepared by British colonial planners led by White, L.W. Thorton, et al (1948). Funded by Municipal Council of Nairobi and the Railway Authorities.	119,000	To establish neighbourhood units for the working class for segregation, and make Nairobi more attractive for industrial investments.
Nairobi Metropolitan Growth Strategy	1973	Formulated by the Urban Study Group of Nairobi City Council (1973). Funded by WB and UN.	509,000	To guide the development of Nairobi City: the plan set an intermediate target of 1985, and ultimate target year of 2000.
1984-1988 Nairobi City Commission Development Plan	1984	Formulated by the Nairobi City Commission (1984).	828,000	To set development needs of sectors including housing, social services, health and environment, transport, sewerage, industry, and finance.

The result of Author's compilation from secondary sources, 2019

These spaces continue to face large-scale neglect and retardation in terms of their connectivity and accessibility to public infrastructure networks (Mundia, 2017). Within these settlements, residents continue to experience a general lack or deterioration of public utilities ranging from poor sanitation, inadequate drainage systems, constrained mobility, and substandard water and electricity supplies (UN- Habitat, 2006, 2010; Badiane, 2008). These residents often resort to a wide range of spontaneous, off-grid and self-help alternatives in their urge to access critical services. This constellation exemplifies the Nairobi's transformation and metamorphosis as a geography which, while highly planned, is also synonymous for the peculiarities of urban informality and poverty. As such, Nairobi has evolved as a co-constitution of modernist urban planning ideals and unplanned and incremental growth patterns. In the

following section, we will draw upon the last decade to examine a more recent wave of plans and visions for Nairobi, considering the city's fragmented realities.

2.4 Smart City Making? The Rise of ICT-Driven Plans

Having introduced earlier planning ideas in the making of colonial and postcolonial Nairobi, and their co-evolvement with of urban poverty and informality, this section examines a more recent wave of city-making and planning that echoes a particular set of rationalities premised upon the ubiquitous role and logics of ICTs in shaping urban worlds globally. In particular, we examine the advent of ICT-driven urban plans including the Nairobi Metro 2030, NIUPLAN, and ICT Transformation Roadmap. These plans are portrayed in table 2.2 below. The table shows how these plans have transpired in the form of large-scale, top-down projects that are prominently rooted in the country's capital and government offices, driven by international developers, spread by global consultants, financed by foreign investors, and shaped by preconceived hegemonic ideals of a modern city in the age of smart technologies.

2.4.1 Envisioning the modern, world-class African metropolis

In December 2008, Mutula Kilonzo, then head of the now defunct Ministry of Nairobi Metropolitan Development, launched the Nairobi Metro 2030 Strategy (hereafter referred to as the "metro strategy"). The metro strategy is part of the overall national planning and development blueprint for Kenya which is encapsulated in Kenya Vision 2030. It proposes to reinvent the Nairobi Metropolitan Region into a world class African metropolis (see, table 2.2), "that is able to create sustainable wealth and offer a high quality of life for its residents, the people of Kenya, investors and offer an unmatched experience for its esteemed visitors" (MNMD, 2008: v). The strategy seeks to transform four principle constituents including: working environment, living environment, business environment, and metropolitan governance (MNMD, 2008: 29-31). Its key interventions include strategic planning of technical infrastructures at a metropolitan level such as energy and water supply, stormwater and waste management, the development of ICT as well as strategic environmental impact assessment (see, MNMD, 2008: 60). According to the metro strategy, all "these efforts are realigned towards the transformation of the region into a regional and global services hub and a preferred destination of choice for local, regional and international investors and visitors" (MNMD, 2008: 104).

The metro strategy was the product of intense stakeholder engagement through participatory and consultative processes across the country that included both experts

Table 2.2 Urban planning and city-making processes in Nairobi since 2008

Plan	Year	Proponents	Scope	Goal	Infrastructure Objective	ICT Focus	Key Issues
Nairobi Metro 2030	2008	Co-created with McKinsey and Company with financing from UN-Habitat	Nairobi Metropolitan Region (NMR)	Optimizing the role of NMR in Kenya's overall development agenda	Build world class infrastructure and utilities in the region	Developing ICT infrastructure and business. i.e. Smart city/ villages. i.e. Konza Technopolis	Priority programs are extremely ambitious, largescale and long-term Prioritizes foreign investment and business process outsourcing
NIUPLAN	2014	Design and formulation funded and supported by JICA	Nairobi City County (NCC)	Optimizing NCC's role as the centre of Kenya and the region	Integrate urban infrastructure provisioning (including water supply, power supply, telecoms)	Adapting ICT skills to urban development and management. i.e. ICT Transformation Roadmap	Priority programs are proposed to be implemented in short-term Operationalization heavily dependent on donor agencies and interests
ICT Transformation Roadmap	2013	Developed by PricewaterhouseCoopers. Contracted by the World Bank	NCC	Optimizing the development of NCC through the judicious use and deployment of ICT	Strengthening institutional capacity and ICT infrastructure at city hall	Automating county business processes. i.e. e-finance and ICT-based service delivery	Priority programs are designed to provide instant results Presents a technologically deterministic solution to urban problems

The result of Author's compilation from secondary sources, 2019

and ordinary citizens (Interview 1, 2016). The latter, however, were not fully engaged, but rather simply "consulted" (Interview 2, 2017). It was co-created with McKinsey and Company, a global consultancy firm which had completed a similar project for Mumbai city in India. Its formulation was financed and buttressed by foreign conglomerates and partnerships such as UN-Habitat. Contributions from these firms and organisations were largely inspired by best practices from other countries.

The metro strategy advances the imperative of tapping into the ICT sector for achieving Nairobi's vision. It encapsulates wider motivations for modernizing the city by deploying "world class infrastructure and utilities" with their development and management contingent on technology investment and integration (MNMD, 2008: 74). Efforts are being undertaken by the state to realise this motivation through the development of smart-city villages or towns such as *Konza Technology City* (see, figure 2.1 below), located 64 km south east of Nairobi (Konza City official website, 2018; KOTDA, 2014: 01). Konza city was officially unveiled in December, 2008 and

Figure 2.1: Smart city making

Clockwise, from the top left. A screenshot off the Vision 2030 and Nairobi metro website displaying the urban plans' progress through the lens of key infrastructural landmarks; the Konza technology city blueprint reflecting the ambition of the ICT-driven urban plans; and pavilion entry imagery into the technology city. Source: Image I: https://vision2030.go.ke/; Image II and III: https://www.konzacity.go.ke/

planned to occupy 5,000-acre parcel of land (Konza City official website, 2018). Upon its unveiling, it garnered extensive attention for its ambitious plan to become the leading hub and economic driver for Kenya and the East African region by deploying world-class ICTs and ICT-based infrastructures. However, over a decade since its unveiling, Konza city is marked only by an incomplete eight storey building that plans to house the headquarters of the Konza Technopolis Development Authority, with this building being the only standing landmark in the land.

While projects such as the technopolis constitute a great step toward the achievement of the visions of the metro strategy, they have come to exemplify what has become one of the strategy's major criticisms: that its imaginaries for the Nairobi metropolitan region are more outward-looking (i.e. attracting international investment) than inward-looking (i.e. promoting existing ICT-innovation designed for those who actually live there) (see for instance Myers, 2015). For instance, Nairobi is expected to reinvent itself as "place of choice" for "investors and visitors" (MNMD, 2008: 104). In other words, it is expected to target big corporations and investment capital and meet the most global and external standards and accreditations (see table 2.1) rather than enhance the everyday reality of urban life.

2.4.2 Toward an integrated infrastructure-led strategy

In May 2014, Evans Kidero, the elected governor of the newly created Nairobi City County, launched a new masterplan, the Nairobi Integrated Urban Development Master Plan (hereafter referred as NIUPLAN 2014-2030). Instead of implementing "individual projects," the NIUPLAN compiles "programs" within its integrated approach with the aim to further universalize networked urban infrastructure (NCC, 2014: 11-1). In its programs, the plan proposes to improve the water supply system and reduce non-revenue for water, minimise electricity costs, waste scattering and illegal dumping in the city, and restrict of vandalism of infrastructure facilities through better technologies (ibid.). Furthermore, it proposes to install fibre optic cables for broadband access and to harmonize communication amongst sectors through integrated ICT infrastructures (ibid.). Hereby, the deployment of new ICTs is seen as central for the realisation of master plan's goals and objectives of sustainable urbanism (ibid.: 130). NIUPLAN seeks to expand "modern" ICT-driven infrastructure facilities, such as mobile-based prepayment and billing systems, which are seen as mediators of "world-class" service provision and modern urbanism.

While sometimes viewed as a "direct successor" to the Nairobi Metro 2030 Strategy (Myers, 2015: 342), NIUPLAN was essentially designed to streamline the city's

planning landscape. It sought to amalgamate all the other less ostentatious plans with the aim of achieving a "sustainable" urban policy regime including the metro plan (NCC, 2014). It was framed as a single unitary, comprehensive, and holistic approach in an otherwise fragmented, conflicting, and overlapping planning landscape. Its design and formulation processes, while funded and supported by the JICA, were formulated through public meetings and engagements with different stakeholders, including private and public actors, technical working groups, media, academia, political leaders and the general public (including views derived from a children's essay and drawing competition called "My Dream City") (see e.g. JICA, 2014). Hence, the NIUPLAN departs from technocratic planning approaches, toward a shared understanding of active engagement with a broad range of stakeholders to advance its vision for a smart, sustainable, and integrated city. This partly explains the general perception among some experts and urban planners about how, in the words of an urban planning expert, "unlike Nairobi Metro 2030, which provides more fantasies than solutions, NIUPLAN offers more solutions than fantasies" (Interview 2, 2017).

The master plan's initial years were marred by confusion regarding its operationalisation. For instance, our interviews with officials at City Hall revealed a general lack of shared knowledge about why the master plan was launched, whom it targets, or how it achieves ICT-related targets (Interviews 1, 3, and 4). Officials at City Hall noted that there was still need for consistency, securing the right skills and knowledge, and transferring the necessary ICT proficiencies for public servants and bureaucrats especially at the city county (ibid.). This includes persuading civil servants to not only share the same vision, but also integrate their everyday responsibilities with regards to the operationalisation of the masterplan. Notwithstanding, the NIUPLAN has inspired a more concerted effort at the county level to further prioritize the deployment of new technologies for service provisioning and city-making. In the subsequent sub-section, we refer to the ICT Transformation Roadmap which has become one of NIUPLAN's flagship projects in the utilization of new and emergent ICTs for urban and infrastructure development processes.

2.4.3 A path towards the smart city? Mainstreaming ICTs for urban processes

The development of the NIUPLAN happened in tandem with the development and deployment of the ICT Transformation Roadmap (hereafter referred to as the "roadmap"). Launched in September 2013, the roadmap is a flagship project of the NIUPLAN under the governorship of Evans Kidero between March 2013 and August 2017. The roadmap was launched in partnership with the ICT authority, a

state corporation under the Ministry of Information Communication and Technology. The roadmap proposes to further the development of NCC through the judicious use of ICTs such as e-payment solutions; development of county government ICT infrastructure; deployment of a modern network and data centre; design and development of an interactive county website and portals; automation of all county processes; and implementation of recovery systems directed towards protecting county business, and implementation of email messaging and collaboration (see, table 2.2). It offers a five-year comprehensive plan with aspirations to transform Nairobi into a smart city. In achieving this goal, the roadmap aims to optimise efficiency in service delivery, and facilitate revenue collection through the implementation and deployment of technology solutions (NCC, 2014, 2018).

The roadmap was developed by PricewaterhouseCoopers and contracted by the World Bank under the Kenya Transparency and Communications Infrastructure Project (KTCIP) executed by the ICT Authority in the Ministry of Information and Communication Technology within its "Smart County Project." The World Bank allocated KES 1.4 billion (USD 1.4 million) to create integrated ICT-driven infrastructure system for NCC as part of the project (Interview 6, 2016). According to Jonathan Mueke, the deputy governor (March 2013–August 2017), the roadmap's creation was the outcome of a rigorous three-month process between April and August 2013 (Antioch ICT Resources, 2017). Its creation was coordinated by the Information, Communication and e-Government sector, which is a department at City Hall devoted to integrating ICTs for the county administration's information and communication services, mass media management and skills development, as well as infrastructure development.

In alignment with the general theme of the National ICT Master Plan "towards a 'Smarter Kenya'" (2013), the roadmap was viewed by the city authorities as a platform with the potential to "set Nairobi on the path towards the smart city" (Interview 4, 2016; Interview 5, 2016). According to interviews with officials at Nairobi City Hall, the roadmap was viewed as a reflection of the digital turn. It was regarded by the county government as "a truly important step forwards in the mainstreaming of mobile technologies for urban development and service delivery" (Interview 6, 2016). Moreover, it signified the critical role of ICTs for the achievement the county's goals and visions—that is, to become the "city of choice" to invest, work and live in (in reference to MNMD, 2008; NCC, 2014). It was thus regarded as aligned with Nairobi Metro 2030 Strategy (and ultimately Kenya Vision 2030) and global conventions such as the Sustainable Development Goals (SDGs), and thus as a

framework for the realization of affordable and accessible services as well as sustainable urbanism for Nairobi.

There has been general fulfilment with the roadmap as portends the mainstreaming of ICTs for urban processes. This fulfilment is revealed through statements from political actors and urban planning and policy advocates. For instance, Mike Sonko, the Governor of Nairobi since August, 2017, has expressed his strong convictions of these plans in public fora, arguing that: "if we continue at this pace, we will surpass our promise to turn Nairobi into a modern, smart, digital city of choice to live, work and invest in" (Sonko, 2017). Similar sentiments are also echoed by officials at the Nairobi City Planning Department where one, for instance, indicated: "we want to see Nairobi transform. We want to restore our city's glory by getting on board with ICTs" (Interview 6, 2016). According to Joy Mboya, an architectural designer, these sentiments and transformations reflect "an understanding within the city planning officers themselves around moving forward and creating a sustainable and healthy city," something that is more explicit from the ways in which "people within the Nairobi urban planning department are very proactive and are very visionary" (Mboya, 2017). These and other statements correlate with our observations of the potentialities of the roadmap as portends the imperative of technology for Nairobi's transformation.

Different projects have been deployed as part of the roadmap for a wide range of the county's urban processes. Key among these is the deployment of a web portal (including redesigning the county's official website), replacement of old and incomplete digital infrastructures, and automation of certain county business processes such as revenue collection and service delivery. During our interviews with the city authorities, these deployments were mentioned as being imperative in echoing the county's ultimate goal to "have everything done digitally" in order to improve everyday operations and address the county's inherent challenges (Interview 1, 2016). They were viewed as achievements evident of the "U-turn from the old ways of doing things to a new way of doing things," wherein ICTs "have become the DNA" of service delivery and access (Interview 6, 2016). Moreover, they were considered within press releases and news articles such as Kiragu's (2017) commentary as "a clear shift" from the "deep-rooted lacklustre culture at City Hall" to a rather more open-minded and forward-looking one. Within this frame, the deployment of ICTs at the county level is viewed as one step further towards the achievement of the county's shared vision for a smart, modern, and world-class city as reflected in the Nairobi Metro 2030 Strategy and NIUPLAN.

2.5 Juxtaposing ICT-Driven Plans with Reality: The Landscape of Digital Infrastructures in Nairobi

The metro strategy, NIUPLAN, and ICT Transformation Roadmap demonstrate the recent centrality of ICTs in processes directed towards envisioning a world-class African metropolis, integrating infrastructure-led planning interventions, and mainstreaming smart city ideas in Nairobi respectively. Three deductions can be made from their development. First, they foreground the promotion and dissemination of ICT in Nairobi as the fundamental influencer of urban development key to solving Nairobi's problems. By doing so, they objectify the role of technology in processes of urban planning and development. Thereby, they reflect a technocratic approach and belief in technological determinism, signifying the modernising and homogenising power and role of technology in processes of urban planning and development.

Second, their determined urge to modernize and "smarten up" the city is largely based upon guidelines and strategies that conform to universal models of city-making or master planning. In other words, they assume a set of universal standards of what a smart city is. For instance, it goes without saying that for the ordinary urban resident in Nairobi, these plans' ideas of Nairobi as a digital city are detached from their everyday reality. During our fieldwork, we found that much of what informs residents about the ICT-driven plans for Nairobi was not these plans' actual projects in the city, but rather the widespread marketisation and branding that followed them. These projects were all increasingly being marketed and publicized through political statements (such as those cited by the governors highlighted in the preceding section), and press releases and advertorials ranging from billboards to TV and online imageries and brochures that depict dramatically glossy and enchanting imaginaries of urban plans (such as those in Image I above). Altogether, these advertisements promote a market-driven, standardized idea of a smart city that predominantly targets the imagined aspirational Nairobian and the business community in general.

Third, these plans' rationalities—shaped largely by foreign experts and consultants—contrast significantly with the actual fragmented and variegated realities of Nairobi as a rapidly growing and partially impoverished city. For instance, from our interviews with experts and consultants based in Nairobi, we found that there was a general level of awareness among urban actors. For example, a technical officer said that the reality for smart city projects was always going to be different, as "it is a different ballgame altogether" (Interview 8, 2016). The official was referring to the ways in which the development and the materiality of ICT-driven plans and infrastructures are

increasingly subjected to contestation, micro-politics and context-based realities in their appropriation. Given its spatially splintered and fragmented nature, Nairobi was being viewed as a place "where wishful thinking and [techno-utopian] fantasies come to die [and] where dreams come to rest" (Interview 9, 2016). In other words, city authorities and technical experts began to contend with the reality that to some extent, the everyday context will impede unrealistic goals and intentions of technology-driven deployments. They started to realise that ideals of modernity and world-class materiality were never going to manifest in the form and shape portrayed in the city's masterplans.

These aspects correlate with our observations of the digital landscape in Nairobi which is far different from the most sophisticated, high-tech systems and forms of automation emerging in some cities across Europe, North America and Asia. Instead, we find that the urban landscape digital infrastructures in Nairobi are shaped largely by less sophisticated, small-scale and more grounded technologies and technical infrastructures as outlined in Table 2.3 below.

The table above illustrates the different modalities of digital infrastructures in Nairobi including mobile money transfer services, mobile payments systems, digital metering projects, mobile-based apps, local tech-hubs, and global technology firms as further elaborated in the remainder of this section.

Modest phone text-based money transfer and banking: "Smart" technologies in Nairobi have predominantly transpired in the form innovative mobile-phone-based applications and systems that rely on simple mobile phone texts and short codes most frequently implemented by mobile network operators. A pioneering example is M-Pesa, a service which in addition to allowing users to store and transfer money through even the most basic mobile phone. Officially launched in 2007, M-Pesa is operated by Safaricom, a dominant mobile network operator in the region. It was originally tailored for users without bank accounts, but has subsequently become more than just a banking service and remained open to incremental changes. Since its launch, Kenya has one of Africa's largest banked populations. Since 2016, 93 percent of the population in Kenya have been reported to have access to mobile payments (Aleem, 2016). Moreover, there are more than 120,000 M-Pesa agents where Kenyans can withdraw cash and exchange virtual currency (*ibid.*). This number is 40 times the number of bank ATMs in the country. Its presence in Nairobi has had ripple effects to the city's innovation space, playing a catalytic role in the spread of modest mobile-phone-based applications tailored for the specific needs and communities of Nairobi and Kenya at large.

Table 2.3 Overview of digital infrastructures in Nairobi

Modality	Examples	Particularities
Mobile money transfer services	- M-Pesa (Safaricom), 2007; Sokotele – later re-branded as 'Zap' – (Zain), 2007; Orange Money (Orange/Telecom Kenya), 2010; yuCash (YuMobile/ Essar Telecom); MobiKash, 2008	- Rely on simple mobile phone texts and short codes - Pioneered by mobile network operators
Mobile payments systems	- eJijiPay (JamboPay), 2014; Tangaza Pesa (Mobile Pay), 2012; Lipa na M-Pesa (Safaricom), 2012; M-Payer (Safaricom), 2013	- Facilitate everyday purchases and transactions in the city
Digital metering projects	- NCWSC: Grundfos 'AQtap' water dispensers, 2015; Jisomee Mita 2014; Token Water Initiative, 2009 - Kenya Power: Electricity prepayment meters, 2009	- Rely both on prepaid and post-paid modes of billing and payment
Mobile-based apps	- Soft loans (M-Swhari, M-Kopo Rahisi, and Mkopo Poa) - Fundraising (M-Changa) - Investing in the bond market (M-Akiba) - Agricultural transactions (M-Shamba; M-Farm) - Health-care-related services (M-Tiba; mHealth) - Water-access-related querying (MajiVoice; M-Maji) - Solar energy products (M-Kopa Solar)	- Small- to large-scale start-ups - Constitute faster, cheaper and smarter solutions that feed into urban demand for better services
Local tech-hubs	- Privately owned: Nailab, 2011; I-Hub, 2010; mLab, 2011; 88mph, 2011; Pivot East, 2014; Kopo Kopo, 2012 - Operating within the framework of an academic institution: Apps Lab (Moi University); Chandaria Business Innovation and Incubation Centre (Kenyatta University), 2014; C4DLab (University of Nairobi), 2013; @iLab (Strathmore University), 2014	- Co-working spaces - Facilitate networks of ICT technicians, entrepreneurs, specialists and activists.
Global technology firms	- IBM, Cisco, Google, Oracle, Microsoft, Nokia, Huawei, Siemens, Intel and Airtel Africa	- Technology development firms with regional or continental headquarters in Nairobi

The result of Author's compilation from field research, 2019

Targeted payments applications: These applications are mostly inspired by the rise of M-Pesa in Nairobi. They have become significant in facilitating everyday processes including purchases and transactions in the city. A typical example of such platforms is eJijiPay, an electronic payments application for revenue collection. Developed and operated by JamboPay, a Kenyan ICT company, eJijiPay is designed to facilitate mobile-based revenue collections for a wide range of bills and expenses such as parking, rent, construction permits, business permits and advertisements in the city. eJijiPay fits the description of the rise of affordable, easy-to-use and easily accessible technologies in Nairobi. Just like M-Pesa, it is an application that is mainly built upon the deep penetration and local enthusiasm of mobile network coverage and mobile phone usage by the city's inhabitants. Since its launch in June 2014, eJijiPay has facilitated the collection of over KES 28 billion (USD 275 million) in revenues through the platform (NCC, 2018: 131). It has become the face of the city's efforts at "smartening up" urban processes and transactions (Interview 6, 2016).

Incremental metering technologies: What has also become particularly common in Nairobi is the rise in digital meters that rely both on mobile phone modes of billing and pre- and post-payment. These meters are especially widespread as Kenya's largest water and electricity utility companies have been leveraging mobile payments to facilitate their acceptability within informal neighbourhoods. They have come to constitute part of the urban water and electricity sectors' strategies to make supply more accessible and affordable for urban residents who live in informal settlements for the most part. In the electricity sector for instance, up to 6 million prepaid meters constituting over 60 percent of total households in the country have been installed by Kenya Power since April, 2009 (Kenya Power, 2015). As is the case in the water sector, these deployments typically target small neighbourhoods and lower-income settlements at the fringes of the city. Within these geographies, these metering technologies have developed in a continuum of formality and informality, where deployments by water and electricity service providers are largely shaped by informal user practices, small-scale entrepreneurs, and survivalist tinkering with technology by the users.

Nascent tech-hubs: Nairobi has become a centre of in-space units for innovation, most of which are fashioned after or inspired by those in California's Silicon Valley and Cambridge's Silicon Fen. These hubs facilitate networks of ICT technicians, entrepreneurs, specialists and activists, and foster software development, technology incubation and co-working activities. Nairobi now ranks among the highest cities that lead in Africa with up to 25 active tech-hubs (GSMA, 2018). These hubs vary across scale and oscillate between privately owned centres and spaces operating within the

framework of academic institutions. A key example is iHub, launched in March 2010 as the first local ICT hub in the city and Africa at large. iHub remains one of the role model hubs in Africa, and a significant catalyst for Nairobi's growing digital space. It is credited for sustaining innovation momentum through locally produced applications, where for instance, over 150 start-ups have emerged out of its innovation space.

Small- and medium-scale, mobile-based start-ups: By extension, Nairobi has come to constitute a wide range of mobile-based start-ups that are synonymous with the word 'mobile' or its initial 'm' which often appears before the service or solution it provides (see, table 2.3). These start-ups provide the baseline infrastructure for a wide range of unique and innovative mobile-phone-based solutions for facilitating soft-loan facilities, fundraising, investment in the bond market, agricultural transactions, health-care-related services, and solar energy products.

Global, large-scale firms and corporations: Nairobi has become increasingly underpinned by private sector-led investments and development corporations. These include large-scale global firms located in Nairobi such as IBM, Cisco, Google, Huawei, and Airtel Africa. These technology firms have settled in Nairobi and realizing the smart city is central to their agenda. Within the global wheel of city-making, these firms have played a key role in foregrounding circulating ideas and best practices around smartness. Moreover, they have become complemented by other efforts from various institutions which have increasingly published opinion pieces, reports, and surveys encapsulating Nairobi as an investment hub for new markets and innovative establishments. These include international think tanks (Intelligent Community Forum), consultancy firms (PricewaterhouseCoopers, McKinsey) and global development institutions (UN-Habitat, World Bank), and the broader media community (i.e. Nation, 2015). For instance, the IBM' White Paper 'A Vision of a Smart City' offers propositions on how Nairobi could turn into a digital, intelligent, and sustainable city (IBM, 2012). The IBM report refers to both large-scale smart city projects such as Konza Technopolis, to small-scale technologies such as "mobile money, crowdsourcing, and even the other small less visible innovations that are actually remarkable" (Wolfgang F., Chief Economist, World Bank, cf. IBM, 2012: 13). As is evident from IBM's White Paper, global and large-scale firms and corporations have played an active role in reflecting Nairobi's innovative spirit. Hereby, they have shaped the discourse around Nairobi as an organic and dynamic ecosystem where new technologies can emerge and innovations thrive. In other words, a digital city in the making.

To sum up, the digital technological transformations portrayed in this section, and outlined in table 2.3 above, have come to exemplify the actual realities of ICT-driven city-making and infrastructure development in the postcolonial city. In true form to a splintered and fragmented city, these transformations have partially emerged, developed, and evolved endogenously. Their implementation has manifested in diverse and reflexive ways. Rather than being directed exclusively by the city's articulated plans, they have been fashioned through bargaining with local actors on the ground—both formally and informally. Hence, their development is largely counterbalanced by informal and small-scale entrepreneurial practices, operationalized through incremental and fragmentary structures and facilities such as ephemeral stalls or kiosks found in strategic locations of the city. This demonstrates that counter to what ambitious planning policies suggest, the implementation of infrastructure plans and the transfer of digital technologies does not occur in a politically neutral and culturally undifferentiated space. Instead, they are shaped through different forms of appropriation.

2.6 Conclusion

This paper has examined strategies in processes of city-making, drawing from the agency of ICT-driven plans and infrastructures in Nairobi. At an aggregated level, contemporary urban plans in Nairobi are shaped by a homogeneous vision for achieving a smart, modern, and world-class city. They subscribe to and amplify a unitary model and a utopian vision for the making of smart city. They reflect the sense in which urban plans are shaped by certain brands and trademarks of global city planning, promoting urban modernity and world class materiality. As such, they send out a clear message to urban developers, investors, residents—rich and poor—of where the city aspires to be. These plans set in motion expectations about the sort of city desired for the future. However, their limitation lies in the fact that they deem the city as an orbit or an elusive object that can be modelled and remodelled to fit technology-driven agendas. In doing so, they underestimate their relationality with—and shaping of ICT-driven infrastructures through—local contexts.

This paper has shown that ICT-driven plans and infrastructures have had to suit specific needs and dynamics of the city. Our findings complement studies which call for empirical and real-world accounts for examining smart city making processes (Karvonen, et al. 2018) and providing evidence of how global smart city discourses and ideals are being translated and applied in situated contexts. In the case of Nairobi, we have shown that digital infrastructure landscape has materialised in the form of

specific low-cost and easy-to-use ICTs ranging from metering technologies, modest phones, and basic mobile payment tools and applications. When paralleled and contrasted with the functionality of contemporary urban planning in Nairobi, this digital infrastructure landscape demonstrates a smart city which hardly reflects the models promoted by well-articulated plans. This landscape reflects the major modus operandi of smart city making in Nairobi where "high-tech" or "smart" technologies visualised through plans, strategies, and roadmaps have materialised very differently from the everyday realities of the city.

The conclusion to be drawn is ambivalent: on the one hand, we can demonstrate that ICT-driven plans have put ICT innovations on the political agenda and have stimulated an entrepreneurial spirit and favourable business environment in the city region. On the other hand, ICT-driven plans are strongly driven by hegemonic smart city ideals that have insufficiently capitalised on and promoted the city's endogenous innovation capabilities such as dynamic start-ups, mobile-based apps, digital metering initiatives, and everyday mobile payment systems. Their systematic development not only offers technological solutions and economic potentials for Nairobi but a market potential far beyond the city region. There is need for a better respond to the reality in which smart city making processes—which while strongly inclined toward technocratic approaches and hegemonic appeals—are highly shaped by context-based practices and politics. This serves as a reminder for practitioners and academicians to consider the role of context-specific realties and endogenous potentials when executing or thinking about city-making processes in the digital age.

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CHAPTER 3

HYBRID CONSTELLATIONS OF WATER ACCESS IN THE DIGITAL AGE: THE CASE OF JISOMEE MITA IN SOWETO-KAYOLE, NAIROBI

Abstract

The digital age has reshaped the supply of infrastructure services in African cities. Over the last decade, Nairobi's water sector has opened up to infrastructure investments enabled by the uptake and integration of digital technologies. These investments have focused on one particular group: the urban poor. This paper examines a new hybrid piped water supply project called Jisomee Mita (Read your Meter) in Soweto-Kayole, a low and average income neighbourhood in Nairobi. Jisomee Mita employs digital technologies to enable self metre reading, and mobile-phone-based billing, payment, and querying systems. In our study, we draw upon science and technology studies to show how as a globally promoted technological device, Jisomee Mita has become locally anchored and appropriated in variegated ways beyond its original design. Our study illustrates how hybrid and dynamic infrastructure constellations emerge through practices of remaking, upgrading, and expansion of centralised systems of water supply through the use of digital technologies by various actors. We argue that the ways in which actors continually modify Jisomee Mita beyond its original design reveal a tension between imaginations of active citizens as 'co-providers' of services inscribed to the project's technologies, and the users' own visions of citizenship. This vision, we contend, becomes apparent in the ways in which these such actors appropriate the project in unforeseen and partly subversive ways.

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3.1 Introduction

In many African cities, water supply reflects broader dynamics of socio-spatial inequality and fragmentation (von Heland et al., 2015; Monstadt and Schramm, 2017; Charton-Bigot and Rodriguez-Torres, 2010). This is especially the case in the larger cities, where living situations, housing conditions, and access to services vary drastically among different income groups. In Nairobi, Kenya, for instance, 84 percent of higher and middle income households have access to a piped water connection, while the figure drops to 36 percent for households in low-income neighbourhoods (World Bank, 2015). It is only in about the last two decades that urban water planning has explicitly considered connection to low-income environments a priority, along with the formal recognition of informal settlements as permanent. This recognition is further reinforced by the Constitution of Kenya 2010 under Article 43(1), and Kenya's Vision 2030, both of which codify the right of access to basic services such as water for all Kenyan citizens (Republic of Kenya 2010, 2007). In addition, in 2008, Nairobi City Water and Sewerage Company (NCWSC) – Kenya's largest and de facto monopolistic urban entity which supplies water and sanitation – established its Informal Settlements Department as a unit that prioritises the city's low-income territories in the provision of, and access to, urban water and sanitation services. The strategic plan of NCWSC states that its vision is "to be a world class provider of water and sewerage services", and that its mission is "to provide reliable quality water and sewerage services in an environmentally friendly manner that delights customers within Nairobi City County" (NCWSC, 2014: 11).

Despite this formal recognition, providing access to water services and extending centralised and universalised access to water remains one of the greatest infrastructural challenges in the city. As has extensively been reported, this endeavour has encountered a myriad of complexities, such as the users' inability "to pay for services" (World Bank, 2015: 25), lack of baseline data on low and average income territories (ibid), a loss of water of as much as 38 percent due to leakages or un-invoiced customers (von Heland et al., 2015: 146), and spatial disparities caused by the legacy of postcolonial policies (World Bank, 2015: 7). In this complex situation, actors attach far-reaching expectations to the role and potential of new communication technologies (Guma, 2019). Over the last decade, for instance, NCWSC has prioritised the integration of digital technologies. Its infrastructural planning significantly leverages on new thinking and innovations in service delivery, new information and communications technology (ICTs), new partnerships, and new financing opportunities. As a case in point, part of the utility company's 2007/8-2009/10 strategic plan recognises "the

tremendous role that ICT has to play" by undertaking "the implementation of several integrated systems" including accounting and financial management, procurement management, human resource management, fleet management, customer care, and billing (Nganga, 2012; Thuo, 2013). Thus, NCWSC is increasingly drawing upon digital technologies. One central motivation for integrating digital technologies is the expectation that these will enable the 'opening up of' or 'tapping into' new markets of unserved and underserved populations, thereby generating more revenues and maximising returns and profits (GWI, 2016: 16; Ndaw, 2015; GSMA, 2016).

In this paper we examine the efforts by NCWSC to expand its centralised water infrastructure networks in Nairobi beyond the city's affluent and well-to-do territories. To do so, we take the case of Soweto-Kayole, a suburb of Nairobi, where a new metering regime called Jisomee Mita (Read your Meter) has been deployed as an extension of the centralised 'large-scale piped paradigm' (Braadbart, 2009). We elaborate on Jisomee Mita not only as a technological device, but also as an infrastructure ensemble of digital technologies, water networks, and situated institutions and practices. In this regard, we view Jisomee Mita as a project that speaks to the idea that water should be provided through a centralised grid. Moreover, we contend that it reflects NCWSC's institutional urge to expand its own jurisdictions and customer base beyond the 'premium networked' spaces (Graham and Marvin, 2001), to include new markets of hitherto 'un-invoiced' populations in the city (von Heland et al., 2015: 146). We examine how, as a digitally enhanced infrastructure development project, Jisomee Mita has become shaped by manifold situated practices (including tampering, repair, repurposing, and removal), which have contributed to the emergence of new formations of water access.

We draw upon an approach inspired by science and technology studies (STS) in our focus on cities and infrastructure in the Global South, in order to examine new mobile-based technical infrastructure systems as rubrics of urban transformation in Nairobi. We start from the central propositions of STS which relate to everyday entanglements of society and technology, and from urban studies' attention to the situation and location of such entanglements in space. We seek to bring to the forefront situated and located infrastructural conditions, practices, and technologies. We recognise that place-specific conditions and technologies, which have long been ignored by central planning and policies, have shaped Soweto-Kayole's inhabitants' everyday lives in the absence of a centralised water supply. At the same time, we consider how inhabitants have in turn shaped their own infrastructural access and top-down infrastructure projects through various practices. We propose that this is an important

intervention, as the literature on the circulations of planning models and technologies has hitherto paid limited attention to everyday urban realities in the Global South (Monstadt and Schramm, 2017). Specifically, our study sheds light on the unintended effects of attempts by international agencies to turn people into active and yet disciplined citizens who take over tasks that are traditionally part of the utility's responsibility. These unintended effects, we argue, emerge in places where people have particular ways of seeing and dealing with technologies and basic service provision, and when these place-specific rationalities contradict the imaginations of those planning and designing infrastructure systems.

This study is based on data that we collected relating to two moments: before the implementation of Jisomee Mita (i.e. the planning) and after its implementation (i.e. the appropriation). This strategy allowed us to comprehend the situated context, practices, and significances prior to and following the deployment of Jisomee Mita in Soweto-Kayole. For the purpose of analysis, we considered the testimonies of both users and providers. Our points of entry were community development assistants and mobile field assistants employed by NCWSC who were stationed in one of their regional offices in Kayole estate. Between February 2015 and January 2017, we observed the team of social and community workers, engineers, and urban planners conducting their operations. We followed and interviewed these actors, and engaged with them during their day-to-day activities for a combined period of four weeks on specific days of the week. We correlated this material with 25 in-home oral interviews in the community of Soweto-Kayole. The interviewees had a variety of occupations (for example teachers, a print shop owner, graphic designers, and stockbrokers) and represented a wide range of established social groups, including community groups, networks, or associations. We also interviewed key informants from global development entities in Nairobi such as the World Bank and UN-Habitat, as well as intermediaries, including two community development assistants, urban planners, infrastructure development experts and consultants, and practitioners from Nairobi City Council. Interviews were semi-structured and open-ended in style. Lastly, we collected secondary data aggregated from variable sources over a period of six years.

The remainder of this paper is structured as follows: the second section presents our conceptual framework; the third section describes the socio-spatial setting and gives an overview of Soweto-Kayole; the fourth section focuses on the deployment of Jisomee Mita as an institutional strategy for extending the large-scale centralised network and achieving universal access; the fifth section examines the everyday remaking of Jisomee Mita as reflected through its hybrid and dynamic rearticulation beyond its

digital operation towards physical necessity, as well as beyond its original design as a self metering regime. We conclude that these dynamics and processes of infrastructural change and remaking through digital technologies reveal how the attempt to expand centralised grids through the deployment of digital technologies and the disciplining of residents as 'active citizens' leads to dynamic and hybrid infrastructural constellations. These constellations, we contend, are shaped by a wide array of actors at different levels who constantly appropriate and transform the predesigned systems beyond planning.

3.2 Hybrid Constellations: Water Systems and the Digital Age

Digital technologies have a considerable impact on African urbanisation and on the provision and use – as well as the regulation and planning – of basic services. A range of authors have studied digital devices and the ways in which they may help to overcome long-standing inequalities in access to services. Authors have analysed the technopolitics of digital devices in African cities from a rather critical angle. They have examined the technological designs of specific artefacts, the ways in which different actors change the designs of these artefacts, and the political claims to citizenship that emerge in the process. Studies on infrastructures in cities of the Global South have focused not only on singular technological devices or practices, but also on the complex relations of technologies and practices that constitute infrastructures with and beyond planning. We draw on these studies in considering digitally enhanced water infrastructures as hybrid and dynamic constellations that consist of manifold practices and technologies and are perpetually changing.

3.2.1 The rise of digitally enhanced water systems in urban Africa

The water service sector in the Global South has been examined by social scientists, researchers, urban planners, and practitioners alike with regard to the potential of new communication technologies for service delivery (von Heland et al., 2015; Koehler et al., 2016; Hope, 2011; Foster et al., 2012). Scientific studies acknowledge far-reaching expectations about the role, impact, and centrality of digital technology in the delivery of basic urban services. Authors are often positive about the benefits of mobile applications for both providers and users, noting how unprecedented growth in Africa's mobile communications sector offers considerable opportunities to address the continent's enduring water challenges (e.g. Foster et al., 2012; Odendaal, 2014).

In general, studies emphasise the transformative nature, responsiveness, and ability to engage customers as active participants in the provision of services. For instance,

some portray digital technology as a medium with the potential to overcome obstacles of accessibility and affordability for vulnerable and low-income settlements (Kyessi, 2005; Kjellen, 2000). According to Hope et al. (2011), key barriers to accessing water services, such as delayed reconciliation of billing systems, limited customer awareness, and lack of physical proof of payment could be overcome through the adoption of digitally enhanced water payments. Odendaal (2014) leveraged technology-driven provisioning as a medium with the potential to disrupt and transform socio-spatial inequalities and exclusions, and thereby to overcome urban 'fragmentation' (Charton-Bigot and Rodriguez-Torres, 2010) and 'splintering' (Graham and Marvin, 2001). Within these contexts, digital applications have been found to be transferable, flexible, and aesthetically desirable (Kyessi, 2005; Kjellen, 2000; Hope et al., 2011). In short, studies often portray (digital) water technologies as a backdrop to innovation in contemporary urban service provisioning and access.

And yet there are challenges related to broader socio-spatial urban conditions – challenges which limit the possible impact of digital technologies in overcoming the fragmentation of urban service provision. In terms of digitally enhanced water infrastructures, these are related to the high costs of building, operating, maintaining, and renewing large water networks, water purification plants, etc. involved in water supply, which are far greater than those of providing digital networks. In this vein, Gandy (2004) states that in cities of the Global South, the 'concrete divide' between those with and those without water infrastructure is far deeper and more persistent than the 'digital divide'. As we elaborate below, authors scrutinising the technopolitics of mobile water devices have furthermore shown how their invention and employment, and the appropriation of related technologies, reflect the variegated politics and political contestations between actors. These politics are inscribed into technological devices, and they may work either towards or against urban socio-spatial cohesion.

3.2.2 Emergent perspectives on prepaid metering for the urban poor

Scholars of urban technology have recently articulated how new and emergent technological devices and networks open up possibilities for urban and infrastructural change, and at the same time are a terrain of political expression and struggle for citizenship. Anand (2017), in his studies on Mumbai, has examined the ability of urban residents to be recognised by city agencies through legitimate infrastructure services (e.g. by-laws, plans, politicians, patrons, and social workers), and the politics of technology (enabled by the peculiar and situated forms of infrastructural artefacts), which together shape the unequal forms of infrastructural citizenship. Other deliberations have focused on how the non-payment of service charges, the bypassing of formal

networks, and illegal connections to services are addressed by prepayment technologies for utility services (von Schnitzler, 2013; Baptista, 2013 and 2015; van Heusden, 2009). Baptista (2013: 3), in her study on prepaid facilities for electric access in Maputo, Mozambique, shows how beyond enabling access to critical services, prepaid facilities possess the capability of facilitating "forms of sociability and social ordering that are not exclusively economic, but also political, familial and technological". Baptista (2015) furthermore shows how these technologies have acted to enable a sense of control and autonomy within everyday economies of estimation and calculation where costs can be paid in small increments.

Other authors have analysed the technopolitics of mobile technological devices in African cities. Van Heusden (2009), through the case of the city of Cape Town, refers to prepaid systems and facilities as a "new logic of delivery", highlighting their neoliberal inscription and the unequal formations of access and power which enable the state to conveniently detach itself from its citizens. Through the case of low-income residents of Soweto in post-apartheid Johannesburg, South Africa, von Schnitzler (2013 and 2016) views prepaid water metres as technopolitical devices bound up with questions of belonging and citizenship, as opposed to them being merely neutral devices for service provision. For instance, von Schnitzler (2013) demonstrates how these digital metres transition from modernist and ideologically driven artefacts to artefacts that eventually become shaped by struggles and politics that draw from survivalist strategies and collective agency. Von Schnitzler (2016) further invites us to examine citizenship and activism in more material terms – specifically through the tangible world of piped- and grid-networks – within postcolonial contexts. Moreover, Anand (2017) focuses on Mumbai's water infrastructure to highlight the critical role that water infrastructures play in producing relations of power and consolidating civic and social belonging in the city. Anand demonstrates that citizenship emerges through continuous efforts of control, maintenance, and governance, showing how the city's water flows not through static constellations of pipes but through dynamic and hybrid systems built through their relationship with residents, politicians, and engineers.

The above accounts and contributions on metering technologies offer a way of seeing new and emergent technological configurations as inherently political, even if outside the traditional political terrain. As such, they highlight how political contestations and their exacerbation of inequalities in access to basic services are inscribed into technologies themselves. These contributions provide a basis for examining artefacts as not only technological but also as political. In this sense, technological artefacts may shape citizenship for, and the public sphere of, the urban poor (Anand, 2017),

and may re-enact inequality and social injustice. Related studies foreground artefacts within wider conceptions of political life, prompting critical rereadings of the politics of centralised infrastructural systems. Building upon them, this paper explores the complexity of local interactions around technopolitical systems in the context of a project whose designs are transformed by the micropolitical involvement and engagement of different actors within and outside of the community.

3.2.3 Framing hybrid infrastructure constellations in the digital age

Studies on the technopolitics of digitally enhanced basic service provision in African cities make valuable contributions to literature on urban infrastructure systems in the digital age. These studies have often focused on larger and more complex infrastructure systems (see, for instance, Coutard, 2008; Zérah, 2008) and single technical artefacts, unveiling the ways in which these change through adaptation and appropriation by different actors. While providing important insights into the effects of complex infrastructural constellations on the inclusion or exclusion of urban residents in terms of basic service provision, these studies have tended to overlook the ways in which these change over time due to various processes of appropriation and adaptation (see Gandy, 2006; Monstadt and Schramm, 2017). That notwithstanding, we draw from them to examine the urban planning and appropriation of urban infrastructure systems in the context of the African city.

In framing our study, we transcend conceptualisations of the 'modern infrastructure ideal' (Graham and Marvin, 2001) that presuppose the existence of a fixed and spatially bound infrastructure system. Rather, we consider the evolvement and shifting nature of top-down, large-scale, and centralised systems. We analyse processes that echo what Monstadt and Schramm (2017) show in the case of Dar es Salaam, Tanzania, where efforts to achieve widespread access to centralised and standardised water and sewerage networks tend to be countered by manifold and place-based dynamics of appropriation by different actors. These processes challenge large-scale European models and ideals within postcolonial contexts. As Edgerton (2006) shows, innovative technologies do not simply replace existing infrastructures with new ones. Instead, they usually add to them and imply new forms of appropriation, interference, and conflict (ibid). As various actors appropriate, negotiate, and contest planned infrastructures, they render them subject to malleability and change (Schramm and Wright-Contreras, 2017; Kirsch, 2006). A wide array of studies adds to these insights, presenting different processes and practices that shape infrastructures as heterogeneous (e.g. Jaglin, 2014; Lawhon et al., 2017). We draw on these studies in our examination of digitally enhanced water infrastructures.

Drawing on these insights, we propose that infrastructures in cities in Africa and beyond are not fixed and uniform but highly dynamic and hybrid, and that digital technologies further add to the complexity and change of infrastructural constellations. By 'dynamic', we refer to processes "emerging to extend routinized community practices into new forms of infrastructural technology and organization" (Simone and Pieterse, 2018: 137). By 'hybrid', we mean a process that involves "the creation of something new by combining elements of the new ideals, models or technologies with existing ones" (Monstadt and Schramm, 2017: 109; Behrends et al., 2014: 9). In this regard, this paper aims to make apparent the different ways in which supply and demand of technology "is constantly contested and renegotiated" (Coutard and Guy, 2007: 3) by various actors, including by "place-based collectives that take charge of institutional requirements to ensure a modicum of service delivery" (Simone and Pieterse, 2018: 38). More specifically, we focus on the role of digital technologies in contributing to the further hybridisation of dynamic infrastructure constellations. We examine the recalibration of Jisomee Mita as a sociotechnical constellation that is developing through complex processes and practices far beyond predesigned plans and strategies. We contend that digital technologies add to the complexity of hybrid infrastructure constellations. We show how these constellations are shaped by the everyday ways in which people access basic services beyond central planning. We demonstrate this by showing how the imaginations of 'active citizens' may contrast with those of the centralised planners, engineers, and policy makers.

3.3 The Urban Condition of Water Access in Soweto-Kayole

Our recourse to Soweto-Kayole, a suburb of Nairobi, is motivated by wider calls in urban studies for new 'geographies of theory' that are attentive to alternative realities, conditions, and contexts (Robinson, 2014). Soweto-Kayole is a low and average income neighbourhood dependent on a survival-driven and *kadogo* (frugal, small-scale) economy. Situated on the fringe of the city, Soweto-Kayole exists in a semi-planned land area under an arrangement that Majale (2002) would refer to as 'quasi-legal' occupation and land ownership. The area is legally approved for settlement. Feasibility studies and tendering processes were conducted, and subsequently guided the subdivision, designation, and appropriation of its residential plots and social spaces, including markets, schools, and hospitals. The first inhabitants occupied the land after 1980, and most of the infrastructural deployments have materialised over the last decade. During our fieldwork we observed, for instance, that the housing units with their courtyard-style layout were built of stone and cement, and not of materials such as *mabati* (corrugated galvanised iron sheets), *matope* (mud), recycled metals,

cardboard and timber, and similar kinds of incremental building materials common for the often-cited slums or informal settlements of Nairobi. This was the case regardless of whether they were occupied by owners or by tenants. Of course, sometimes, a few mabati or matope buildings were seen in some pockets of the settlement and on its periphery. These are randomly positioned along the tarmacked and non-tarmacked roads, in some cases changing the original layout of the settlement by restricting internal pathways and encroaching on spaces initially designated for social spaces. In short, the settlement's built and residential structure does not correspond to the many, at times lurid, portrayals of the dramatic poverty of Nairobi's informal settlements.

Notwithstanding, the challenge of access to critical amenities such as water and energy in the settlement is a pressing one. The settlement's inhabitants have long improvised different modes of water access outside the realm of the long-established centralised, large technical system of Nairobi. In fact, NCWSC has faced not only severe challenges in meeting the settlement's high demand, but also stark confrontations with hybrid constellations of water supply systems operating outside of Nairobi's formalised institutional and policy frameworks. These range from boreholes and small-scale vendors to clandestine water connections. Those involved include, for instance, operators of unlicensed water kiosks and boreholes, and cartels and gangs who often engage in practices of bypassing pipes and reclaiming or rechannelling water to strategic locations, creating branches and collection points outside the purview of the utility company. Additionally, NCWSC often had to contend with 'inverse infrastructures' (Egyedi et al., 2012), such as small bottom-up, user-driven, and self-organising infrastructures which are easily accessible to residents (even if rather unreliable and often of low quality), are less expensive to build and operate, and offer more incremental services. These networks are sometimes backed by users' creativity and tinkering, and in other cases by small-scale entrepreneurs co-providing services to residents, often at high rates. In addition to these networks, however, residents in Soweto-Kayole often resort to such options as distant yard taps and standpipes; unlicensed public or private water kiosks in neighbouring settlements; non-piped networks including tanks, community-based boreholes, rainwater, and a highly contaminated river on the settlement's periphery. Residents sometimes must trek long distances with 10- or 20-litre jerry cans on their backs, or cycle or push a cart, to access water in neighbouring satellite towns and settlements. These challenges reflect the well-documented inadequacies and limitations of the conventional centralised grid in providing reliable and accessible services across the fragmented city (see Kariuki et al., 2003).

The historical and socio-spatial context of Soweto-Kayole has made the settlement popular among state and non-state agencies for urban redevelopment programmes. This is the case because the settlement accentuates a contrast with the city's 'premium networked spaces' (Graham and Marvin, 2001), where the wealthier sections of Nairobi's population enjoy largely unrestricted access to piped water from the central network at a low price. Hence, there is clearly the need to improve supply in Soweto-Kayole. At the same time, the stated goal of liberating residents from exploitation by water cartels and gangs who use the absence of formal provision channels to sell water at exorbitant prices – appears to be relatively easily attainable in Soweto-Kayole, as disputes between residents and the state with regard to land ownership are less intense in the settlement than in other low-income areas of Nairobi, which in turn is partly because much of Soweto-Kayole is legally approved for settlement. Due to these two actualities, the World Bank considers Soweto-Kayole "an excellent ground for mass formal solutions such as reticulated sewer and water on a demand-driven and affordability basis" (World Bank, 2015: 7). It is within this context that Soweto-Kayole becomes an ideal space for international agencies and the water utility to deploy Jisomee Mita, which they promote as a tool for the 'in-situ replacement' of heterogeneous constellations of water access in the settlement, as we further examine in the following section.

3.4 Towards a New Metering Regime: The Jisomee Mita Project

Having presented the socio-spatial setting of Soweto-Kayole, this section sketches Jisomee Mita as a pilot-based project that targets a small community within a city plagued by large-scale deficits in the provisioning of services. We explain the project's innovation typology and system architecture; configurations of frugality that essentially enhance its acceptability to urban residents; and its local anchoring and global promotion. Finally, we explore the project's ambivalences as a sociotechnical infrastructure in the making, to set the stage for a discussion of the ways in which actors have reassembled Jisomee Mita to create new dynamic and hybrid constellations of water access beyond planning.

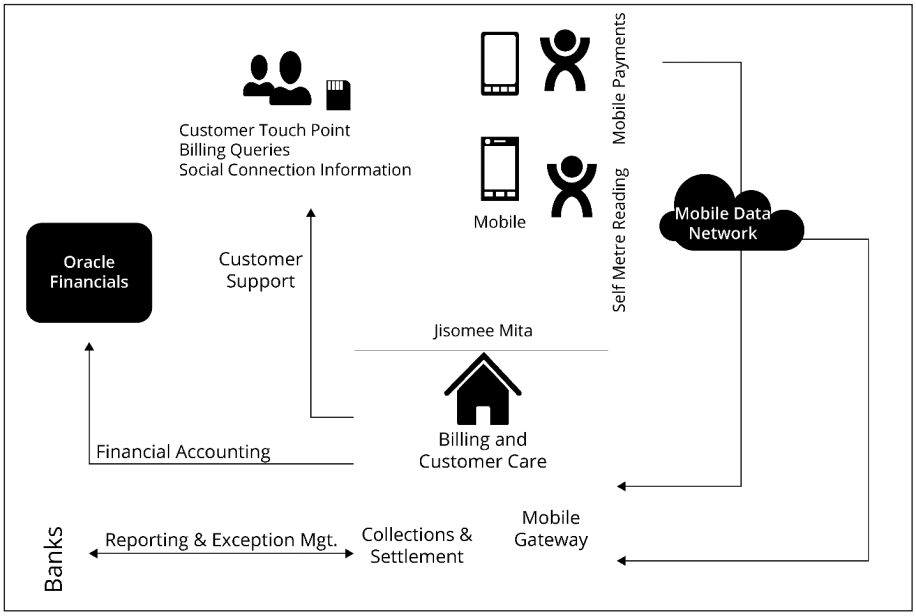
3.4.1 Innovation typology and system architecture

Jisomee Mita was launched in May 2014 by NCWSC. It is an infrastructure development project that is designed to provide access to networked water services in Soweto-Kayole. It is based on a hybrid technological constellation which combines ICT tools with an expansion of a network of water pipes. Jisomee Mita portrays a technology-

centred pathway for water access, which is designed to enable a linear interaction between users (Soweto-Kayole residents) and the service provider (NCWSC) in facilitating self metre reading. The technical infrastructure and design of Jisomee Mita was originally planned to allow users to read their own metres and send readings through SMS (short message service) texts to the water utility. This process was intended as an improvement on the conventional system whereby residents who were connected to the centralised network waited for monthly paper bills from utility agents for water used. Mobile communications companies – for example Safaricom and Airtel Kenya – provide the technical infrastructure for mobile payments through their platforms, in this case, respectively, M-Pesa and Airtel Money. Technology firms such as JamboPay provide the payment gateway at the interface of mobile communications companies, NCWSC, and the user. In this process, users are expected to send their SMS texts with metre readings to NCWSC, either in written form or with graphics and visuals. The 'Query Invoice' option is used through the short code '20618' (Interview 1, 2016). The SMS text is toll-free for some mobile network operators such as Safaricom, where NCWSC (through funding from the World Bank Global Partnership on Output-Based Aid – GPOBA) meets the KES0.80 (US$0.010) charges on behalf of the user. However, users registered with other telecom companies such as Airtel Kenya must pay this fee themselves (Interview 1, 2016). The way in which this international aid project therefore contributes to a restructuring of the national telecommunications market in Kenya must be discussed elsewhere.

Jisomee Mita, however, is deployed in Soweto-Kayole as a digitally enhanced solution to previously experienced complications of water access, billing, and payment. It is part of a broad range of digitally enhanced projects deployed and prioritised by NCWSC as 'quick fixes' for the stubborn problems of service provisioning. According to NCWSC, Jisomee Mita is a significant part of the company's endeavour to enhance service delivery through the integration of ICTs, and is an approach towards achieving automation of services and accelerated bill payments, as well as enhanced operational efficiency and effectiveness in urban planning, metering, finance, and supply (Interview 2, 2016). The team at the utility company offices in the community reported that Jisomee Mita was essentially intended to reconfigure or dissolve spatial and temporal barriers through the accessibility of 'anywhere-anytime' payments. It was supposed to support the necessary routines related to the provisioning of water and electricity in the city. The standard mobile billing and payment platforms were originally designed to allow for anywhere-anytime payments, perceived as important for reconfiguring daily routines and rituals for billing users.

Figure 3.1: Jisomee Mita system architecture



Source: Mwangi et al. (2015).

Figure 3.1 depicts the system architecture of Jisomee Mita. On receiving the reading, within one or two minutes (on a normal working day) NCWSC computes and determines the amount of the water bill and the user's outstanding balance, as well as the status of any outstanding microloans. The user is thus able to receive bill credits through a mobile-based customer-complaint handling and management system, and is then able to make payments through the phone's system. In order to execute these mobile processes for billing and payment purposes, users follow a series of on-screen steps through menu options. The architecture of Jisomee Mita thereby provides a mobile-based communication cum transaction cum financial model, which allows self metre reading, mobile-based invoice acquisition, system-related querying, water billing, and payment making. Jisomee Mita incorporates prepaid crediting mechanisms, self metre reading taps, and mobile payment. Beyond these services, however, the platform's original design also enables other subsidiary services, such as allowing users to add or remove another phone from the account, and affords users the possibility of prepayment without the need to upgrade to a new prepayment infrastructure system.

3.4.2 Infrastructural logics – frugal configurations

As an infrastructure development project, Jisomee Mita was configured to perform several functions. It was designed as a 'do-it-yourself' technology purposed to enforce an 'individualist' management of issues related to water access and billing by users. For instance, it was aimed to allow remote applicability, through functions ranging from self metre reading, to self-operation, self-repair, and self-maintenance. At first glance, therefore, Jisomee Mita enables a kind of self-control, self-accountability, and self-regulation by the urban resident. At the same time, certain mechanisms of the sociotechnical system reflect the urge of system designers to enable the outsourcing of tasks that were hitherto part of the utility's responsibility, and yet to continue to direct users' behaviour. This pertains especially to the payment of bills, which is essential for the utility that has – in line with internationally circulating ideals of modern service provision – set as one of its goals the increased cost recovery of investments based on adequate tariffs.

In order to enable the outsourcing of functions to urban residents while still directing their behaviour, Jisomee Mita was designed as a frugal technology that allowed "multiple billing on one cycle" through incremental configurations. At its launch, users were persuaded to pay for water access in small increments and instalments, with 0 to 6 units each costing KES25 (US$0.25); 7 to 60 units each costing KES54 (US$0.54); and 70 or more units each costing KES60 (US$0.60) (Interview 3, 2016). Users were also made aware that if they did not pay their monthly bill, the units they consumed would be charged according to the next higher bracket (Interview 4, 2016). The logic of this arrangement is essentially designed to exploit the Soweto-Kayole's survival-driven and kadogo economy. The idea that users had the option to pay their bills on any day of the month and in small incremental instalments was viewed by the agents from the utility company as 'an asset' for the project. It was justified as being better than waiting for the monthly billing cycles, when the bills would have increased to much higher amounts. On the other hand, however, this arrangement bred contingent misunderstandings for users who saw their bills considerably accumulate due to delayed bill payment and sometimes non-payment. This is largely because the users were expected to pay a monthly connection fee which accumulated automatically. When users delayed making their payments in a timely manner they, in subsequent months, were expected to pay more, hence contradicting the whole rationale of Jisomee Mita as an incremental, small-scale, and survivalist facility.

As can be observed, the infrastructural logic of Jisomee Mita mirrors Nairobi's spatial legacies of segregation and fragmentation. Herein, frugal technologies are deployed

with the aim of penetrating low-income territories which would otherwise not have been accessible to the utility companies. In other words, they are deployed in territories that are notorious for being secured mostly by cartels and gangs who profit from the absence of the state, or in areas which would otherwise require more labour due to the deployment of new-flagged infrastructure grids and networks, in settlements that have till then been developing incrementally. Indeed, as was communicated to us during our interviews with officials at the pro-poor department at NCWSC, Jisomee Mita is designed with the aim of reorganising, reconstituting, and opening up such territories as Soweto-Kayole to targeted development (Interview 6, 2016). Hence, Jisomee Mita reflects a much broader interest for utility companies determined to create new and potential markets for water supply by the state, thereby expanding their market share, returns on investment, and revenue streams and generation. It also reflects global agencies' professed agendas of achieving advancement of specific technologies, access to public services, and empowerment of inhabitants in low-income spheres.

3.4.3 Appropriation: Globally promoted, locally anchored

Rather than being a user-driven, self-organised infrastructure originating from the grassroots, Jisomee Mita is a top-down, market-based intervention. While approved and regulated by Kenyan state-level actors and urban administrations, it is also heavily financed and supported through external donors and development organisations. Among the international governmental and development agencies that dominate its deployment are the International Development Association (IDA), Water and Sanitation Services Improvement Project (WASSIP), World Bank Water and Sanitation Program (WSP), and GPOBA. Seen in this light, Jisomee Mita is symbolic of the partnerships between NCWSC and global agencies, with the latter providing the financial support upon which its deployment and sustainability hinge. Their approach is to replicate best practices, to experiment with new and emergent technological interventions, and to modernise access through initiatives directed towards urban upgrading and redevelopment. As we elaborate below, Jisomee Mita can be said to be part of a global-level infrastructure, characterised by hegemonic notions of modernisation and urban redevelopment.

While globally promoted, the utility company has strategically employed locally anchored approaches. For instance, Jisomee Mita was part of a decentralised arrangement of service planning and delivery for informal settlements under NCWSC's Informal Settlements Unit, referred to as *Maji Mashinani* (Water for Grassroots). Maji Mashinani is an established programme in the settlement that is intended to

realise NCWSC's Social Connection Policy (Wamuchiru, 2017), whose main objective is to promote initiatives and interventions that target the city's low-income areas and marginalised households. The program pays GPOBA for every completed metre installation, upon independent verification by the World Bank's Water and Sanitation Project. In this arrangement, first-time connection loans, for instance, are awarded through subsidised microcrediting schemes, facilities, and mechanisms, in tandem with the country's telecommunications sector and the World Bank, and through K-Rep Bank, a commercial bank that specialises in microfinance. For instance, we were told during our interviews with field assistants from NCWSC at their facility in Soweto-Kayole that the initial cost of a metre installation, KES8,000 (US$80), had been subsidised by the World Bank, which paid at least KES4,000 (US$40) for each household connection (Interview 3, 2016). The rest of the cost's reimbursement was spread over a three-year period through microcredits (GWI, 2016: 16). These subsidies by GPOBA are essentially reflective of a disposition described by Amin and Thrift where institutions have become 'circumspect' in their operations and philosophy, avoiding ambiguous plans for more short-term and incremental prognoses, and becoming more 'calculative' through 'actionable targets' (2017: 132-133). Similar to recent World Bank initiatives to electrify slums in Nairobi (de Bercegol and Monstadt, 2018), they are ostensibly designed to enable inclusive and equitable supply and connectivity for poor residents who can otherwise barely afford metre installation costs given the precarious and survivalist economy they are embedded in.

The social connections policy was actualised through task forces and household-based committees within or among different courtyard plots (Interview 6, 2016). In so doing, the project's proprietors sought to delegate some roles to local representatives, including village elders and area chiefs (Mwangi et al., 2015). According to the community development officers at NCWSC, the idea behind this practice was essentially that local representatives of the settlement would become co-regulators in helping the utility company to minimise its own overheads, and its operational and transaction costs especially associated with periodic monitoring (Interview 4, 2016). Local residents would be expected to carry out oversight tasks, functions, and responsibilities, such as securing metres and administering the project. The integration of local representatives into the operation of the project was premised on the idea that socio-spatial justice could be reached by delegating regulatory tasks to the residents of a settlement. For instance, according to NCWSC officials in Soweto-Kayole, a 'collective spirit' was beginning to emerge within the settlement (Interview 4, 2016). This practice was thus based on the idea that a 'collective' exists in Soweto-Kayole, and that it could be mobilised to make residents take over tasks that are traditionally the

responsibility of the utility company. One of the tasks assigned to the urban residents is regulation of the infrastructure project, through a practice that the World Bank and NCWSC referred to as 'peer-to-peer policing' (Interview 7, 2017; Interview 8, 2016).

3.4.4 Ambivalences of technical infrastructures in the making

By 2017, Jisomee Mita had not only connected at least 2033 courtyard-type plots in Soweto-Kayole, but had also become an almost ubiquitous technical infrastructure in the settlement. Its digital operation, which allows do-it-yourself options such as self metre reading and remote transactions and querying, had indeed instilled a sense of ownership among many residents who owned the metres. Residents, for instance, recognised the 'power' and 'control' that Jisomee Mita had given them. This reality is encapsulated in such responses as "I feel empowered because of the control I have over my meter" (Interview 9, 2016), or "It gives me freedom to be in total control of my own consumption and meter readings" (Interview 10, 2016). However, while the infrastructural logic of Jisomee Mita has enabled self-control and self-regulation, it also brought about ambivalences.

One ambivalence is related to some users' unwillingness to read, regulate, and control their own metres. These users felt deprived by realising that the utility company had 'externalised' the labour costs of its operation, maintenance, and transaction to them, namely the 'poor' users (Interviews 9, 10, 11, and 12, 2016). These people felt that they were technically left with no choice but to get more involved and engaged with the operation of the metres. They were, for instance, expected to read their own metres, repair them, and make remote payments for their bills. And yet there were other inhabitants who, due to old age, illiteracy, or language barriers, were not able to read their own metres and report their readings or query their balance via SMS text. Hence, the utility company set up a facility in the settlement, and stationed workers at the facility to deal with personal complaints and queries from residents within the settlement. These residents would sometimes visit the NCWSC station in person with their inquiries. Most residents, for instance, said that they had visited the local utility offices more than once with inquiries.

Another ambivalence that this arrangement had served to re-enact was the pre-existing power dynamics and challenges, as the 'customer' and 'end user' do not form one single uniform actor category. For instance, the so-called peer-to-peer policing and regulation had unsurprisingly re-enacted pre-existing power relations within the settlement, hence contradicting Jisomee Mita's foundational goals of empowerment, self-control, and self-accountability. The local representatives too came with their

own interests and goals. These presented new challenges to the growth and development of the project. For instance, they provoked futile conflicts, hierarchies, and power struggles between these representatives and end users. Amidst uneven power relations and related struggles within Soweto-Kayole, this deployment of Jisomee Mita through the more powerful individuals from within and outside Soweto-Kayole perpetuated the highly unjust and exclusionary distribution of resources within the settlement. These served to further heighten the residents' dissatisfaction with the system. Moreover, due to the informal nature of the local representatives' operation in the settlement, their responsibilities and those of the village elders and area chiefs became increasingly unclear. Notwithstanding, actors from NCWSC and the World Bank justified the delegation of tasks to local representatives and particularly the so-called peer-to-peer policing, by maintaining that this measure had become inevitable for enhancing responsiveness towards metre reading, billing, and payment (World Bank, 2015). Moreover, it was viewed as being essential for reducing labour costs for the utility company, and thereby for the project's long-term strategy and sustainability in the settlement.

Hence, some residents felt that they had been tricked into subscribing to the project. This was even more so as they started to realise the exorbitant loans they had incurred or failed to refund upon deploying the digital metres in their households. In addition, they had become subjected to standard prices and penalties of water supply and non-payment respectively, especially as these prices and penalties were determined by the state and imposed on the community. Many therefore regretted subscribing to the project and argued, for instance, that while the utility company provided a vital commodity, the commodity came at a tremendous cost. Many users felt that their agency had been diminished. They felt that the new project was indebting them through aid. An example of this is the credit facilities that many of the residents were expected to acquire. Although some inhabitants had repaid their loans, many others had been indebted and could not afford to repay. They still had outstanding charges where, in some cases, the invoice had shot up after defaulting for several months, with interest rates set at 1.23 percent (Interview 5, 2016). There were several instances where users had accumulated bills of up to KES21,000 (US$210), in addition to the defaults they had accrued from loans and standing charges (Interview 5, 2016). As this fee is more than 20 times the average monthly rent of KES700 – 1500 (US$7 – 15), many users were beginning to complain that they had been forced, coerced, or 'arm-twisted' into taking on loans that they could not afford (Interview 11, 2016).

These ambivalences reflect not only the conceptual gap between Jisomee Mita's intended design and Soweto-Kayole's distinctive socio-spatial condition, but also the increasingly widening disparities due to the new infrastructure development project. They reflect an unequal donor – recipient relationship. We found, for instance, that human (and resource) rights activists had emerged and were speaking out against such approaches, partly reasoning that access to critical services such as water ought to be free or at least affordable, and not disempowering. This explains the frustration among many residents with how the project had turned out. As one of the residents said, "we thought we were falling into things, but little did we know we were being fallen on" (Interview 12, 2016). For the resident, 'falling into things' reflected the hope, optimism, and anticipation that they had felt about the new project being deployed as it had been explained to them by the utility, which had led them to sign up for it. 'Being fallen on', on the other hand, conveyed the feeling of desperation and despair at the unfulfillment of the promises made by the project's engineers and architects at the inception of the project.

To sum up, the limits of the digital application of Jisomee Mita show that deployments proposed as technological fixes by service providers and development agencies do not always work as planned. Sometimes they constitute trade-offs, and often tend to be unfaithful to their intended design and purpose. This is best portrayed by the practice of 'peer-to-peer policing' which, when seen through a Foucauldian lens of power, highlights its imperative in making spaces more governable for planning purposes (see, for instance, Foucault, 1980). We have shown that while acting as a means of enforcing behavioural norms by regulating and controlling individual citizens through involving them in their own surveillance and policing, this – and similar practices – also breed ambivalences resulting from non-compliance. In the following section, we examine hybrid and dynamic rearticulations that emerged in the process of Jisomee Mita's assembly beyond its digital (or virtual) operation towards its physical necessity, as well as beyond its original design as a regime that did not entirely achieve the purpose of providing direct, remote, and real-time digital interface as initially promised.

3.5 Reassembling Jisomee Mita: New Hybrid Constellations

As a result of the ambivalences elaborated above – with users interpreting Jisomee Mita as an unaffordable means, a tool for exploitation and exclusion, and a control mechanism by NCWSC – two things happened. First, bottom-up, self-organising networks, or 'inverse infrastructures' (Egyedi et al., 2012) began increasingly to

reappear, co-existing alongside Jisomee Mita. As such, we observed that many residents were again resorting to multiple water sources. They were resorting to heterogeneous means of water access, including private, informal, and unlicensed water delivery mechanisms: distant yard taps, standpipes, and kiosks, as well as non-piped networks such as tanks, community-based boreholes, and rainwater. As Jisomee Mita is essentially representative of a centrally governed large-scale network that was designed to replace small, bottom-up heterogeneous infrastructures for service provisioning in Soweto-Kayole (Ndaw, 2015), this development could be defined as constituting one of the deviations from the original plan of Jisomee Mita as an infrastructure development project.

Second, upon finding themselves in a precarious situation, and realising that the project's goals were shifting and that they had been 'arm-twisted', some residents started to take issues into their own hands in an attempt to regain agency by changing the technology. During our field visits to the neighbourhood, there were numerous cases where different users had reshaped Jisomee Mita rather than just adjusting their practices and behaviour to it. For instance, some had begun to tamper with and falsify metre readings, illegitimately expedite connections, and pilfer water through diverted pipes. By doing so, they had reassembled and re-engineered the workings of Jisomee Mita. Hence, while originally implemented as a top-down infrastructure development project, Jisomee Mita essentially became malleable to the settlement's place-based needs and realities. The people's own versions of how they imagined digitally enhanced water access had acted to remake the project beyond its original visions, models, and plans at inception. Essentially, Jisomee Mita had become susceptible to the intricacies of Soweto-Kayole, a process that provided a leeway for people to regain power by changing the technology yet leave them in a highly precarious place.

These practices reflect how residents have dynamically acted to re-engineer predesigned products. They depict a kind of do-it-yourself engineering where urban residents have acted to renegotiate and creatively reassemble the everyday systems and their operational functioning and technology. But most of all, they reflect the embedded and institutionalised nature of infrastructural configurations within Soweto-Kayole as a situated urban sphere. They depict a planned infrastructure development project that has been opened up to hybrid dynamics and constellations.

The more such mechanisms have transpired in Soweto-Kayole, the harder it has become for NCWSC to rely on the project's digital operation. Simply put, the initial hands-off approach inscribed in remote and digital applications of Jisomee Mita have

proved to be unsustainable and hard to enforce. User-initiated practices and processes of repair, tampering, bypassing, and improvisation demonstrate how the premise that Jisomee Mita would discipline urban dwellers in terms of metering and payment of bills had proven to be incorrect. These practices and processes are symbolic of the ways in which infrastructure development projects encompassing ICT solutions remain highly place-bound, despite the incorporation of remote-based and digital options which are directed towards relaxing distance/time constraints.

Although its original design sought to achieve the digitalisation of everyday billing, payment, crediting, and metre reading processes, Jisomee Mita's appropriation unfolded in different ways. For instance, beyond its design as a self metre reading and digitally enhanced incremental billing and payment programme for the poor, designed and marketed as one that allows users to read their own metres, Jisomee Mita shifted to 'show me your meter'. The project's design, which rested on its ability to enable remote-based control and order, turned out to be flawed. For instance, the idea of an inherently disciplined, dependable, and trusted consumer who would be able, willing, and relied-upon to read their own metre and send correct metre readings, and then pay in a timely manner through digital facilities, was unrealistic. As it turned out, the water utility could hardly enforce this behaviour and it became hard for utility staff to tell if, or even conclude that, the users in fact submitted correct readings. And even when the users sent correct and updated readings, regular system failures and the many incidents of incorrect or missing metre readings created a general climate of distrust between users and providers.

It is for this reason that the utility company set up regional utility offices within the settlement, in part to supplement the digital operation of the project. Jisomee Mita began to operate intensely through physical interface. NCWSC retained personnel within the community directed more towards personally administering the Jisomee Mita project. The office employed a team of community development assistants (CDAs) who also worked on behalf of the utility company as intermediaries, brokers, and sometimes mediators at the intersection of the user and provider. The CDAs began to operate as part of door-to-door operations and inspections of water metres. They enforced random inspections and supervision at the household level, and were tasked with imposing timely payment and dealing with residents' queries, often in person rather than digitally. Their operations and inspections became enforced rather unrelentingly, with agents specifically asking landlords or tenants to 'show me your meter'. To a large extent they replaced the human intermediary that Jisomee Mita originally intended to eliminate.

The CDAs recounted to us that, in the process, sometimes they became the subjects of harsh treatment from landlords and tenants. The CDAs reported that in some plots and households inhabitants were unwilling even to open their doors for inspection, let alone allowing themselves to be interrogated. In refusing to be inspected, the residents reasoned that this was not how they had been briefed that Jisomee Mita would work. The CDAs also claimed that they were often especially harassed by residents during processes of inspection and disconnection of water supply in the event of non-payment or illicit practices by the user. At other times, the users refused to provide information necessary for the utility agents to track or monitor payments and revenues. In fact, we further observed that some inhabitants had taken further measures to safeguard or protect their metres from any outside intrusion or interference, such as caging the water taps and metres (see images in Figure 3.2 below), in part to prevent theft, but also to prevent constant monitoring and supervision by the CDAs.

Figure 3.2: Reassembled metre installations

Clockwise, from top left: a caged water metre; a metre virtually buried in the ground; a metre hidden beneath a repurposed plastic container; and a caged and locked metre, further protected with a heavy stone on top. Source: Author, 2016.

To encapsulate Jisomee Mita's evolvement since its deployment, two deductions can be drawn from these events. The first concerns how the piped Jisomee Mita, in its appropriation, did not perform its main intended function of reliably providing water to its consumers. As could be seen during our site visits, for instance, Jisomee Mita was mostly ineffective, with water supply being increasingly restricted and intermittent. The taps were mostly dry and the residents received water for only a few hours, about two days a week. As a result, the residents often had to devise ways of manoeuvring by getting active in providing their own services, sometimes through other sources. This practice meant that users were not simply passive consumers of a rather ineffective system. Instead, they were active in appropriating and hybridising the infrastructure as a way of maximising its limited benefits and bypassing its challenges and inadequacies. The second has to do with how, while Jisomee Mita did in practice build on the hybrid notion of the user as a proactive self-regulator of services, its proponents did not seem prepared to deal with the other ways in which residents became active beyond their predesigned role as active citizens. Rather, as they began to re-engineer and renegotiate the technical infrastructure beyond its functionality, their proactive behaviour became difficult to deal with for regulators and the utility. In this sense, the view that users would simply turn into co-regulators only through the originally prescribed applications of self metre reading turned out to be wrong. The perception that users would stick only to their originally prescribed role – active only in ways that had been inscribed into it by its designers – turned out to be unrealistic. The experience with Jisomee Mita in Soweto-Kayole shows that the idea of disciplining citizens into taking over very specific tasks of the designed project fails, not because residents remain passive consumers of services but because of their active appropriation of projects through their everyday manoeuvres and coping strategies. Moreover, active appropriation plays out through rather unintended ways, in which technological scripts are remade in ways that undermine the intended functionality of the technological device.

3.6 Conclusions

This paper examined a water supply project called Jisomee Mita – a hybrid infrastructure constellation combining a new piped water network with digital technologies that enable self metre reading and mobile-phone-based billing, payment, and querying systems in Soweto-Kayole, a low and average income neighbourhood in Nairobi. We have demonstrated the complexity of local interactions around Jisomee Mita, proposed as a technological fix by the water utility company and donors. As a techno-political system, Jisomee Mita epitomises the complex, localised power dynamics and

infrastructural work resulting from attempts to incorporate a peripheral community into a centralised system operated by a public utility company. We have shown that while planned in a certain way, Jisomee Mita has been appropriated in multiple ways by its users and the multiple intermediary actors, reflecting their politics and everyday urban rhythm. Where urban actors and residents in Soweto-Kayole have acted to renegotiate and re-appropriate the infrastructure development project, modifying it and recasting it, hybrid and dynamic constellations echoed the modes of situated practice as well as the politics of the different variegated actors.

We have shown how Jisomee Mita has been recalibrated through processes of subversion, reinforcement, and reclamation. In a symbolic and fundamental way, the shift of the project from 'Read your Meter' (Jisomee Mita) to 'show me your meter' reflects how the project has shifted from its original premise to a more hybrid and dynamic constellation. The requirement of the utility to have the residents 'show them their meter' instead of being able to rely on residents' own readings particularly illustrates the failure of the attempt to create a system that caters to the needs of the urban poor by providing reliable and affordable services and, at the same time, fulfils the utility's requirement of cost efficiency by reducing staff through the outsourcing of tasks to residents and through the application of digital technologies. This, we argue, happened because it rested on a false imagination of the 'active citizen' inherent to the project, as residents reassembled the project in unforeseen ways that partly subverted the project's original goals.

Jisomee Mita thus represents a reality in which infrastructure plans and deployments aligned to organisational and institutional visions do not always align with situated and place-based rhythms of everyday life. It represents a reality in which projects diverge beyond their "institutional set-up and technical infrastructure", adjusting to "new circumstances" (Behrends et al., 2014: 3). In other words, projects while being framed as enabling affordable access to critical services through the rationalisation and outsourcing of tasks to residents using digital technologies, are reassembled into hybrid and dynamic infrastructure constellations. These constellations reflect the users' vision of service delivery by the public utility company and their own role therein, a vision that may clash with centralised ideas of the 'active citizen'. Our articulation therefore contributes to literature on heterogeneous infrastructures in the Global South that considers the everyday coping practices and contestations in which ordinary people actively access basic services and thus shape public planning and service provision in rather unforeseen ways.

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CHAPTER 4

POST-, PRE- AND NON-PAYMENT: CONFLICTING RATIONALITIES OF ELECTRICITY ACCESS IN KIBERA, NAIROBI

Abstract

Over the last decade, Kenya's main electricity provider has established a system of prepaid supply for urban residents. This paper builds upon urban studies scholarship on prepaid meters to provide a more nuanced examination of the ways in which different actors transfer, install and appropriate prepaid meters. We focus on Kibera slum, Nairobi, to examine Kenya Power's "rationality" for the deployment of prepaid technologies, and the ways in which actors incorporate social relations into these systems and negotiate them through these systems. Specifically, we consider the politicians, donors, residents of the slum Kibera and informal power distributors. We show how upon the deployment of prepaid systems in Kibera, residents and informal power distributors not only appropriate these technologies but also sometimes reject them by reverting to post-payment or non-payment options. In doing so, they enact rationalities that conflict with those of the utility provider, donors and politicians. The conflicting rationalities of different actors regarding energy provision and access, we argue, make the formalisation of electricity provision in slum areas through "technological fixes" a particularly daunting task. Ultimately, we contend that this study of actors' conflicting rationalities in the deployment of prepaid electricity systems is an important contribution to studies of urban technology because it explains not only what limitations utility providers face when extending their territorial monopoly to slum areas, but also the hybrid outcomes of planning and development interventions in the global South and elsewhere.

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4.1 Introduction

Although centralised energy grids are important elements of urban energy provision across Africa, urban dwellers generate and access energy in various ways other than direct connection to the centralised grids of official power distribution companies. In Nairobi, energy supply and access by no means reflect the "modern infrastructure ideal" of uniform and centralised citywide networked infrastructure providing energy for the entire population (Graham and Marvin, 2001). Instead, urban residents draw on multiple options. Even where the centralised electric grid may be available for a neighbourhood or household, its high cost and unreliability (i.e. in terms of frequent outages and low voltage) mean that it may not be feasible to rely on it for all energy purposes (Butera et al., 2015). Hence, urban residents are forced to spend significant portions of their incomes on alternative off-grid solutions such as backup diesel generators, rechargeable batteries, solar systems and paraffin (ibid.; Godinho and Eberhard, 2019), traditional fuels such as firewood or scrap wood scavenged for use as fuel, and charcoal (or energy derived from carbonised wood) for cooking, and other biomass residues and especially for lighting and cooking (Butera et. al., 2015). Although the use of off-grid solutions is apparent in the city's rich and poor areas and in planned and unplanned spaces, it is most common in slum areas where most low-income residents live. Residents in the rich and planned areas and in middle-class areas mostly rely on electricity, use gas for cooking and often have a diesel generator as a back-up.

Kenya Power (henceforth KP), the main electricity transmission, distribution and retail company in Kenya, seeks to universalise its centralised electricity networks and thereby achieve formal status as a territorial monopolist. In order to reach these goals, KP has turned to digital systems such as prepaid technologies. These allow access to electricity that has been paid for in advance through a mobile phone or digitally produced voucher. Prepaid technologies have become a popular modality of supply and access in Nairobi, with KP following the path of many utilities across African cities in employing them as a "technological fix" to solve the challenges of cost recovery and limited network coverage (Baptista, 2015b). Over the last decade, KP has deployed prepaid technologies, taking a cue from South Africa which since 1988 has been the leader in prepaid technological innovation in the global South including the African continent. In Nairobi, the prepayment model has evolved over the years and become increasingly adopted by the city's residents. It has become employed as a strategic business concept, technological solution and operational best practice for tackling infrastructural challenges of low access and non-payment. Prepaid technology has

become the "new logic of delivery" (van Heusden, 2012), which some have touted as "the way of future" (Ruiters, 2007: 493) for public utilities determined to expand their own centralised networks and territorial monopolies. Its implementation in slum areas is at the heart of current interventions aiming at utility electricity supply and access in the city.

In this paper, we combine insights into prepaid systems with the concept of conflicting rationalities to provide a more nuanced and differentiated understanding of the ways in which urban actors make sense of, deploy, adopt or reject prepaid technologies. Our lens reveals how complex and precarious KP's seemingly straightforward project of slum electrification is. We examine Kibera, Nairobi's largest slum as a "zone of encounter and contestation" (Watson, 2009: 2270). Kibera is a place where highly conflictual and extremely complex relationships exist between KP, residents and intermediary actors. Thus, we examine "the differences in world-view between the various parties involved" in deploying and adopting prepaid technologies and how different "conflicting rationalities" materialise in relation to electricity access and provision (Watson, 2003; de Satgé and Watson, 2018). Accordingly, we examine: KP's notion that extending its grid to Nairobi's slums requires a "technological fix"; the "informal power distributors" (henceforth IPDs) determination to constantly reposition and reinvent themselves; some residents' resistance to (pre)pay for KP's electricity and desire for negotiated and alternative channels of access; politicians' goal to deliver on campaign promises; and donors' motivations to deliver on performance-based investment funding by raising the household connection rates to formal utilities. We argue that at the heart of these different rationalities are two prime misconceptions held by KP. Firstly, the mistaken idea that it can effortlessly foresee or even control IPDs' reasoning and activities. Secondly, the notion that the residents of slums are a rather homogeneous mass that will welcome a technological artefact designed to provide better quality and affordable electricity access. These misconceptions, we argue, are rooted in a deeper lack of understanding of slum areas and the manner in which residents in Kibera form strategic coalitions with IPDs who are willing to strategically change there status. And yet, as our study further finds, KP does not seem to fundamentally question or revisit its approach to expanding the physical connectivity to networks and socio-spatial access to electricity services in the slum. Instead, the electricity company is determined to deploy more advanced "smart systems" as a new technological fix to counter the challenges of prepaid deployments.

For this article, we conducted four rounds of data collection between October 2014 and February 2019. Our empirical material covers data ranging from strategy-related

documents pertaining to focal aspects of prepaid deployments, project-related memos, KP's minutes and presentations, to newspaper and magazine articles about the deployment of prepaid meters in Nairobi. We also conducted 12 semi-structured interviews with engineers and social scientists from KP, personnel from the World Bank (henceforth, the WB) and UN-Habitat, and experts including consultants and academics based in Nairobi. Moreover, we supplemented these data with 25 interviews with residents, including prepaid electricity users (15) and the multifaceted IPDs (6) and other local recruits of KP (4) in Kibera. Kibera has been variously described as an informal settlement, a squatter community and a slum. As one of the few affordable settlements close to the city centre, many residents of Kibera live in extremely precarious situations shaped by hierarchical informal power structures through which actors manage unequal access to land, housing and infrastructure such as electricity (Schramm, 2017). We chose Kibera because since the early 2000s it has been subjected to repeated attempts to formalise housing and infrastructure access. We used the snowball sampling method to identify key informants and executives with knowledge of the deployment of prepayment systems for electricity.

This paper is structured as follows. In the next section we examine urban studies scholarship on prepaid systems, showing how prepaid meters have become critical sites of engagement for conceptualising infrastructural politics, power and control. In the third section, we introduce the notion of "conflicting rationalities" as an analytical tool to explain the different ways in which different actors make sense of electricity provision in general and of prepaid systems in particular, and how their different and dissenting rationalities make collective action to provide a basic infrastructure service extremely complex. We argue that the concept of conflicting rationalities (see, Watson, 2003; de Satgé and Watson, 2018) is imperative in providing a more nuanced picture of prepaid electricity systems in a context where various actors' practices speak of radically different ways of sense-making in relation to infrastructure provision and access. The fourth section explains informal power distribution in Nairobi's slums as a reflection of the various and often conflicting views of citizenship and access to services as enacted through the provision of and tinkering with electricity networks by different actors. The fifth section examines the attempts by the utility provider, donors and politicians to formalise electricity access in Nairobi's slums through the installation of prepaid meters as a technological fix to cope with the volatility of slum residents constantly seeking room for manoeuvre. The sixth section focuses on the articulations of conflicting rationalities by different actors, including KP, politicians, donors, slum residents and the multifaceted IPDs. We conclude that studying actors' conflicting rationalities in the deployment of prepaid electricity systems makes

an important contribution to studies of urban technology in contexts where actors have radically different understandings of planning and of certain development interventions.

4.2 Debates on Prepaid Systems for Service Provision in Southern Cities

The rise of prepaid systems for the provision of infrastructure services in Southern cities has led tostridenta wide-ranging body of urban studies research at the intersection of geography, anthropology, and science and technology studies (STS). At its most strident, it has examined prepaid meters as artefacts that are neither neutral nor closed-ended. As such, the technology is widely viewed as one that is "endowed with 'political qualities'" (Baumgardt, 2018: 47). Much of this literature has engaged with the artefacts as tools of politics, power and control, reflecting the extent to which these artefacts exploit and are exploited by the wide array of social, political and economic actors and processes (Steen, 2015) in urban contexts.

Within this literature, some STS scholars have investigated how as an artefact, the prepaid meter, is intricately entangled with politics and power dynamics (Baptista, 2015a). The concept of "technopolitics" has thus become a focus in energy studies to account "for the ability of competing actors to envision and enact political goals through the support of technical artefacts" (Gagliardone, 2014: 3). Technopolitics can be defined as "hybrids of technical systems and political practices that produce new forms of power and agency" (Edwards and Hecht, 2010: 619) whereby political action is expressed through technological design and tinkering rather than through explicit political debates in the "traditional" political sphere (cf. von Schnitzler, 2016). An example can be taken from Nairobi, where de Bercegol and Monstadt (2018) situate the politics of extending electricity networks to slums by examining state strategies to control and regulate electricity supply in the urban area and local resistance to them. In their paper, prepaid systems are viewed as political tools or tools that serve political ends and as mechanisms with the rationality of "formalising" the informal ways of the slums, and thereby an "affirmation of state hegemonic power over slum dwellers" (ibid.: 7). Another example is provided by von Schnitzler (2016), who demonstrates how, in the context of South Africa, the state, utility companies and citizens engage in conflicts and contestations via the deployment and appropriation of prepaid technologies. Von Schnitzler convincingly maintains that it is through these processes that different ideas of citizenship are enacted and struggled over.

Within this context, scholars consider the prepaid meter as a technology that blurs conventional areas of responsibility of the state, energy providers, and citizens and users and that devolves responsibilities from the provider to the user. Scholars have shown how the prepaid meter allows the state (i.e. through public utility companies) to delegate key responsibilities to urban citizens (also, Foster, 2018; van Heusden, 2012; von Schnitzler, 2013). Ruiters (2007: 501) considers the prepaid meter a form of "neo-liberal responsibilization," with its users being expected to take on roles and responsibilities that were traditionally designed for the state. Hence, the prepaid meter is viewed as an artefact that makes new demands of the user (also, van Heusden, 2012), reworking normative conceptions of relationships between providers and consumers.

Furthermore, urban scholars have viewed the prepaid meter as a technology that enables utility companies to extend networks to areas where regular payments by users are not a given (Baptista, 2015b; Jaglin, 2008). Thus, the prepaid meter has served the purpose of extending the formal monopoly of universal and centralised large-scale systems and of universalising and homogenising service provision within the context of increasingly splintered cities. As this kind of technology, it has become a mechanism of entry into "non-networked" spaces by public agencies, inherently accommodating, rather than countering, geographies of urban diversity and differentiation (Guma, 2019). Hence, in light of the segregated temporalities of many Southern cities, the prepaid meter is viewed as a tool that reflects a significant shift towards differentiated service provision (Jaglin, 2008; Schwartz et al., 2017).

By extension, a debate has emerged around the prepaid meter as a "disciplining" technology with governing, ordering and controlling powers over everyday urban processes. For instance, Baptista (2015a: 1017) shows how in Maputo, prepaid meters have forcefully shaped a kind of "disciplined autonomy" whereby household members have no choice but to regulate and restrain themselves, individually or collectively (ibid.: 1015). Hence, the prepaid meter facilitates "control over electricity consumption" in part, by requiring "constant estimation and calculation of when and how much can be bought and consumed" (ibid.: 1005). This is, for instance, shown in the ways in which the prepaid meter demands and mandates incremental, cyclical payments, encouraging responsible self-management of household finances (Schubert, 2018), or what Donner (2015: 123) referred to as a "metered mindset" in which users must regularly check the balance of their accounts. As this kind of technology, the prepaid meter "becomes reified" and "attains a governing power over ordinary rhythms, imposing itself on prior habits" and patterns of electricity use

(Jacome and Ray, 2018: 265; van Heusden 2012; Ruiters 2007). While this view is particularly poignant, it is partially deterministic as it considers prepaid meters as a transformative tool that determines user practices. As such, it ignores or underestimates the agency of users and other subaltern actors in shaping and appropriating technology.

This criticism speaks to wider critiques of extant debates on prepaid technology that employ unrealistic binary frames that conceptualise prepaid technologies within minimalist state–citizen dichotomies (see e.g. van Heusden, 2012; Ruiters 2007; Foster, 2018) that barely acknowledge the actual and highly differentiated rationalities of a multiplicity of stakeholders at play. In light of these critiques, it becomes important to provide a more nuanced understanding of the multiple and indeed contradictory rationalities that drive different actors and stakeholders in the deployment and appropriation of prepaid meters in informal areas of the global South. Accordingly, the following section introduces the concept of conflicting rationalities as one that is imperative for achieving this objective.

4.3 Understanding Conflicting Rationalities in the Deployment of Prepaid Systems

This paper employs the concept of conflicting rationalities introduced and articulated by Watson (2003, 2009, also de Satgé and Watson, 2018). The concept refers to the central tension which plays out in cities "between, on the one hand, techno-managerial, modernising and marketised systems of state planning, administration and service provision, in various forms of alliance or collusion with other actors […] and on the other hand, marginalised and impoverished urban populations surviving largely, but not only, under conditions of informality or 'illegality'" (de Satgé and Watson, 2018: 29). As an analytical tool, the concept instigates a particular frame of conceptualising new planning and development interventions within situated urban spheres of the global South. Here, the modernising ambitions of the state often clash with the highly different world views and divergent social and cultural contexts of the shack dwellers, who themselves are fragmented and conflictual (ibid.: 3). Planners and administrators may underestimate these differences and assume a shared rationality in the modernising ambitions where there is none. The concept thus provides a "way of making sense" of the agency of users, and the suite of values or world views that encompasses multiple stakeholders' motivations within a particular setting (ibid.: 26). It highlights that a Southern perspective on planning and development interventions "not only implies an understanding of the processes of colonialism, postcolonialism, imperialism, and

capitalism" (Galland and Elinbaum, 2018: 15), but also recognition that these are subject to varied and sometimes conflictual logics and "rationalities enacted by urban dwellers in organizing social life" (Baptista, 2015: 1008). As a result of these conflicting rationalities, "modernising" projects of international development agencies and national and urban governments often have ambivalent and unintended outcomes that may be contrary to their original designs (Harrison, 2006: 328).

In recent decades, conflicting rationalities have been examined in different ways to capture the contradictory and conflictual demands and responses of various actors in urban planning practice. In an earlier account, Harrison has discussed conflicting rationalities in broader planning theory debates, using Johannesburg as a prism for looking at and understanding the multiple logics that shape urban planning in the global South, with a view of constructing "an 'other way' of thinking that is situated both within and outside dominant representations" (Harrison, 2005: 319). Recently, Makhale and Landman (2018: 130), focusing on gated communities in the city of Tshwane, have demonstrated how communities in the city "highlight the challenges facing the planning practice and the consequent tensions [that emerge] due to conflicting rationalities and deep differences between the various stakeholders where planners are caught in the middle." Baptista's (2015a) work, examining the everyday practices surrounding prepaid electricity use in Maputo, has revealed "the multiple rationalities implicated in the use of the electricity infrastructure via prepayment" (ibid., 1005). And Massey (2013) has investigated urban planning rationalities of the in situ upgrading of the informal settlements in Cape Town, and the contradictory practices and implications of such rationalities for specific groups in these settlements, including women's social networks. Altogether, these contributions have particularly been central in understanding how different rationalities coalesce and sometimes conflict irreconcilably in a specific context, undermining developmental ambitions. For planners who work within or for state agencies and for public utilities and international donors it can be "frustrating, as planned interventions, more often than not, have outcomes that are unintended, unexpected and, even, quite contrary to original designs. There are copious examples of planned interventions that come up against logics that are unfamiliar to the policy-maker, or against conflicts between divergent rationalities" (Harrison, 2006: 328).

In the following, we use the concept of conflicting rationalities to understand the logics at play that shape the varied demands, responses and agencies of local stakeholders within the modernising ambition to electrify slum areas in Nairobi. So, by applying the concept of conflicting rationalities to the deployment and appropriation

of technology, this paper offers a "way of seeing" or "making sense" of the varied actors' different and conflicting rationalities at play in large-scale infrastructure interventions, and their unintended outcomes.

4.4 Electricity Access and the Rise of Informal Power Distributors in Kibera

Nairobi's slum areas have for a long time been bypassed and ignored by urban planners on a large-scale. In the postcolonial era, municipal authorities, state bureaucrats and utility companies have refused to recognise them or even provide services for them. This has been on the grounds that land tenure for the slum dwellers has not been secured, which is why they lie outside the established parameters of formal urban and infrastructure planning. As slum populations have grown, little or no effort has been made to supply these areas with "public" services. This echoes the policy approach adopted in the colonial period when Nairobi municipal officials simply anticipated that such settlements as Kibera "would disappear altogether in a relatively short time" (Mortimer, 1945). However, instead of disappearing, Nairobi's slums have grown exponentially, with this trend continuing today. Successive governments have recognised the increasing value of the land on which some of Nairobi's older slums sit and have made some attempts to acquire it, albeit with limited success (Schramm, 2017). Thus, both colonial and post-colonial governments have failed to enact consistent policies regarding the city's slums, neither formally recognising them nor successfully clearing them.

Until the early 2000s, the authorities prohibited the construction of permanent housing in slum areas and the provision of infrastructural services such as electricity to these slums. Nonetheless, many residents stayed and created new modalities of unregulated access, with the result that informal electricity distribution has become one of the most prevalent forms of providing electricity access in the slums. In this way, Nairobi's slums have come to possess intricate "quasi-legal" (Majale, 2002) regulatory structures where local chiefs regulated the construction of infrastructure and access to housing. They have come to constitute a kind of "gray space" (Yiftachel, 2009), where dwellers constantly act outside formal laws and regulations.

In Nairobi, KP is the formal electricity provider. Incorporated in the early 1920s, KP has operated post-paid supply, through electromechanical and fixed-billing meters. Under this arrangement, customers consume electricity and pay their bills after their meters have been read by KP employees (KPLC Strategic Plan, 2011). Being largely

analogue, for KP and its customers this process entails large amounts of paperwork to handle multiple procedures, and tools and spreadsheets to record the operation of the electricity meters. This has regularly led to delays and errors on the part of consumers and staff. Billing processes for electricity access are error-prone, induce confrontation between KP staff and clients, and are sometimes usurped by individuals posing as KP's field staff, breeding suspicion among residents. Some residents actively subvert the formal system of electricity supply, for instance by deliberately shutting out meter readers by caging their meters or locking them behind residential gates on weekdays. Others falsify meter readings by reversing the counting wheels or bypassing them. Yet others reconnect their supply, leading to both energy and financial losses. Most forms of subversion and resistance (at least for KP) take the form of processes and practices directed towards recalibrating or bypassing the centralised system.

In the slum areas, practices of subversion, falsification and bypassing have materialised through enterprising groups which we to refer in this paper as informal power distributors (IPDs). These IPDs have come to constitute a type of syndicate in different parts of the city, redistributing electricity via a makeshift tangle of cables and wires strung above the shacks on repurposed poles Up to 30 households in a settlement can be connected by a single IPD whose connection (tapped from an electricity transformer or household in an adjacent estate) would have been sufficient (in terms of watts) for just one household (own observation).

As a result of these practices, IPDs have created the de-facto power grid for residents. Their rise has been driven by the "spectral state" (i.e. present but barely active) and populist politics. For example, between 1978 and 2002, for populist and political gains Daniel Arap Moi's government supported the *kadogo* ("small", or frugal and survivalist) economy – sustained by the *jua-kali* sector (i.e. informal, small-scale entrepreneurship) which constituted Moi's strongest political base. By the early 1990s, this sector had become the "glue" that was holding the urban economy together by providing the basic necessities of everyday life, including electricity (Widner, 1992). As part of this rising sector, IPDs in the slum areas became increasingly powerful and emboldened in their capacity to provide certain sociotechnical services such as electricity. Their prominence has been highly bewildering for KP. The reasons for that lie not only in the difficulties of managing electricity loads, stabilising electricity grids and establishing safety standards for their customers, but also in the undercutting of KP's revenue base and cost recovery. The remainder of this paper demonstrates how KP's attempts to disempower IPDs eventually culminated in contestations and manifestations of conflicting rationalities.

4.5 Digitalisation and the Deployment of Prepaid Systems

In the preceding section, we explained the informal power distribution in Nairobi's slums as enacted through redistribution of and tinkering with electricity networks by different actors, including IPDs. In this section, we examine the innovation and design of prepaid meters, the strategies of KP and the WB in fostering electrification through prepaid systems, the integration of diverse and frugal technologies, and the employment of IPDs in deploying electricity networks in Kibera.

4.5.1 Innovation typology and design of prepaid meters

The type of innovation and installation set-up of the prepaid systems in Kibera constitutes a "ready board" (see also, de Bercegol and Monstadt, 2018), namely a cost-efficient system typically mounted inside (but sometimes outside) the user's dwelling (see image 1), in a visible and accessible location that enables the user to have better access to and control over it. The ready board is normally installed as a single set for each household, serves as the electricity dispenser and incorporates a keypad in addition to associated accessories (see image 1). It consists of internal wiring, a free compact fluorescent tube holder and at least one socket. The ready board design is a simple and user-friendly set-up that is intended to enable slum residents to light their homes, charge their phones and use basic electronic appliances such as radio and TV. Through beeps and blinking lights, it alerts the user when the credit balance is low. Once the credit is entirely consumed, the user is automatically disconnected.

The prepaid meters deployed have also been adapted to the living situation in Nairobi's slums to enhance their functionality in low-income households (see image 1). For instance, their accompanying technologies have been adjusted to slum conditions by KP and the WB and include low-cost aluminium wiring as opposed to copper electrical wiring that is regularly stolen in slum areas (see e.g. de Bercegol and Monstadt, 2018: 255). KP has also started using concrete poles and raising the height of the power lines to prevent theft of electricity (Interview 5, 2017). Both the security standards and the regulations concerning these technologies have been minimised. As one KP official pointed out: "A few years ago, we had policies where if you decided, 'I have a shelter on the road, I need electricity', this would not work because we already have our policy which can't allow us to give electricity to such a structure. You had to show proof of ownership of the land before you were supplied. But this has been waived specifically for the informal settlement places" (Interview 1, 2017).

The design of distribution networks and prepaid systems were thus adapted to the sociospatial conditions of slum settlements. This adaptation reflects KP's aim to consolidate and extend its monopoly by expanding its centralised grid to slum settlements which had hitherto been bypassed. Hence, prepaid systems have become a standard means for formalising electricity access in Nairobi's slum areas. This demonstrates general acknowledgement and acceptance of slums as permanent parts of Nairobi. This acknowledgement and acceptance then became incorporated into the very deployment of the prepaid meter as a technology mostly oriented towards the poor, which in turn has the effect of perpetuating the slums' existence, and in the

Figure 4.1 Outdoor and indoor ready boards and customer interface units.

Images by Author, Kibera, 2016

mid- to long-term, serves to open up slums as a source of revenue for KP. In the following section, we explain the shifting rationale of KP, the national government and donor agencies in the implementation of prepaid systems in slum areas.

4.5.2 Enrolment of slum residents through subsidies and lifeline tariffs

With the aim of solving some of the challenges it had experienced with the post-paid system, KP deployed prepaid meters in a broader techno-political move to enrol slum residents into state-driven programmes. This followed the broader shift from thinking about slum areas as temporary settlements that should disappear and therefore not be served to seeing them as potential "markets" for infrastructure services to be tapped by the state and parastatal actors. Prepaid meters were presented as a technological fix for achieving automation, facilitating payments and attracting more consumers who had been uncomfortable with the bureaucratic processes of the former technology (Interview I, 2017). First, KP saw prepaid meters as an opportunity for recovering operational costs by curbing and replacing illegal connections and the heterogeneous modalities of electricity access assembled by syndicates that existed mostly in slum areas (see e.g. Kang'Arua, 2016). Second, slum areas "made sense as a business strategy" for the utility company as one expert argued: "KP needed connections. Slum areas can give you the fastest connections. […] You have your very high target to achieve and you know that there's a huge population in the slum areas. Electrify the slums and you get your numbers" (Interview 3, 2017). Third, and most importantly, the new government led by president Uhuru Kenyatta and deputy president William Ruto that came into power in March 2013 put KP under increased political pressure, as Kenyatta and Ruto were determined to honour their election campaign pledge to extend electricity services to all Kenyans: an "annual target of one million new connections" and an electrification access rate of 80 per cent by the year 2020 (Interview 2, 2016).

The WB provided substantial funding for the enrolment of slum residents, plus support through the International Development Association (IDA) and the Global Partnership for Output Based Aid (GPOBA) within its performance-based investment funding for the utility and financial incentives for low-income customers (Dave et al., 2019). The total funding allocated by the WB between May 2009 and December 2017 was USD 28 million for the scheme, which was a subcomponent of the Kenya Electricity Expansion Project that cost a total of USD 406 million (Kenya Power, 2015b). Under this funding and support, the WB paid part of the connection fee for all electricity connections in Kibera comprising KES 19,350 (≈USD 192 in 2015) per connection, while KP contributed KES 11,970 per connection to make up

the rest of the standard capital contribution of KES 32,480 (≈USD 320) per connection (ibid.). According to the WB, this breakdown was arrived at after considering a wide range of research surveys and lessons learned about good practices from successful slum electrification programmes worldwide (Interviews 5, 2017; 1, 2017). The funding allowed KP to maintain affordable lifeline tariffs for the urban poor up to the first 50 kWh of access, with monthly electricity costs of around KES 590 (≈USD 6) (World Bank, 2016). It also enabled slum residents to be connected to prepaid meters for a special reduced annual connection fee of KES 1,160 (≈USD 11.5) per connection. Customers purchased prepaid tokens for a period of 12 months, which translated into instalments of KES 100 paid at the beginning of the month (Kenya Power, 2015; World Bank, 2016).

Through these lifeline tariffs, the WB sought "to support the Government's initiatives of ensuring increased electricity access to Kenyans" (Kang'Arua, 2016: 11) and to consolidate and extend the monopoly of centralised grids to underserved urban areas. In its mandate, the bank sought to realise "full electricity access" in Kenya by 2020 (Dave, et al., 2019) and universalise access, strengthen KP's cost recovery, formalise power supply and enforce territorial monopolies in power distribution (e.g. Diop, 2016). By mid-2016, a total of 1.14 million new low-income customers, including 524,813 households, had been connected since piloting in 2014 (Herbling, 2016; World Bank, 2016). However, despite the success achieved in connections, the distribution component of the slum electrification programme in general has not been very successful, particularly with regard to the actual use of the prepaid meters in Kibera households. As we will argue later on in this article, despite the integration of frugal digital technologies to enhance formal supply of and access to electricity, the actual access to and adoption of this mode of electricity have been marred by hurdles of prepayment and non-payment, increased pressure and repression from IPDs, and the escalation of theft practices and illicit electricity connections.

4.5.3 Integration of frugal digital technologies

Since 2009, the standard processes of purchasing prepayment electricity tokens and the associated manual loading have been similar to the processes of buying airtime credit from a scratch card or a digital voucher from selected stores for a mobile phone. Electricity tokens are purchased in the same way as mobile phone or SIM-card vouchers: by acquiring prepayment alphanumeric codes that are typically 20 digits long, otherwise referred to as "tokens". The tokens are bought either from a designated point-of-sale – for example a petrol station, shopping mall, bank or supermarket – or from small shops, vending machines or kiosks distributed across the city and its

outskirts. The customer provides the local electricity dispenser number and the amount of electricity they want to buy. The agent hands over the "token" in the form of an encrypted, digitally produced and meter-specific code for the customer to load or punch into the customer interface unit (see image 1). This code instantly loads the meter in real time. The process of purchasing tokens is also facilitated through centralised KP token-vending systems using an authorised automated data network. In addition to this vending system, KP has introduced mobile-phone-based payment and crediting components, with the goal of enhancing payment options for its users, especially the urban poor, most of whom live in slum areas.

According to KP, the preferred option for purchasing prepayment tokens is via mobile phone (Interview 5, 2017). Mobile systems such as Safaricom's M-Pesa ("M" stands for mobile and "Pesa" is Swahili for money) in Kenya are popular for purposes such as purchasing services, making payments and settling electricity bills. They are popular because they do not require a physical presence, as they work through an integrated SMS-based mobile service that enables subscribers to use money transfer services to purchase prepaid electricity units. This process thus relies upon short message service (SMS) and encrypted supplementary service data (USSD) sessions, supported by a subscriber identity module (SIM) card. The two major mobile phone networks used for purchasing tokens in Nairobi are Safaricom's "Lipa Na M-Pesa" ("Pay with M-Pesa") and Airtel's "Airtel Money". KP employs these platforms to collect and receive its revenues remotely. For their part, the mobile service provider gains from transaction fees and users receive their purchased tokens immediately.

Wishing to increase the success of prepaid systems, KP has introduced additional components to the prepaid system. One such system is the frugal mobile soft-loan facility "Okoa Stima" ("Okoa" is Swahili for rescue and "Stima" means electricity). Launched in April 2015 through an alliance with Safaricom, Okoa Stima prevents clients with prepaid meters from having their power cut off if they unexpectedly or unavoidably run out of credit. It capitalises on one of the prepaid system's major challenges: prepaid meters have had the reputation of literally leaving their users in the dark due to non-prepayment, delinquency and lack of planning (for example, if shops with point-of-sale for credit are closed or the client lacks credit to purchase electricity tokens through "mobile money"). The size of the loan that a Safaricom or KP client can receive depends on a pre-determined credit limit based on past undertakings with the telecommunication company and comes at a facility fee that is payable within seven days (Energy Sector News Review, 2015).

For KP, the above incremental modalities of payment and crediting were essential for it to achieve its goal. And yet these modalities also present several benefits for KP. For instance, in partnering with Safaricom to offer payment and crediting packages, KP sought to provide reliable avenues for collecting money from residents of slums with many defaulters. At the same time, the adaptability of these packages to the living situations in slum areas has made it possible for KP in Nairobi to extend facilities to individuals who lack financial "footprints", or have no credit rating or cannot afford electricity access on an everyday basis. Hence, these packages align strongly with the *kadogo* ("frugal") economy, enabling cash-constrained prepaid electricity consumers to cope with the challenges of unforeseen and often untimely blackouts when they run out of credit. Some residents in Kibera told us that they welcomed these initiatives in their household and appreciated their deployment in the slum, arguing for instance that they were happy that the system's self-billing, self-monitoring and self-regulation applications empowered them and allowed them the much-needed space for them to be in control (Interview 10, 2016) and not be harassed by state officials or IPDs (Interview 11, 2016). However, others were not comfortable with these mechanisms for payment and crediting, especially as for many, not using them would mean they would be denied electricity (e.g. Interviews 6, 2016; 7, 2016; 8, 2016). Others were unhappy that these options failed to take account of the fact that many residents in the slums lack access to steady flows of income (ibid.).

4.5.4 Employment of informal power distributors

To realise its goal, KP put together teams of engineers and technical staff with the sole aim of disconnecting illegal connections in these low-income households – what KP referred to as a "'clean-up' of the old systems" and unregulated connections (see image 2). KP achieved some success in ousting the IPDs and replacing them by prepaid KP systems. One of the strategies adopted by KP was to "keep removing the illegal, unregulated connections until they [the IPDs] get tired" (Interview 9, 2016). In some instances, we witnessed shack dwellings in the slum settlements being raided by men wielding shovels, hoes and spades to excavate and remove all elements of the non-prepaid "single-wire" electricity connections via underground cables or overhead lines. The operations included forceful measures whereby culprits and victims were fined and arrested with help from the police and other security operatives (see image 2).

The other strategy used by KP was to employ IPDs with the goal of enhancing the acceptability of prepaid meters in slum areas: members of IPDs were hired temporarily to install the technology and were trained to disconnect the illicit "spaghetti" lines and to erect poles and install meters under KP's direction and supervision. By so

Figure 4.2 Removing and replacing the old system

Images by Author, Kibera, 2016

doing, KP sought to to transform IPDs from illegal vendors of electricity not investing in electricity generation, transmission and distribution – and thereby jeopardising not only KP's revenue stream but also the lives of those exposed to the unsafe incremental grid extensions – into KP contractors paid to install formal distribution grids, household connections and meters. In this way, some IPDs became important actors in the deployment of prepaid systems. According to KP, the more pragmatic option was to develop a good working relationship with IPDs in Kibera and to incorporate them in KP's operations, rather than to fight and compete with them (Interviews 8, 2016; 9, 2016). However, this approach later turned out to be unsustainable, partly because once the the deployment of prepaid systems was completed, the IPDs lost their temporary jobs with KP.

Intent on finding other sources of revenue, the IPDs began to mobilise residents dissatisfied with KP's technologies by illicitly diverting, manipulating and circumventing the same prepaid meters that they had helped to deploy in the slums. Thanks to the skills acquired from KP during their involvement in the deployment, the IPDs possessed the capability and equipment required not only to tap and redistribute electricity from KP transformers, but also to purchase from the power provider electricity meter boxes and other miscellaneous electrical equipment such as transformers, conductors and cables. Moreover, they knew how to break into and reassemble electricity systems. In some cases, they retained KP uniforms and the necessary apparatus and outfits required to climb concrete poles to reconnect some slum residents. The strategies they employed included placing a powerful magnet next to or inserting a metallic or non-metallic object into the meter box, tampering with the sensor magnetic cores through saturation or disabling the meter completely (Interview 11, 2016).

It is noteworthy that according to our interviews, many residents welcomed these practices because they had not appreciated their status being unilaterally changed by KP from people "paying IPDs" to "prepaying KP clients". Others did not like the often extreme strategies employed in the deployment process. The residents we spoke to said they felt like they were being "pushed against the wall" (Interview 8, 2016). Others believed that the IPDs had connived with KP by taking away their connections to the informal power distribution. One interviewee, for instance, told us that she now perceived IPDs to be the same as state employees – interested only in taking away from the likes of her (Interview 10, 2016). Thus, while highly welcomed by some, the IPD's reinvention from actors serving KP to actors serving residents (through recalibrating prepaid systems to allow for free, tampered or negotiated access to electricity) was deprecated by many in the slum. In the next section, based on the different actors' particular frames of reference we will highlight the conflicting rationalities of the different actors in Kibera.

4.6 Conflicting Rationalities of Electrification

Thus far, we have examined the different actors that have contributed to the deployment, adoption and appropriation of prepaid systems in Kibera. We have described the attempts of the utility provider, donors and politicians to formalise electricity access in Nairobi's slums by installing prepaid meters as a technological fix and the flexibility slum residents have exhibited by reappropriating new technologies. We have further demonstrated that KP and the WB have tried to adjust to the contested

nature of Kibera: for example, KP has employed innovative approaches such as engaging IPDs as intermediaries in the slum, introducing subsidies and lifeline tariffs below those which slum residents had to pay to the IPDs and adapting the technologies to better target the urban poor. These approaches show that the deployment of prepaid systems in Kibera has been largely pragmatic and contextually specific in its search for win-win solutions intended to drive IPDs out of the slums by offering a better service. And yet it is evident today that many residents are still either not yet connected to the prepaid meters, or are connected but do not use KP's electricity, or – most commonly – are increasingly misusing the meters with help from the IPDs. The IPDs have been successful in mobilising residents, especially those who have generally been dissatisfied with KP and the WB's interventions in the slum. To the puzzlement of KP and the WB, an initiative whose architects had assumed would provide a service superior to that provided by IPDs in these slums has resulted in slum residents responding by appropriating, subverting and rejecting the prepaid systems. As such, it begs the question as to why an allegedly win-win solution for slum residents has turned out to be a failure. Below, we reveal that part of the reason for this outcome has to do with the fact that the differences among KP, donors, IPDs, slum residents, governments, politicians and regulators create conflicting rationalities, leaving service providers at a crossroads with regard to striking a balance between the different actors and stakeholders, and between planning ideals and practice. Table 4.1 below presents a differentiated view of how the rationalities enacted by the different actors and stakeholders in the deployment, appropriation and use of prepaid technologies conflict.

As demonstrated in table 4.1 above, the efforts of the WB attest to its goal of "[accelerating] progress towards universal access [by] improving the performance of utilities in Sub-Saharan Africa, [and] making electricity connections and consumption more affordable while minimising utilities' financial losses" as expressed by the former Vice President of the World Bank for Africa, Diop (2016). At the heart of this goal lies the rationality that universal access can only be reached by the expansion of formal energy services. Hence, the WB believes that for universal and affordable energy access and cost-efficient energy supply to be achieved, it is imperative to order, formalise and regularise service provision and use (ibid.; Interview 4, 2017). As the table further highlights, this rationality aligns with the rationalities of politicians, governments and regulatory authorities in their desire to push "illegal" distributors out of the "market," as well as to increase the influence of the state and allow for better control or regulation by the state (Dave et al., 2019). It speaks to their goal of scaling up and consolidating centralised networks and their urge to establish and enforce

Table 4.1 Conflicting rationalities

Actors	Rationalities	Conflicts
IPDs	Extract surplus and redistribute electricity (by selling illicit electricity) for profit without covering the overall costs of electricity generation, transmission and distribution. Earn a livelihood by charging fees for illicit power distribution and metering manipulations and circumventions that allow slum residents to access electricity without having to pay for it.	Conflict with KP's rationality of being the sole electricity provider in the slum. KP undercuts the revenue base of the IPDs with its new installations.
Slum residents	Access electricity without having to pay or pre-pay for electricity from KP; many residents contend that electricity should be free for poor users. Negotiable terms for access; manoeuvring by physically disturbing the wiring integrity of the electricity meter, circumventing connections and repurposing cables.	Conflict with KP's rationality for collecting and receiving its revenues. Strategies employed to realise these rationalities undercut KP's revenue base.
World Bank	Deliver on performance-based investment funding; secure access for all citizens to eliminate "energy poverty" in urban areas; and raise the household connection rates to formal utilities.	Conflict with the local modalities of access in slums provided by IPDs and slum residents.
Governments and politicians	Deliver on political campaign promises, i.e. realising one million new connections every year. Deploy large-scale solutions for urban problems. Align to donors' conditionalities.	Conflict with locally-based, small-scale modes of access in slums provided by IPDs, slum residents, and gatekeepers determined to maintain their own heterogeneous and informal electricity systems.
Kenya Power	Extend, universalise and formalise the electricity network in Nairobi's slums. Increase cost recovery and align to political goals. Achieve former status as a monopolist in local electricity distribution. Curb and replace illegal connections.	Conflict with local actors in the slums – i.e. IPDs, and the slum residents who are always seeking room for manoeuvre.

territorial monopolies of KP in slum areas which have hitherto been bypassed or underserved by state-driven agencies.

The rationalities of KP and the WB, and of politicians, governments and regulatory authorities conflict with the rationalities of the users and, even more, with those of IPDs. For example, some Kibera residents see the WB's rationality as problematic and would rather have different alternatives and "markets" for energy access in their communities (Interviews 10, 2016; 11, 2016). As we have shown, despite the WB's subsidies and lifeline tariffs directed towards removing barriers of affordability for residents, some residents were still unwilling to pay for the service and later to prepay. Other residents thought that the monthly connection fees, which rolled over to the next month if not paid, were indebting them so much so that they began to perceive the whole project as a means for KP to take money away from them (e.g. Interviews 6, 2016; 7, 2016; 8, 2016). Moreover, the wider view shared by many residents was that KP was more interested in serving the project's proponents (among them the WB) rather than its intended beneficiaries (ibid.). The residents argued that KP's interest was to achieve economic gain. This was at odds with their perception of KP in relation to its role as a state-driven provider of a basic service. These residents were beginning to believe that KP's main goal was explicitly to enhance revenue collection by "taking away from the poor", rather than to provide a community service for the urban poor (Interview 6, 2016). The dissatisfaction some of these residents expressed about KP's intervention makes apparent that when it comes to electricity provision, their way of thinking differs fundamentally from that of KP and the WB: for example, KP and WB have economic and political motives, whereas residents view electricity as a social service. As such, they see it as product that the state should provide for free rather than in subsidised form. Apart from the remaining affordability challenges of electricity supply (even if subsidised), the inflexible payment modalities of the connection fees and the costs/kWh leave little leeway for negotiation and cannot be adapted to the fluctuating incomes of many residents.

Some residents therefore feel justified to take matters into their own hands and to be civilly disobedient by misappropriating power lines and manipulating prepaid systems with help from the IPDs (e.g. Interviews 7, 2016; 8, 2016). Also, some residents, as we have further revealed, think that it is preferable to pay for power provided by the IPDs even if IPDs are exploitative and charge higher prices for their electricity than KP. The rationale behind these users' preference is that electricity obtained via the IPDs is negotiated and allows for different kinds of social and human interface between users and IPDs than is the case with the prepaid systems whose

interface is mostly automated (ibid.). Indeed, the IPDs have further exploited this situation by presenting themselves as actors no longer serving KP but the residents. Aware that many slum residents are unable (or unwilling) to pay for electricity from KP, and that other residents are keen to manipulate and circumvent their prepaid meters, IPDs have sought to recover their lost territories from KP (interviews 7, 2016; 11, 2016). As such, while residents espouse a survivalist rationality, the IPDs espouse a rationality driven by profit-seeking logic – and both rationalities are inherent to the urban informal economy.

Ultimately, these processes have affected the success of KP's, state authorities' and donors' efforts to implement slum electrification programmes. As a result, KP is now considering installing "smart meters" as another technological fix that could remotely detect meter tampering and fraud, as emphasised by one of KP's engineers: "With the new smart systems, if a meter is bypassed, it will indicate that it is being tampered with. So, the new meters now have the capacity to help us to deal with revenue protection to more easily identify people who are stealing power" (Interview 12, 2017). According to KP: "Once such an interference appears, the meters go into "tampering [sic] mode." The meter is able to detect that there is power in this installation that is not basically moving into this meter. The meter will then display a bypass and it can even lock itself" (Interview 13, 2017). The move to deploy new "smarter" systems for KP is seen as an innovative business model and one way of countering the puzzles presented by prepaid deployments, and can be seen as a response to the limitations constraining KP and the WB from expanding centralised networks, rooting out IPDs, and allowing remote monitoring and balancing of electricity supply and demand, and more reliable service for lower operational costs. It speaks to KP's further rationalisation and regularisation of electricity supply as a way of universalising service provision in slum areas.

4.7 Conclusion

In this paper, we have examined the deep and abiding conflicts of rationalities between electricity providers, politicians, donor agencies, residents and other IPDs in the deployment and appropriation of prepayment systems in electricity provision in the context of a slum area. Building upon urban studies scholarship on prepaid systems, we have provided a more nuanced and differentiated account of the various actors and stakeholders involved, and how they enact contradictory visions and rationalities within the context of a contested urban setting. Notably, what becomes apparent in this account is how the multiple and indeed countervailing interests and

necessities of the different actors and stakeholders involved reflect the unpredictability of slum residents' employment of different practices for appropriating new technologies. Thus, our account reveals an extremely complex interface between the utility company (and donors such as the WB) and urban residents (including intermediaries such as the IPDs). This account suggests a different course from Baptista's (2015a) findings in Maputo, where residents in informal settlements appreciated the deployment of prepaid meters as recognition and acknowledgement of their citizenship by the state and associated them with more decent, dignified and "modern" urban living in the city.

In contrast, we have argued that despite the mixed effectiveness outcomes of prepaid metering, the way KP and the WB have implemented their electrification programme has been praiseworthy. For example, they have adapted their strategies to local contexts by employing IPDs, engaging experts and intermediaries, integrating adaptive and frugal technologies, and incorporating significant subsidies and lifeline tariffs. These strategies, we argue, demonstrate considerable progress from KP in acknowledging the slum residents' energy needs and the necessity of using and building on residents' extant rationalities and informal practices to further enhance physical connectivity. However, as our findings demonstrate, electrification programmes in slum areas cannot be appraised by solely considering the side of physical connectivity to the network, but by also gaining a better understanding of the social access to and the actual use and appropriation of electricity systems. The manipulations and circumventions of the prepaid technologies, and the continued illicit practices of IPDs in tampering and bypassing systems reveal a complex story.

As outcomes of conflicting rationalities underpinning the deployment, appropriation and use of prepaid meters in Kibera, these processes have been used to explain KP's response as an attempt to improve its metering technologies by considering the deployment of smarter systems. However, as a policy-oriented recommendation, we argue that although smarter metering technologies might be effective for addressing some of the challenges of electricity networks that are subjected to tampering, successful and viable slum electrification requires greater engagement with the slum residents' rationalities and livelihoods. In the long term, it might be beneficial for KP to abandon or reduce the fixed monthly connection fees that users must pay before being able to upload credits for actual electricity use. Moreover, KP needs to take seriously the variegated realities and rationalities of slum residents, who are not a homogeneous group and should not be treated as such. As debates on conflicting rationalities (e.g. Harrison, 2006) have demonstrated, infrastructure plans and

development interventions need to build more strongly on existing practices and acknowledge the (co-)existence of informal arrangements and protocols. However, the answer to the question of whether existing IPDs should be further integrated into KP's provision activities depends on practical and ethical considerations. On the one hand, IPDs could act as intermediaries between KP and local residents, have in-depth knowledge of local conditions and practices and could either facilitate KP's access to slum residents or considerably undermine KP's activities. On the other hand, they put residents under considerable pressure to remain users of their services and, as economic beneficiaries, they have an interest in consolidating an unjust system of splintered formal access to electricity at the expense of residents, KP and the WB.

Summing up, this study contributes to debates around prepaid technologies by showing how prepaid meters become critical sites of engagement for conceptualising infrastructural politics, power and control. What we learn from a differentiated use of the notion of conflicting rationalities as an analytical frame is that it allows us to better explain the different logics and rationalities that drive different actors and stakeholders to act the way they do in the deployment, appropriation and use of prepaid systems. It allows us to better conceptualise and make sense of electrification processes in Southern urban communities in particular, beyond a simplistic state–citizen frame. It reminds us that urban residents cannot and should not be seen as constituting a homogeneous mass that will enact common concerns about central plans or development interventions but will tend to employ different practices in the appropriation of such plans and interventions. As such, the differentiated usage of the notion of conflicting rationalities offers a more nuanced understanding of infrastructure development in the global South. However, more research is needed to examine how such different rationalities that underpin large-scale infrastructure interventions in the global South may shift over time in response to the needs and interests.

Finally, our study demonstrates that the general presumption that planning should engage more closely with conflicting rationalities and contribute to their strategies for the variegated informal practices (e.g. de Satgé and Watson, 2018; Harrison, 2006) produces exceptionally complex tasks for planners, utility managers and regulators. In electricity systems, small interventions in one place may interfere with the larger functionality of the overall system. Planning a functional and consistent urban electricity system that combines networked, off-grid solutions and informal network extensions, that aligns public utilities with multiple co-providers and that tailors tariffs and socio-technical solutions to the spatially variegated user needs, financial capabilities and practices in a city is extremely challenging. In particular, the integration of

slum electrification projects into broader urban electricity systems raises multiple, yet unanswered, questions: technically, with regard to organising grid stability and balancing electricity loads; politically and economically, with regard to the overall (re-) allocation of costs for lifeline tariffs and incremental network extensions; and institutionally, with regard to the governance of urban electricity systems that are fundamentally technically, organizationally and spatially hybrid. The task for future research and planning practice is thus to explore ways to engage more productively with conflicting rationalities *within* and *across* different neighbourhoods and, at the same time, assure greater functionality and sustainability of electricity systems and other networked infrastructures.

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CHAPTER 5

SMART URBANISM? ICTS FOR WATER AND ELECTRICITY SUPPLY IN NAIROBI

Abstract

In recent years, the study of urban infrastructure has become central to examining African cities. This paper is a contribution to this scholarship. Of particular interest is the interface between telecommunications and urban water and electricity utility systems. I examine the degree to which ICT deployments for urban water and electricity supply shape and are shaped by the urban context of Nairobi, Kenya. I show how in recognition of the city's splintering and fragmentation, service providers have employed spatial targeting, strategically deploying "pro-poor" services. I argue that while framed along narratives of spatial justice, "pro-poor" deployments demonstrate market-led priorities for utility providers in their desire to maximize returns on investment, expand centralized networks, increase market share, and counter competition from private and heterogeneous providers. I also show that these deployments have had to contend with micro-political dynamics and implications. Ultimately, the objective for this paper is to offer an empirical perspective on the efficacy of the urban nexus and the contested nature of the politics and spatialities of smart or ICT-led urbanism especially in the context of an African city.

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5.1 Introduction

Recent years have seen the rise of a new era of nexus – or interface – between the telecommunications and urban water and electricity providers in African cities. This development is characterized by the gradual transformation and vast expansion of the existing scale and the information technology (IT) savvy of telecommunications providers in the East African region. In Kenya, for instance, telecommunications providers have grown beyond typically discrete and rudimentary entities whose networks allowed no more than an exclusive two-way basic voice and communication contact, towards mobile and wireless services and platforms mediated by information and communication technologies (ICTs) (Omwansa and Sullivan, 2012). Consequently, the telecommunications sector has become increasingly associated with a surge of new entrants and a diversity of small- and large-scale actors tapping into increasingly dynamic ICT markets (Ndemo and Weiss, 2016). Since mobile telecommunications operator Safaricom launched *M-Pesa* – a "mobile money" transfer and payments service – in the mid 2000s, mobile telephony has shifted from being simply a communication tool to a tool of finance (Omwansa and Sullivan, 2012). Today, not only has *M-Pesa* expanded its scale to become a ubiquitous transaction service in Kenya, but it has also inspired a vast number of spin-offs from communications companies both in and outside Kenya. By extension, the mobile money and payments landscape has gradually grown from a novelty into a necessity (Poggiali, 2017). It has become not just a bona fide platform, but an essential technology for urban utilities determined to overcome key challenges relating to revenue collection and payment for basic services such as water and electricity (Hellström and Tröften 2010; Heymans, et al., 2014; Krolikowski, 2014).

Moreover, the ensuing innovations and technologies from the nexus between the telecommunications and urban water and electricity providers have become rather more complex, bringing into alignment a network of actors from different domains such as finance and banking, technology innovation enterprises and development agencies. In addition to enabling mobile payments, a wide range of innovative solutions and smart applications that facilitate mobile-based billing, querying, crediting, vending, dispensing, metering and consumption tracking have spiralled across the country and beyond its borders. It is these unconventional interfaces that arouse my curiosity. My goal in this paper is therefore twofold: to examine how ICT deployments are redefining urban water and electricity supply, and to examine the socio-spatial and micro-political dynamics and implications of such deployments in the urban sphere.

For this purpose, I draw from the case of Nairobi. Sometimes referred to as Africa's "Silicon Valley" (or "Savannah"; Graham and Mann, 2013; Poggiali, 2016), Nairobi has been recognized by critics and scholars alike as a sphere of smart technologies, innovations and approaches (Omwansa and Sullivan, 2012; Poggiali, 2016; Graham and Mann, 2013). Moreover, as Kenya's capital, and political and economic hub, with a population of over three million, Nairobi represents some of the most salient transformations with regard to infrastructural development and investment (Mwaniki, 2017). Considerable resources and efforts have been invested in improving the city's planning and governance structures and service sectors within the context of new urban agendas (Myers, 2015). For instance, Nairobi's key planning and strategic frameworks – namely the Integrated Urban Development Master Plan (NIUPLAN) for 2014 to 2030 and the Nairobi Metro 2030: A Vision for a World Class Metropolis – are both anchored to the imperative of ICT as a critical pillar to realizing the service delivery goals (Government of Kenya 2007; Poggiali, 2016). Moreover, the ICT Transformation Roadmap 2015–20 drawn up by Nairobi City County (NCC) outlines the crucial importance of ICT solutions in improving urban service provision through achieving operational efficiency, effectiveness and transparency (Kiragu, 2017). In this regard, smart technologies have become increasingly prioritized at the city level with a wide range of actors viewing Nairobi as a city-scale testbed upon which to place or try out new socio-technological systems. This paper presents illustrative cases from urban water and electricity providers to demonstrate nexus relations across utility sectors in Nairobi.

This paper is based on extensive document analyses and empirical fieldwork in Nairobi, which comprised three periods of data collection between October 2014 and August 2016. The first dataset was derived from a review of grey literature, including policy, strategy and related documents pertaining to urban infrastructure and technological development in Kenya. Materials included pieces of editorials, brochures, regulatory plans, and policy and strategy documents, as well as government, regional and international reports, websites, statistical data, and figures on water, electricity and telecommunications. The second dataset consists of expert interviews conducted with staff and engineers in water, electricity and telecommunications industries, including Nairobi City Water and Sewerage Company (henceforth, NCWSC), Kenya Power and Lighting Company (KPLC; rebranded as Kenya Power in 2011, henceforth, KP) and Safaricom Limited, as well as technical experts and communications staff within supranational and intergovernmental organizations including the World Bank and UN-Habitat in Nairobi. Snow-ball sampling was employed to identify key informants, including executives, staff and technical experts

and engineers. Lastly, a user perspective was sought through non-structured interviews with residents of urban areas in which ICTs have been deployed for urban water and electricity supply. These interviews were conducted during our site visits in areas including Buru Buru, Kibera, Soweto-Kayole and Mathare.

For the remainder of this paper, I will examine dynamics in the rise of constellations of ICT-based systems for urban water and electricity supply, and the ways in which these constellations reflect a spatial configuration of "splintering urbanism" (Graham and Marvin, 2001) through the deployment of spatially targeted solutions. I provide evidence to show how NCWSC and KP have tailored their services as typically "pro-poor" with the principle aim of universalizing supply, maximizing returns on investment and expanding centralized networks in the most cost-efficient manner. I demonstrate the ways in which this articulation of spatial targeting has opened up such ICT-based infrastructures to a wide range of micro-political dynamics and contestations especially from residents who seek to recalibrate and re-appropriate them. I conclude that the spatialities and politics of the nexus of the telecommunications and urban water and electricity sectors in Nairobi provide a critical angle on smart or ICT-led urbanism, especially as seen through the standard postcolonial African city in transition. The following section provides the foundational framework upon which this analysis is based.

5.2 Framing the Debate

5.2.1 The rise of urban ICT studies: toward smart urbanism

There has been an increase in contemporary attempts to articulate the rise of emergent telecommunications networks and their relationship with the urban sphere. This exploration began with Graham and Marvin's (1996) *Telecommunications and the City*. Along with the work produced by Castells (1996), Graham and Marvin's book foregrounded a new and emergent discourse and stimulated a large number of specialized studies covering a wide range of sub-themes and perspectives (i.e. Graham and Marvin, 2002, Wheeler et al., 2000; Jackson et al., 2007). This work has seen telecommunications shift "from the margins to the centre of urban studies and policy" (Graham and Marvin, 2002: 75), and ultimately become established as a sub-discipline of urban studies labelled "urban ICT studies" (Graham 2004: 3).

This scholarship has been instrumental in stimulating an emergent intellectual paradigm: *critical* smart urbanism. Luque-Ayala and Marvin's (2015) pioneering work played a critical role by engaging with its "different logics and rationales" as a

discourse that was still in its infancy but steadfastly taking shape and developing as a distinct sub-discipline within urban studies (Luque-Ayala and Marvin, 2015: 2105). As a rising discourse at the interface of technological and urban networks, smart urbanism envisages ICT-driven societies. It characterizes a form of urbanism composed of sociotechnical assemblages of derivatives centred mostly on the centrality of integrated technologies and constellations ranging from smartphone applications and sensors, algorithms and heuristics, computerized networks and centralized control responses, to big-data analytics and data-driven governance, fixed and wireless telecommunications networks, digitally controlled utility services and innovations, etc. (Luque-Ayala and Marvin, 2015; Kitchin, 2014, 2018).

However, while scholarship around smart urbanism has widely examined technologically advanced cities and constellations of the global North, research on this theme is only beginning to emerge within the global South (Datta, 2015; Odendaal, 2011). This is surprising given the nature of technological advances that are emerging in the urban South, not least in African cities. These advances have ranged from high-tech and smartphone-based applications to low-tech and feature-phone-based platforms, becoming central for service sectors such as water and electricity (Hellström and Tröften 2010; Heymans, et al., 2014; Krolikowski, 2014). This paper therefore adds these new ICT-based infrastructure developments to the scope of literature on smart urbanism in the global South which thus far has mainly questioned utopian and Western-centric technocratic solutions and prototypes that are being transplanted to Southern megacities and satellite towns (Datta, 2015; Watson, 2014; Odendaal, 2011).

5.2.2 Emergent studies on ICT-based services in urban Africa

In examining ICTs for urban water and energy access in Nairobi, I acknowledge the vital importance of recent studies from the fields of anthropology, geography and adjacent ICT disciplines that portray the centrality of mobile technologies in shaping new sociotechnical constellations are also of vital importance. These studies for instance have moved beyond examining the imperative of their uptake in expanding access to water (i.e. Krolikowski, 2014; Foster et al., 2012) and electricity (i.e. Baptista, 2016; Baptista, 2015), towards exploring key possibilities (Heymans, et al. 2014), prospects (Gambe, 2015) and setbacks within urban contexts in Africa (Hellström and Tröften, 2010). These studies remain some of the preeminent resources of their kind in examining the efficacy and limits of mobile-based technologies for the supply of critical services in African cities.

Additionally, a rather more focused debate on prepayment technologies has also materialized. This debate is exemplified by Von Schnitzler (2008), who draws attention to manifestations of citizenship within the livelihoods of Soweto in Johannesburg, South Africa, and by Baptista (2015), who points to the ways in which everyday practices of prepayment facilities in Maputo, Mozambique, alter the everyday dynamics of the urban condition. In this debate, a considerable amount of attention is paid to the politics involved in the deployment of these technologies for urban livelihoods. Van Heusden (2009), for instance, highlights the rationalities of such technologies as representative of a "new logic of delivery" synonymous with neo-liberal regimes and inscriptions of unequal formations of access and power where the state is able to conveniently detach itself from its citizens. Beyond reflecting rather more considerate attention to the centrality of new technologies for the supply of urban services, Van Heuden's work and similar debates around prepayment technologies in African cities (i.e. Baptista 2015; Von Schnitzler 2008) have been instrumental in explicitly foregrounding human and social dimensions as well as spatial contestations and politics resulting from new technological deployments. These works reflect the recognition by scholars that the importance of ICTs should be foregrounded not only to address enduring utility challenges or drive infrastructural transformation, but also to overcome socio-spatial disparities of postcolonial geographies of service provisioning.

5.2.3 Framing connections between ICT-based infrastructure and the urban sphere

The above insights provide a foundation for examining the nexus between the domain of ICTs and that of water and electricity utilities, and more generally, between ICT-based services and the urban sphere. This paper adds to this scope of work by offering an empirical perspective on the contested nature of the politics and spatialities of smart or ICT-based urbanism within the context of the postcolonial African city.

In doing so, I acknowledge an emergent body of literature in the domain of Urban Studies that examines the interface of large technological systems and the urban sphere in African cities (Jaglin, 2008; Nilsson, 2016; Monstadt and Schramm, 2017; Lawhon et. al., 2018). This literature has scrutinized the "modern infrastructural ideal" (Graham and Marvin, 2001) which continues to underpin urban planning and service delivery in African cities. Employing a wide range of case studies notably from water and electricity systems, this literature has demonstrated how this ideal has given rise to uneven development characterized by spatially fragmentated and dislocated arrangements in cities or regions, a condition described as "splintering urbanism"

(Graham and Marvin, 2001). For instance, scholars have shown how cities become constituted by – and articulate – spatial characteristics in part through service differentiation (Coutard, 2008; Jaglin, 2008; Odendaal, 2011), and the context-specific politics that lead to a kind of hybrid, heterogeneous and "contextually creative translations" (Monstadt and Schramm, 2017: 6; Lawhon, et al., 2018; Jaglin, 2014).

The above insights offer a basis for conceptualizing connections between technology and urbanism. Moreover, they offer a great foundation for discerning spatialities and politics of ICT-based infrastructures within the urban sphere. Hence, I build upon them in examining new constellations of ICT-based systems for urban water and electricity supply, and the ways in which these constellations reflect the politics and spatialities of splintering urbanism. But first, the following section places these constellations into context by providing an overview of the urban landscape of water and electricity supply in the postcolonial city of Nairobi.

5.3 An Overview of Urban Water and Electricity Access in Nairobi

Nairobi was founded by the British in 1899 as a transport centre in the Kenya–Uganda railway corridor (K'akumu and Olima, 2007; Charton-Bigot and Rodriguez-Torres, 2006). Nairobi later became an administrative centre, and in 1907, the capital of British East Africa (Owuor and Mbatia, 2012; Guma, 2016). Upon Kenya's independence in 1963, Nairobi became the country's capital, subsequently transforming into one of the most sought-after cities in the region, partly as a locus of multilateral and corporate establishments such as UN-Habitat and IBM Services (Mwaniki, 2017; Poggiali, 2017).

Like many other agglomerations, however, Nairobi is still increasingly affected by a myriad of historically entrenched challenges. One such challenge has to do with its fragmentation, entrenched within legacies of European colonialism (Owuor and Mbatia, 2012). For example, just like planning modalities of Nairobi in the colonial era were aligned with the colonial masters' priorities, planning blueprints in the postcolonial present are aligned with the interests of the elites. Myers (2015), for instance, illustrates how urban plans in Nairobi continue to serve the purpose of reinforcing dominant patterns of hegemonic accumulation, segmentation and control. This too is reflected in the spatial organisation of urban water and electricity supplies. Water and energy access in Nairobi still remain closely aligned with a few elites' priorities to the detriment of ordinary residents in low-income spheres, despite being prioritized

by the 2010 Constitution (Government of Kenya, 2010) and identified as critical to the government's realization of its "2030 Vision" (Government of Kenya, 2007).

This challenge is partly illustrated by the structural and long-standing limitations of formal water and electricity providers. These include counterproductive performances, dysfunctional slothfulness and bureaucratic inefficiency, and wasteful paper-pushing practices (i.e. KPLC, 2006, May; NCWSC, 2011; Johnson, 2009). Notwithstanding, the utility companies have undergone structural transformation in pursuit of higher productivity and efficacy in the supply of water and electricity services to Nairobi and its environs. For instance, in August 2004, Nairobi City Council's Water and Sewerage Department (NCC-WSD) transformed into NCWSC, incorporated under the Companies Act (Cap. 486, December 2003). In the same vein, the years between 1998 and 2008 saw the functions of generation, rural electrification and transmission split or hived off from then KPLC.

At a more strategic level, however, both utility companies in Nairobi remain highly reflective of "the colonial technological paradigm" (Nilsson 2016): synonymous with vestiges of traditional neo-liberal supply-based economics that include inequitable, exclusive and ill-fitted supply modalities. As such, they remain increasingly affected by insufficient investment and support at national level, impeding their ability to provide services to urban residents (Nilsson, 2016). Many residents remain either completely un-serviced for prolonged periods, or face persistent power blackouts and water rationing. For instance, only about 50 per cent of urban residents in Nairobi receive piped water from NCWSC, and of these, only about 40 per cent have 24-hour access to water (NCWSC, 2017). Likewise, although KP reports that it is now supplying over 80 per cent of Nairobi's households with electricity, this figure is often politicized and refers only to physical grid connections rather than actual consumption which still remains highly minimal (Kuo, 2017). These challenges are further compounded by processes of vandalizing, bypassing or tampering with water pipes and electricity transformers.

In the midst of these complexities, in situ incremental and self-organized schemes for energy and water supply have emerged (Hailu, et al. 2011), mirroring do-it-yourself (or DIY) urbanism and "people as infrastructure" (Simone 2004). For energy, auxiliary and heterogeneous sources include firewood and charcoal for cooking, and candles and torches (including mobile phone inbuilt-torches) for lighting; while for water, schemes include overhead reservoirs – such as storage tanks – and underground systems, such as drilled boreholes. Moreover, there are also informal water and electricity

distributors who bypass and "tap" from centralized networks, in turn selling to households and individuals through a kind of "spaghetti" networks.

Notwithstanding, different constellations of actors as evidenced by a wide range of strategic partnerships and technical assistance have emerged over the years mirroring "corporate-led urban development" (McFarlane and Söderström 2017: 312). Institutions such as the Japanese International Cooperation Agency (JICA), UN-Habitat and the World Bank, have prioritized sectoral and organizational efficiency, transmission and distribution of networks in their targeted financing and investment programmes (Power Africa, July 2015); as well as deployment of technologies that target low-income areas for urban water and electricity supply. The following section examines the rise of such ICT-based innovations as the technocratic solutions of water and electricity providers in response to facets of Nairobi's urban problems, and how these shape and are shaped by the urban context.

5.4 Deploying ICTs for Urban Water and Electricity Supply

Since its formal liberalization in 1999, the telecommunications sector has moved on from electric-grid-like networks and fixed-phone connections, to mobile phones and mobile-based innovations. Its wireless networks embrace targeted technological innovations diverging into non-traditional sectors such as water and electricity. The earliest attempts in Nairobi to incorporate ICT innovations in the domain of water and electricity utilities date back to the mid 1990s. KP first introduced ICTs in 1995 (KPLC, May 2006), and they became an integral part of NCWSC's processes in 2002 during its restructuring and redefinition. In both cases, these processes primarily centred on the implementation of institutional frameworks, visions and mission statements that would guide the companies' efforts in expanding the integration of ICTs within their departments for business processes and interfacing with users. In some cases, the utility companies created new ICT units and subdivisions. For instance, NCWSC established an ICT directorate tasked with ensuring the company's integration of mobile solutions and technologies to automate and digitalize industry and supply processes (Thuo, 2013). These included low-cost applications such as the Internet, email and short message services (SMS) facilities for issuing invoices and managing water bill payments and user records in NCWSC, and managing customer services, handling complaints, recording and archiving user records, and handling querying systems in KP (KPLC, May 2006; Thuo, 2013). Since then, the scope of urban water and electricity innovation has grown beyond these humble beginnings to become increasingly shaped by a multifaceted range of ICTs as demonstrated in the following subsection.

5.4.1 The beginnings of mobile payments

The late 2000s saw water and energy providers in Nairobi begin to look beyond basic tools that enabled the computerization of records, towards the automation of billing, depositing and connection/reconnection processes, and mobile payments (Interview 1, 2016). These processes were especially accelerated by the rise of the mobile phone and the deployment of new technologies spearheaded by mobile telecommunications networks. For instance, KP implemented a mobile-based transaction system (MBTS) strategy, launching the electronic bill querying facility ("E-Bill") in August 2005, the E-Bill SMS service in June 2006, the "SMS alert" in December 2008, and the EasyPay e-payment module in 2007, with the aim of computerizing and mobilizing billing and revenue collection. These facilities became critical in offering consumers real-time electronic ways to check and query their electricity account balance, bill due date, new connection fees, or payment through online, SMS or email platforms.

It was, however, the introduction of *M-Pesa* in March 2007 that offered a rather more viable digital platform for bill payments. As a mobile payment platform, the strength of *M-Pesa* lays in the fact that the system was not necessarily app-based, nor did it require a smartphone or high-speed Internet connection, but simply worked via SMS text threads and/or unstructured supplementary service data (USSD) menus on basic feature-phones or handsets. Within a decade, *M-Pesa*'s functionality expanded, evolving well beyond primary person-to-person (P2P) payments (i.e. between friends without bank accounts), and as such providing a technological infrastructure for mobile and real-time payments. For instance, the PayBill interface launched in April 2009 quickly became the most dominant payment facility for NCWSC and KP. *M-Pesa* consequently scaled further, increasingly becoming a much-needed platform for facilitating payments for water and electricity supply and access in the city.

M-Pesa and PayBill facilities marked the emergence of a standardized payment service integrated in the supply of critical services, including mobile banking, acquisition payments, and settling water and electricity bills (Interview 2, 2016). They also marked the beginning of direct partnerships between the telecommunications and urban water and electricity providers, and essentially allowed end users to make electricity and water bill payments through Safaricom's mobile money service *(Lipa Na) M-Pesa*. Later, other mobile telecommunications operators such as Airtel and Orange also joined the market with their products, including Airtel Money and Orange Money, providing more mobile-based bill payment options for critical utilities. ICT innovations thus served to address KP's and NCWSC's challenge to reduce access to non-revenue water and electricity networks in the city. At the same time, they offered

a great opportunity for telecommunications providers to diversify their service supply beyond traditional realms, and thereby increase their revenue streams and markets, as shown in the table below.

Table 5.1 Integrating ICTs for urban water and electricity supply: identified drivers

CATEGORY	TELECOMS	KENYA POWER, NAIROBI CITY WATER	M-KOPA, UMANDE TRUST
REVENUES	Revenue generation More revenue streams Low-cost financial services	Revenue loss reduction Additional revenue streams Maximize returns on investment Guarantee cost recovery	Recuperate returns on investment Recover costs
EFFICIENCY	Economic viability	Detect tampering; theft control Real-time information and control Enhance transparency Reduce operational costs	Value-added services Foster resource utilization Enable real-time flows and pricing
RESPONSIVENESS	Meet users' speed and need Diversifying services	Ease payments Achieve greater customer value Achieve customer responsiveness	Expand access to social goods Create remote customer connection Enable better consumer experience Enable secure and equitable supply
MARKET SHARE	Gain market advantage Counter competition Expand market share	Expand access and networks Increase sales Expand market share	Penetrate new markets

The result of Author's compilation from field research, 2018

As the above table shows, the motivations for water, electricity and telecommunications providers to deploy ICT-based payments were in fact not significantly different. For both NCWSC and KP, the key drivers included the realization of efficiency and responsiveness, an increase in revenue collection and cost recovery, and a reduction of losses. This shows how these processes have tended to give rise to corporate and

centralized control, sometimes at the expense of the needs of recipients. Moreover, these utility providers also sought to further marketize traditional public services and increase their market share. It was reported, for instance, that ICTs reduced long queues in "paying halls", thereby also reducing operational costs (Interview 3, 2015; Interview 4, 2016). KP and NCWSC traditionally engaged in over-the-counter services: bills would be posted to customers, who would then pay them in cash at the companies' halls and cash offices, or sometimes at designated payment centres, such as banks and post offices in the city. These facilities were often hand-operated, not-automated, or in other words supported by a manual system. Their processes required designated floors and spaces that acted as paying halls. At the end of the month, the queues would be long and the paying halls would be congested. As for the Postal Corporation Kenya (PCK) offices, which offered similar bill payment services to water and electricity consumers, the manual system was generally exhausting for management and staff alike. Processes such as monitoring consumer readings from time to time through agents, identifying consumers by their plot-registered meters, and ensuring that consumers paid for what they had actually consumed were, to say the least, costly.

Transformations within energy and water companies following the incorporation of mobile-based billing and payment systems thus played a major role in complementing manual and non-electronic means. They reduced the need for staff thereby enabling the companies to cut back on costs, eliminate lengthy end-of-month billing processes and collect more revenues. They also helped decongest company paying halls and facilitate the operation of alternative collection points mediated by mobile tools and agents. Specialized payment services offered by small convenience shops and outlets, banks and retail outlets (e.g. Uchumi and Nakumatt) quickly became a common feature of Nairobi. These developments facilitated the creation of platforms enabled by the integration of optimized communications systems. One of these is Jambo Pay, a mobile and online query and payment facility that aggregates multiple payment channels, including browsers, USSD, and mobile and digital apps and platforms such as M-Pesa, Airtel Money, Orange Money, VISA and Mastercard debit and credit cards.

My observations in Nairobi revealed that the deployment of these integrated technologies has increased not only access and payment options, but also the engagement of energy and water providers. Through the deployment of mobile technologies, service providers sought to improve their efficiency and responsiveness, because they were becoming increasingly portrayed by users, especially in poor neighbourhoods, as

"disengaged". The integrated developments had thus served to bridge the gap between users and providers, bringing the two into more contact through mediation by ICTs. Of course, it is also the case that service providers still to some extent remain disconnected from Nairobi's everyday realities and predominantly focus on premium services for the urban elites (Nilsson, 2016: 481). In their deployment of mobile technologies, they still prioritize corporate and technocratic goals – such as increasing sales and revenue collection, expanding the market share, maximizing returns on investment, and guaranteeing cost recovery – more than contextual and socio-political dimensions. In the following sub-section, I show how utility providers, in their attempt to connect more to contextual and socio-political realities, began to emphasize a kind of bottom-driven and socially-organized pro-poor initiative, largely shaped by the spatial diversity of Nairobi.

5.4.2 Towards a new regime of "fractured" constellations

Since the late 2000s, the ICT innovation sphere in Nairobi has expanded beyond mere innovative billing and payment initiatives towards a new constellation of "pro-poor" initiatives reflecting a "fracturing of geographies" (Wheller 2000). The table below presents the deployment of differentiated arrangements of ICTs as a functional means for targeting spatial spheres, implying an explicitly growing connection of ICT-based modalities to the actual and ordinary realities of the city as a fragmented sphere.

Kenya Power's "targeted" prepayment installations

In its bid to ensure greater access to and the expansion of its centralized networks, KP has deployed "pro-poor" services that reflect Nairobi's splintered and differentiated urban landscapes. An example of such a service is the prepayment meters launched in 2009 as pilot in Kibera, a low-income neighbourhood in Nairobi. These meters, which were initially targeted at Nairobi's low-income neighbourhoods, are often referred to as "token meters", referring to the single-use 20-digit alphanumeric "token" or pin code that has to be entered on the meter's keypad as a way of crediting power for the user. A pin code can be bought as a scratch-card or a voucher at resale points and vending units on estates, in shopping centres and from strategically located kiosks, similar to airtime credit scratch-cards that mobile telecommunications networks use. They can also be bought through the mobile service, PayBill. This process is enabled by the prepaid meter system's architecture, which provides digital display technology allowing users to manage their meters, credit and consumption. By February 2017, KP had received support from the World Bank, Kenya Informal Settlement Improvement Project (KISIP), the government of Kenya and communication providers, such as Safaricom.

Table 5.2 Key characteristics of ICT-based constellations for urban water and electricity supply in Nairobi

OPERATION	ICT SOLUTION	SCOPE	LAUNCH	MODALITY	TYPOLOGY	KEY ACTORS	FOCUS	PARTICULARITIES
TELECOMS	Lipa Na M-Pesa	Nairobi	June 2013	Mobile payment	Water and electricity billing system	Kenya Power, NCWSC	Safaricom users	A mobile interface that facilitates water and electricity bill payments.
KENYA POWER	Electricity prepayment systems	Nairobi	May 2009	Digital meters	Self-meter reading; remote-based querying, revenue collection	World Bank, UN-Habitat KISIP	Household-based connections	A prepaid electricity meter systems project enabled by digital technologies. Rechargeable with 20-digit pin-code scratch-card, or through SMS facilities.
	Okoa Stima	Nairobi	April 2015	Mobile micro-crediting	Mobile-based soft loan facility for prepaid electricity	Safaricom, Kenya Power	Safaricom and Kenya Power users	A mobile phone-based predetermined emergency loan facility for purchase of electricity tokens for the Kenya Power prepaid electricity meter users.
NAIROBI CITY WATER	AQtap Water Dispensers	Mathare	June 2015	ATM-style dispensers	Automated services, smart card-based dispensing technology	Grundfos Lifelink UN-Habitat	Social and community-based	Pilot: automated water dispensers, installed in NCWSC's water supply network.
	Majivoice	Nairobi	April 2014	Mobile services	Querying	WASREB	NCWSC consumers	A mobile and online based querying and feedback system.

	Jisomee Mita	Soweto-Kayole	May 2014	Digital meters	Self-meter reading, SMS reporting, consumption tracking	WSP - World Bank AWSB	Social and community-based	Pilot project: a digital system that allows users to read and directly send their own meter readings and pay bills through the mobile phone.
	Token Water Initiative	Kahawa Soweto	June 2009	Token-based dispensers	Mobile connectivity; dispensing technology	WSUP	Social and community-based	Pilot: a prepaid water meter system enabled by mobiles and digital technologies.
PRIVATE OPERATIONS	M-Kopa Solar	Nairobi	October 2012	Rent-to-own solar products	MNO distribution network and mobile payment	M-Kopa Solar, Safaricom	Last-mile connections	A rent-to-own and pay-as-you-go mobile-based initiative for affordable solar energy systems and products.
	M-Maji	Kibera	March 2012	Mobile services	Mobile access point, querying and payment	Umande Trust, Wezatele	Kibera residents	As pilot: a mobile-based water access and supply information system that was launched in Kibera.

The result of Author's compilation from field research and review of secondary sources, 2018

In 2015, a mobile-based service emerged through the interface between the energy and telecommunications utilities in Kenya. Constant electricity disruptions and blackouts resulting from unpreparedness and a lack of funds inspired KP and Safaricom to launch a mobile soft-loan facility called "Okoa Stima". The Okoa Stima service thus became a solution to the constant and sometimes inevitable electricity disruptions and blackouts, by allowing KP consumers and Safaricom subscribers to acquire predetermined credit to settle power bills ranging from 100 Kenyan shillings (KES) (1 USD) to 2,000 KES (20 USD). Under this arrangement, the poor are charged an extra cost (i.e. facilitation fee) of 10%, payable within 7 days. This concept is a similar to Safaricom's "Okoa Jahazi" facility, which allows users to load airtime on credit. Safaricom's Julia Obura, who is credited as being the inventor of the concept, said that: "[Safaricom telecommunications] kept receiving complaints from customers that they were not getting their tokens. There was a problem [with the KP utility digital system] and they kept calling Safaricom instead of Kenya Power" (Sum, 2015: 8). Indeed, this scenario coincides with the accounts I heard during my fieldwork interviews, which indicate that ever since the KP started rolling out prepaid power meters in 2009, "there have been times when [KP's digital] systems have run down. Or when due to problems of poor planning and financial difficulties on the side of the consumers, the electricity units or tokens expired at awkward times where users are not in position to purchase tokens, that they are left in darkness" (Interview 5, 2016; Interview 6, 2017). These limits necessitated the novel interaction between Safaricom and KP, materializing in the form of Okoa Stima.

However, there is a conceptual gap between KP's belief in the necessity and functioning of its prepaid meters, and the way that their users within such spatial spheres as Kibera, Mathare and Soweto-Kayole regard them. KP considered these initiatives essential for realizing customer enrolment mostly among residents of low-income urban areas. While the initiatives were perceived as guaranteeing effectiveness and enhancing the responsiveness, efficiency and accuracy of electricity meter reading and billing, urban residents had mixed feelings about them. In Kibera and Soweto-Kayole, for instance, some users believed that the prepayment meters charged slightly more for the units they used. There was also a widely held perception that the meters were not as accurate as KP officials claimed them to be. Some said that they had been paying much less to cartels before the arrival of the prepayment meters. Yet others expressed discontent at how the service provider was essentially a disengaged outsider intent to "take" from them. In other words, they did not feel that the utility providers had installed prepayment meters to benefit them, the users, reflecting the long-standing debate about technocratic approaches and their competing notions of socio-spatial justice in their deployment.

Nairobi City Water's spatially differentiated modalities

KP's experiences are not that different from those of NCWSC. For instance, both utility providers were driven by similar interests and motivations, as shown in table 5.1. Also, as table 5.2 shows, both providers framed their new and emergent ICT-based modalities as "pro-poor initiatives" (i.e. Interview 9, 2016). As "pro-poor", these modalities targeted specific urban niches or clusters of Nairobi's fragmented city; for example, AQtap Water Dispensers targeted Mathare, the Token Water Initiative targeted Kahawa-Soweto and Jisomee Mita targeted Soweto-Kayole. Moreover, all three initiatives were grounded in the utility company's ambitious social connection policy, which aimed to ensure enhanced access through the installation of communal water pipes specifically intended for low-income neighbourhoods (Interview 4, 2016; Interview 7, 2016). This constellation represents a shift for NCWSC from individual connections towards social, community and household-based connections (World Bank–WSP, 2015; NCWSC, 2016; NCWSC, 2011). But, most importantly, it also represents a shift from a homogeneous modality of service provisioning in Nairobi towards increasingly diverse, splintered and slightly differentiated modalities targeting specific neighbourhoods.

As "pro-poor", ICT-based deployments in NCWSC were also highly funds-driven and supported by such institutions as the World Bank Water and Sanitation Program (WSP-WB), UN-Habitat, and Water and Sanitation for the Urban Poor (WSUP). Beyond their strong ties to multinationals and private NGOs, however, these modalities had also gradually become fashioned by the communities in which they had been deployed. There were, for instance, cases in which some of them had become increasingly shaped by urban configurations of improvisation and heterogeneity. For example, some users actively engaged in protecting and maintaining the everyday operation of the new deployments. However, there were also cases in which such deployments had become increasingly contested and politicized. The "token water initiative" listed in table 5.2 is a case in point: while over 600 household connections had been installed across the city's low-income neighbourhoods, a key informant from NCWSC said that in Kahawa-Soweto, where the system had been piloted, residents had belligerently demanded their removal (Interview 7, 2016). In other words, the residents in the neighbourhood insisted that they wanted the pre-payment meters to be replaced by post-payment meters. As a result, some of the meters were vandalized by residents or bypassed, often by illicit operators in the neighbourhood who were referred to as "cartels" or "gangs" and were sometimes helped by corrupt utility personnel who connived against the utility provider. Many more of such meters were eventually abandoned, mishandled or wrecked, preventing the project from ever scaling (Interview 8, 2016).

These processes reflect the manner in which some neighbourhoods such as Kahawa-Soweto posed enormous challenges for service providers determined to deploy ICT-based initiatives. They reflect the nature of the dynamics involved in the deployment of ICT-based infrastructures. In other words, the kinds of politics or micro-politics, disengagement and contestations that technocratic solutions become subjected to within such low-income contexts present unique power dynamics. They show the ways in which ICT-based deployments remain susceptible to the endemic challenges of urban politics. Organized communities that seek to enact or re-enact their social power as a form of control and governance, and the so-called cartels and gang-like units that are intent on destroying the newly installed networks as a way of consolidating their unfettered markets, pose great challenges for utility service providers in the city. My visits to the low-income settlements of Kibera, Mathare and Soweto-Kayole revealed the extent to which many urban residents still had to deal with extortion from gangs and cartels, as well as the frequent shortages, breakdowns and rationing. As such, the automation and digitalization of billing, payment, crediting, querying and metering systems for urban water supply have served to further enhance extant regimes urban splintering and fragmentation.

Private sector-led hybrid consortiums

ICTs in Nairobi have also stimulated competition from small-scale, private sector-led supply and retail consortiums. Two examples, also given in table 5.2, provide a sharp contrast in relation to their hybrid nature. On the one hand, *M-Maji* – a mobile-based initiative for water access in Kibera – while highly lauded by residents as vital for providing real-time information about clean water access points, failed due to its inability to develop partnerships with telecommunication providers such as Safaricom or Airtel (Interview 10, 2016). On the other hand, *M-Kopa Solar* – a solar energy company based in Nairobi – due to its ability to create an institutional hybrid with Safaricom has succeeded in entering spaces formerly unserved or underserved by electricity but connected to mobile telecommunications networks. According to *M-Kopa* (April 2014; October 2017), over 500,000 connections had been made in Kenya, accounting for about 10% of all off-grid homes in the country. Despite the success, however, *M-Kopa* still mostly targets swathes of rural areas, aiming to supply communities with "green energy in a smart way" (Interview, 11 2016). Thus, *M-Kopa*, *M-Maji* and similar initiatives in Nairobi reflect the ways in which rather than guaranteeing stabilization, expansion and monopoly for large-scale centralized utility providers, ICTs have also allowed small-scale private sector-led consortiums to disrupt the dominance of public utility providers, which are determined to expand their own networks or push out – and in some cases, counter competition from – potential competitors.

5.5 Conclusion

The new arrangements created by the interface between the telecommunications and urban water and electricity providers in Nairobi illustrate the transformation of service provisioning from humble technological beginnings into dynamic and complex modalities. But most importantly, they illustrate the ways in which ICTs have brought into alignment a network of other actors such as finance and banking institutions, small- and medium-scale technology companies, and supranational entities in the United Nations system, including the World Bank Group and the UN-Habitat. Ultimately, the nature of these arrangements makes for smart or ICT-driven urbanism (Luque-Ayala and Marvin, 2015) as seen in the standard African postcolonial city in transition (McFarlane and Söderström, 2017; Watson, 2014; Poggiali, 2017). As such, they have three critical implications for our understanding of the politics and spatialities of the urban nexus.

The first concerns the spatialities of ICT-based deployments by utility providers (listed in table 5.2) reflecting the splintering and fracturing of urban provisioning. This is demonstrated by the employment of spatial targeting within the frame of ICT-based infrastructure provisioning, wherein utility providers have deployed innovative initiatives mostly for low-income areas of the city. It is also demonstrated by the exposure of utility providers to rather more distinctive social and community-based approaches. These approaches have come to primarily rely on collective connections, and on ownership and maintenance practices supported by mobile technologies. Rather than treating Nairobi as a homogeneous space to be supplied with more or less homogeneous and standard services, utility service providers have started to acknowledge the city's socio-spatial inequalities, deploying "splintered" and "differentiated" services. This has come to represent a symbolic shift from a kind of homogeneous and standardized modalities and mechanisms which served the urban elites in premium enclaves to the detriment of poor neighbourhoods which were often left to fend for themselves in the absence of formal networks.

The second implication is that as a highly technocratic approach to service provisioning, the deployment of ICT for urban water and energy supply has largely functioned within a framework that "prioritizes market-led solutions to urban issues" (Kitchen, 2018: 20). As this paper has shown, utility providers in their motives exploit the process of universalization through diversification. For example, they are essentially driven by the desire to expand their market share, recover costs, generate revenue, universalize supply, realize monopolies, push heterogeneous service constellations such as

"informal" service providers and "cartels" out of the market, and by design, universalize urban space as well as achieve a kind of spatial ordering with regards to service provisioning. Within this frame, ICT-based options for processes of billing, querying, crediting, vending, dispensing and metering have afforded a cost-effective means for utility providers to realize their goals by deploying segmented, multiple, demand-driven and need-based solutions targeted at specific (often low-income) communities. In this regard, ICT-based options have allowed utility providers to apply spatial targeting as a niche-based strategy directed towards specific user groups and areas. And yet within these spheres, this paper has also shown the ways in which these solutions have become subject to micro-politics, contestation and sometimes disengagement on the part of urban residents intent on recalibrating and re-appropriating them to fit their everyday lives.

The third and final implication relates to the explicit inclination of constellations of ICT-based infrastructures towards a further politicization of access along narratives of spatial justice in the form of "pro-poor" approaches and innovations. By design, ICT-based deployments have come to reflect two longstanding aspects. The first concerns the city's fragmentation, which is characterized by social exclusion and disparities in power and socioeconomic situation. The second, however, has to do with the aspirational desire of the different actors to achieve urban sustainability through digitalization and thus bring services closer to the "urban poor", or in other words, to extend services further into low-income spheres. In the process, this has led to the aggregation of ICT-based constellations, as shown in table 5.2, bolstering an ICT-driven urbanism where "city services, infrastructures and populations" are increasingly being "managed in real-time using ICTs" (Kitchin 2018: 20). These articulations should prompt us to think further about the politics and spatialities of the urban nexus of ICTs and sociotechnical systems within transitioning contexts.

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CHAPTER 6

CONCLUSIONS AND DISCUSSION

Although urban water and energy services in African cities are characterised by the presence and in many cases a dominance of centrally planned networks, service provision and access are highly fragmented (Laros and Jones, 2014; Pieterse and Parnell, 2014). In Africa, urban water and energy provision and access by no means reflect universal and standardised coverage by a single, homogeneous network – or what Graham and Marvin (2001) labelled the "modern infrastructural ideal". Instead, they are generally complemented by hybrid and heterogeneous provision systems that exist complementary to, or outside of, the formal structures of infrastructure provision in cities (Simone, 2004; Simone and Pieterse, 2017). Heterogeneous infrastructure constellations are to be seen as a general characteristic of cities in Africa (Jaglin, 2014; Lawhon et al., 2018; Smiley, 2020). They reveal the general limits of large conventional infrastructure networks. However, utility service providers have recently recognised the role of digital technologies to enhance their service delivery to urban populations in African cities. Digital technologies have been identified as a tool for dealing with Africa's significant urban challenges of the 21st century (Nel et al., 2014; Njoh, 2018; Ndaw, 2015; Nique and Opala, 2014). In the last decade, both researchers and practitioners have held far-reaching expectations concerning the use of digital technologies to improve large conventional infrastructure networks (United Nations, 2015), enhance the quality of life (Sachs et al., 2015) and realise smarter and more sustainable cities (United Nations, 2015).

This dissertation is based on the premise that despite the emerging interest in the uptake of mobile-based technologies in the global South, there is still little awareness of the complex and dynamic interface of digitalization, urbanization and infrastructure development. Studies have yet to examine the critical role of digital technologies in enhancing the capability of large-scale infrastructure systems in the age of smart urbanism. Moreover, the limitations of research on this issue are more significant in the context of African cities than in North American, European and Asian cities, where smart city technologies and initiatives have increasingly been studied. However, most importantly, because much research on the digital age has examined universal visions and plans of smart urbanism – as opposed to contemporary attempts at

implementation through infrastructure development and the actual implications of these attempts in urban localities – this dissertation makes a valuable contribution to emergent engagements with urban infrastructures and Southern urbanism.

The main goal of this dissertation was to empirically explore and understand the multiple ways in which cities and infrastructures are constructed and reconstructed through ICT innovation and appropriation, and to explain existing infrastructure constellations through countervailing processes and rationalities in the context of splintered urbanism. Drawing on the case of Kenya's capital, Nairobi, the dissertation examined the relationship between urban plans and digital infrastructure development, place-based contexts that shape digital infrastructural deployments and appropriations, and the extent to which these processes facilitate utility companies' rationale for expanding centralised networks to new territories. The main goal and research objectives were translated into the following research questions:

1. What is the relationship between urban plans and the ICT-driven development of technical infrastructures? And to what extent is the implementation of plans and policies contingent upon politicization, contestation and context-specific realities?

2. What are the place-based contexts shaping the deployment and appropriation of ICT-driven water and energy projects, and which technopolitical relations does the project implementation reveal?

3. How and with what impact does the proliferation of ICTs in urban water and energy utilities facilitate utility providers' ambitions to universalise and homogenise service provision in the splintered city?

4. What lessons can be drawn from ICT-driven urban and infrastructure development projects in processes of city making, and how could they more effectively contribute to the sustainability of cities and infrastructures?

In answering these questions, the dissertation seeks to provide evidence of new configurations of infrastructure development, and to expand our understanding of digitalization processes and the resulting infrastructure dynamics within the context of an African city. Accordingly, section 6.3 presents some theoretical reflections in this regard and section 6.4 provides research and policy recommendations. The following section summarises the main empirical findings.

6.1 Main Findings

This section presents a concluding synthesis of the key findings from the analyses contained in the separate chapters. This synthesis is structured around my main research questions.

RQ 1: What is the relationship between urban plans and the ICT-driven development of technical infrastructures? And to what extent is the implementation of plans and policies contingent upon politicization, contestation and context-specific realities?

The wave of smart city making and planning over the last decade in Nairobi echoes a particular set of rationalities premised upon the ubiquitous role and logics of ICTs in shaping cities globally. Chapter 2 examines the advent of ICT-driven urban plans – including the Nairobi Metro 2030 Strategy, Nairobi Integrated Urban Development Master Plan 2014-2030, and ICT Transformation Roadmap – both of which demonstrate the recent centrality of ICTs in processes directed towards envisioning a world-class African metropolis. These contemporary plans integrate infrastructure-led planning interventions, and mainstream smart city ideas in the continuous making of Nairobi city. The chapter demonstrates that these plans have transpired in the form of large-scale, top-down projects. They are prominently rooted in the country's capital and government offices, driven by international developers, spread by global consultants, financed by foreign investors, and shaped by preconceived hegemonic ideals of a modern, world-class city in the age of smart urbanism. As the chapter demonstrates, these plans reflect a technocratic approach and belief in technological determinism. For example, they have been driven by the desire to realise a smart, modern and world-class city (MNMD, 2007, 2008; NCC, 2014, 2018). In addition, they are based on guidelines and strategies that conform to universal models of city making or master planning. As such, these plans reflect ambitions that subscribe to a hegemonic model and amplify a utopian vision for city making. They demonstrate how processes of urban development in Nairobi are shaped by internationally circulating ideals and models of smart city making.

However, the chapter reveals a disconnect between the ambitions expressed by city plans for ICT-driven infrastructure development and its actual implementation in Nairobi. The contemporary plans' flagship projects and initiatives ignore what is actually going on in Nairobi. While these projects visualise high-tech and complex smart technologies, satellite cities and tech-hubs, the most predominant technologies

in the city include mobile money transfer services, mobile payments systems, digital metering technologies, feature-phone-based apps, basic mobile payment tools and applications, and nascent local tech-hubs. These technologies and infrastructures rather than being intricate and sophisticated, are rather low-cost and easy-to-use ICTs primarily tailored to the urban poor. Moreover, many of them are pilot-based and small-scale. The nature of these technological developments highlights that urban plans, strongly inclined toward technocratic approaches and hegemonic appeals of smart city making, hardly capitalise on the city's endogenous innovation capabilities such as dynamic start-ups and local technologies. Thus, the chapter reflects a divergence between ICT-driven development of technical infrastructures and urban plans in Nairobi. Rather than being directed exclusively by the city's articulated plans, these initiatives are often locally driven and fashioned on the ground. Here, ICT development is largely counterbalanced by informal and small-scale entrepreneurial practices, and operationalised through incremental and fragmentary facilities such as ephemeral stalls and kiosks found in the most strategic locations of Nairobi.

Concerning the contingency of plans and policies on politics, contestation and context-specific realities, this chapter shows that political actors as well as urban planning and policy advocates have hardly publicly politicised or contested digital infrastructure projects. They have instead promoted them through their public statements, or if not, subtly subverted or simply ignored them. Nairobi city governors and global organizations such as UN-Habitat, World Bank and the Japan International Cooperation Agency have played an active role in driving these projects and initiatives as principal actors, while telecommunication companies and the finance sector have increasingly invested in their urge to digitalise (NCC, 2014, 2018). As revealed through their statements, Nairobi's political representatives have expressed general fulfilment with the integration of digital technologies in processes of service provision. The chapter demonstrates that in a practical sense, city plans have scarcely led to compliance and effective implementation by local stakeholders. Instead, it is evident that plans have become significantly contingent on the actualities of the local context and that due to their social embeddedness, relationality and urban co-construction; they hardly met their original goals and objectives.

RQ 2: What are the place-based contexts shaping the deployment and appropriation of ICT-driven water and energy projects, and which technopolitical relations does the project implementation reveal?

The Jisomee Mita project in Soweto-Kayole represents a hybrid infrastructure constellation that combines a new-piped water network with digital technologies, enabling self-meter reading and mobile-phone-based billing, payment and querying systems. Presented in chapter 3, Jisomee Mita is an example of a technology project shaped by local realities in Soweto-Kayole. The local conditions of Soweto-Kayole have recalibrated the project via subversive strategies of the local population. For example, while deployed as a technology designed to enable remote processes of meter-reading (hence the name Jisomee Mita – 'Read your Meter') through its remote-based payment application, it later became necessary for the utility to hire personnel for its regional office to intervene. The personnel were mandated to personally administer the Jisomee Mita project as it had become apparent that the residents were not to be trusted to take correct meter readings and pay their water bills promptly, as has been envisioned at the deployment of the project. Thus, they enabled a physical interface with consumers, in contrast to the remote-based design of the project. This case therefore reveals how in a symbolic and fundamental way, Jisomee Mita shifted from 'Read your Meter' to 'show me your meter'. By extension, it reveals that the infrastructure design, which rested on the image of the 'active citizen', had not necessarily taken into consideration place-specific conditions in the project's planning and design processes. It demonstrates a process through which a project that was supposed to function as an entirely digital operation became a more hybrid and dynamic constellation through incremental and makeshift improvisation directed by the users. However, most importantly, it represents a situation in which infrastructure plans and deployments aligned to organizational and institutional visions do not always align with place-based realities of urban life. This development reflects the appropriation of technologies beyond formal plans.

The prepaid systems for electricity access in Kibera, a slum settlement in Nairobi, exemplify an infrastructure development intervention that has become increasingly contested. Chapter 4 examines the rationality of the utility provider, donors and politicians in the deployment of the technological systems, and the ways in which residents and informal power distributors in Kibera not only appropriate prepaid systems but also sometimes reject them, often by reverting to post-payment or non-payment options. Consequently, the chapter highlights a 'conflict of rationalities' (Watson, 2003, 2006; de Satgé and Watson, 2018) that has emerged, and played out at the interface of opposing logics and interests of the various actors. The chapter points out that while Kenya Power's rationality was to extend its grid to Nairobi's slums, thereby formalise access and recover return on investment, the residents in the slum have largely frustrated these efforts. Powerful cartels and informal power

distributers have played active roles in negotiating and subverting meters and thereby frustrating Kenya Power's efforts to formalise access. Slum residents have sought the assistance of the cartels and informal power distributers to circumvent and bypass the technological systems, in the urge to avoid paying or prepaying for formal electricity. The chapter examines not only what limitations public service providers face when extending their territorial monopoly to slum areas, but also the diverse outcomes and sometimes unintended consequences of their plans and development interventions. Ultimately, this case highlights the daunting task of the formalisation of service provision and access, and the socioeconomic and governance complexities of urban infrastructure interventions within the context of a contested urban sphere.

Chapters 3 and 4 reflect the place-based contexts shaping the deployment and appropriation of ICT-driven water and energy projects. In both chapters, the ICT-driven projects reveal different ways through which technological systems are appropriated by a diverse range of different actors including utility companies, national and urban governments, donor agencies, slum residents and intermediaries. The projects demonstrate how place-based contexts of Soweto-Kayole, in the case of Jisomee Mita, and Kibera, in the case of prepaid meters, shape infrastructural constellations that suit local needs and demands, sometimes beyond how the designers envisioned the technologies to operate. Hence, these projects demonstrate residents' creativity in reconfiguring and reassembling infrastructure in unforeseen ways.

In terms of the technopolitics, the deployment and appropriation of ICT-driven water and energy projects add to extant views of digital meters as objects that are not only technological, but also political: shaping citizenship for the urban poor, sustaining neoliberal goals, and re-enacting prevailing inequities and social injustices within the context of a splintered city. Thus, chapters 3 and 4 offer a way of seeing new and emergent technological configurations as inherently political and as reflecting and at the same time shaping political contestations. Jisomee Mita and prepaid meters demonstrate how attempts by utility providers to incorporate the urban areas of Soweto-Kayole and Kibera into the central grid reveal complex power dynamics. Subsequently, these chapters highlight a technopolitics that materialises in ways through which urban residents tactically and strategically appropriate the technologies that have been presented to them in pursuit of their own goals. The case of Soweto-Kayole in particular is a case that reveals digital meters as critical sites that evolve as a result of appropriation and sometimes contestation. As techno-political systems, digital meters highlight complex power dynamics in the efforts by the state to extend a centralised infrastructure system to the peripheral community of

Soweto-Kayole. Their appropriation reflects urban citizens as political agents who, through the process of renegotiating the infrastructure development project by modifying it or recasting it in varied ways, make technological artefacts to echo their political interests.

RQ 3: How and with what impact does the proliferation of ICTs in urban water and energy utilities facilitate utility providers' ambitions to universalise and homogenise service provision in the splintered city?

Chapter 5 reveals a two-way interface between telecommunications operators and urban water and electricity utility systems, and subsequently demonstrates how urban infrastructures are being reconfigured through digital technologies. By elaborating on this interface, the chapter reveals the impact of ICT applications on the broader arrangements in water and electricity utility systems. The chapter shows that Kenya Power has not achieved its formal monopoly in supplying energy in Nairobi, given the wide range of other formal and informal competitors and complementary players in the market that co-provide electricity or alternative sources of energy. However, the utility has collaborated with a network of other actors and entities from different domains to expand further its market share, monopolise and universalise supply, and push heterogeneous service constellations out of the market. These actors include finance and banking institutions, small and medium-sized ICT firms, and supranational organizations such as the World Bank and UN-Habitat. This also applies to the water utility company, which has formed strategic alliances with emerging ICT companies, and international organizations including UN-Habitat, that have led to the introduction of new modalities of water access. The chapter contends that through these arrangements, utility providers are beginning to provide services through hybrid technological systems in order to capture new territories and fresh revenue streams. The hybrid technological systems that this chapter refers to are constellations that include public and de facto public-private driven infrastructure development projects that allow consumers to manage and control their own meters, recharge power bundles, query utility systems, vend and dispense services, track their consumption, buy rent-to own water and power meters and products, and pay outstanding bills. This chapter presents evidence of these constellations for urban water and electricity provision and demonstrate the ways through which their deployment – as small-scale and place-based projects – reflect a spatial configuration of urban splintering and fragmentation.

The chapter finds that while the aim of utility companies is to extend their networks and formal monopoly, as well as to universalise and homogenise service provision,

their impact has been quite different. For instance, this interface has led to a shift towards a spatial differentiation, whereby the formal water and electricity companies through the integration of ICTs have differentiated and adapted their service provision to different urban contexts and user groups depending on their economic status. The chapter also finds that while these services were largely originally targeted at the urban poor, they are increasingly adopted by other user groups in the city. This reflects a clear shift in the approaches, strategies and tactics employed by utility providers, which historically were mostly oriented towards wealthier urban areas and the central business district of the city, and are now in addition focusing on the urban poor. While this shift has mostly been driven by pressure from international institutions, the chapter reveals that it is also driven by the utility companies' desire to achieve a territorial monopoly and to recover their costs. Thus, the chapter shows that urban water and electricity providers in Nairobi are increasingly adapting their services to the splintered nature of Nairobi's urban and infrastructural landscape. In this process, digital technologies have allowed utility providers to apply spatial targeting as a strategy aimed at specific user groups and areas such as the urban poor.

RQ 4: What lessons can be drawn from ICT-driven urban and infrastructure development projects in present processes of city making, and how could they more effectively contribute to the sustainability of cities and infrastructures?

The ICT-driven urban and infrastructure development projects studied under chapters 2-5 reflect the need for engaging more productively with place-based contexts. Chapters 3 and 4 demonstrate that new technological projects need to align with situated contexts as well as to engage more closely with logics of actors and politics of infrastructure to be successful. The chapters establish that aligning with such realities requires a recognition that universal and standardised infrastructure networks in urban contexts can and ought to coexist as well as to legitimately compete with informal systems. This requires planners to acknowledge off-grid solutions as much as they do informal networks for the realisation of more efficient and dependable urban planning. However, they also point to the complexities apparent in fragmented urban contexts of Southern cities such as Nairobi. Thus, it becomes imperative for urban planners to consider the splintering and fragmentation of cities in the planning and development of infrastructure services. As chapter 5 indicates, in addition to offering urban planners a tool for formalizing and universalising "markets" of service provision and realising territorial monopolies in an otherwise fragmented city, new ICT-driven infrastructure development interventions are also likely to re-enact uneven and unjust landscapes.

Thus, contributing to sustainable cities and infrastructures requires acknowledgement of the city's socio-spatial inequalities rather than treatment of cities as homogeneous spaces that can be supplied with more or less homogeneous and standard services. Such an approach would serve not only the urban elites in premium enclaves, but also the poor urban areas which are often more prone to being excluded from investment and political support. As can be seen in the case of Nairobi – through experiences from electricity and water utility providers – the employment of spatial targeting within the frame of infrastructure provision has the potential to extend innovative initiatives to low-income areas of the city. In this regard, ICTs have served the city's aspirational desire to achieve smartness and sustainability, particularly through approaches that primarily rely on distinctive social and community-based approaches including collective connections and ownership as well as maintenance practices supported by mobile technologies.

To realise further the potential of the above approaches, smart city making processes could start by engaging more closely and specifically with the place-based rationalities and politics that underpin the dynamics of these initiatives on the ground. For example, chapters 3 and 4 highlight the need for urban planners, utility managers and regulators to take note of the variegated informal practices. The chapters suggest that planning must acknowledge and combine both networked systems, off-grid solutions and informal network extensions. These chapters further suggest that planning must align public utilities with multiple co-providers, and tailor tariffs and socio-technical solutions to the spatially variegated user needs, financial capabilities and practices. Realising this objective means attending to small and situated realities of large-scale infrastructure networks in the city. Thus, planning must engage more productively with specific urban areas to ensure infrastructures that are more functional and achieve more sustainable solutions.

6.2 Theoretical Reflections

6.2.1 Urban studies of infrastructure in the digital age

One of the key theoretical contributions of this dissertation is that it takes digital infrastructures as entry points for understanding processes of urban processes of splintering and fragmentation. As mentioned in the introduction, while critical engagement has emerged on urban infrastructures in Southern contexts highlighting the role of users in theorizing cities and infrastructures within contexts of urban splintering (i.e. Monstadt and Schramm, 2017; Jaglin, 2014; Lawhon et al., 2018), this has not yet been extended to the study of ICT-driven infrastructure development. This

dissertation extends said focus (i.e. the study of everyday practices and contestations through which poor urban residents actively access basic services from utility companies) to ICT-driven infrastructure projects. The dissertation offers grounded and context-specific examples of new automated and virtual payment types. It highlights the different business models that contribute to a better understanding of the different ways through which infrastructure systems are automated, and how this automation intersects with and shapes incumbent modes of service delivery within low income urban areas often categorised as informal settlements.

In the process, this dissertation revives and builds upon established debates on urban and infrastructure development and appropriation, to make an explicit contribution that draws on the postcolonial African city. Furthermore, the dissertation provides a range of synoptic views and mainstream presumptions of infrastructure planning and development in the digital age. It reveals digital infrastructures as socio-technical constellations supported by varied low-cost technologies, international efforts, social enterprises and locally grounded NGOs. It offers a middle ground between the enthusiastic or celebratory accounts on one hand and indifferent or dismissive accounts on the other, which are inherent in debates on smart technologies and cities. Thus, this dissertation examines digital infrastructures not just as manifestations of urban entrepreneurialism and a technocratic development agenda and acknowledges its context-specific appropriation. It adds to studies that are empirically grounded beyond utopian descriptions of circulating techno-centred visions and deterministic views of urban innovation.

This chapter makes this contribution by providing vivid case studies from a city whose recent political ambitions and plans strongly promote digital technologies and data-driven platforms. For example, Chapters 3 and 4 portray the steady rise of new infrastructure projects in Nairobi. Beyond highlighting the nature of private sector-led, large-scale digital infrastructure projects through their speculative 'world-class city' aspirations, these chapters offer specific examples from urban water and energy sectors. It examines how dynamics and processes of infrastructural change and remaking through ICTs reveal dynamic and hybrid infrastructural constellations as actors on different levels appropriate them. Chapter 5 reveals the challenges or limitations of digital infrastructures as 'technological fixes'—both as an opportunity as well as a political tool that may further exacerbate inequalities in access. In sum, these chapters make this contribution in urban and infrastructure studies in transition.

6.2.2 Postcolonial critique of urban studies of technology

The previous chapters have demonstrated that ICT-driven infrastructures provide a fresh insight into urban studies of technology. Chapters 2–5 examine an African city in the digital age as a site of technological innovation and appropriation (as opposed to a diffusion of technologies from elsewhere). They provide vivid examples of a shift beyond determinist views of urban development, towards one where infrastructures are investigated and theorised from the viewpoint of the different actors, including the experts, utility companies and engineers, and "those at the 'receiving' end" (Edwards et al., 2009: 371) that are more often "excluded or by-passed" by the utility companies and governments and exposed to cities' segregated territoriality (Fernández-Maldonado, 2008). These chapters demonstrate that even when technologies are introduced, the different actors within the city may slightly modify them, drastically transform them or combine them with existing technologies and processes; moreover, they may even sometimes resist them or at least create new meanings and uses for them (see e.g. Monstadt and Schramm, 2017). Thus, I have highlighted the need to view varied urban populations not as passive recipients of technologies from elsewhere, but as active participants in their production (ibid).

Essentially, urban studies of technology were important in that they espouse technology not as a monolithic or placeless medium, but as one that is embedded in and shaped by their users and urban environments and develops place-based styles. They were key in demonstrating that technology is used by diverse people in diverse ways, and that it is shaped by ordinary practices and processes. Extant urban studies of technology provided a valuable basis for examining the appropriation of infrastructure projects. These studies offer great insights into how urban infrastructure projects are essentially constructed through the deployment of digital technologies, as well as through the active and continuous role of different actors, including local and national governments, utility providers, mobile network providers, large corporations, small and medium-sized enterprises, and urban residents. This dissertation adds a new dimension to work within urban studies of technology by drawing from new ICT-driven infrastructure development interventions within the context of a splintered city, to examine the role of top-down planning vis-à-vis place-specific realities and local politics and dynamics in the use and appropriation of development interventions.

My theoretical contribution lies in heeding the call from urban studies of technology for scholarship that is attentive to everyday contexts of low-income communities, who are exposed to stark inequalities in access to basic services and are left

marginalised. In doing so, this dissertation extends a constructivist angle to studies of technology (see e.g. Bijker, 2001) in African cities by drawing from the perspectives and experiences of the urban poor. It fills an observable theoretical gap in urban studies of technology where the poor in urban areas are rarely seen as creative participants in the appropriation of digital infrastructure. Thus, the dissertation challenges the instrumentalist idea that considers technical designs and infrastructures as neutral phenomena and therefore responds to calls for "conceptual framings that would allow us to think about Africa in ways that are more hopeful and positive; that acknowledge the success of Africans in constructing productive lives at a micro-scale" (Harrison, 2006: 323). It foregrounds the imperative of postcolonial critiques of urban studies of technology by providing an important contribution to the study of the often-overlooked ordinary processes and modes of practice in Southern cities (Roy, 2009). As I argue in the following sub-sections, this dissertation adds critical engagement to these debates, by applying technopolitics and conflicting rationalities' perspectives as well as a situated approach to the study of ICT-driven infrastructure projects, with the goal of bringing new insights to smart urbanism in critical urban studies.

6.2.3 Technopolitical relations and conflicting rationalities

In addition to presenting empirically grounded evidence about the practices of urban residents in the deployment of ICT-driven infrastructure development projects, this dissertation puts forward the view of technical infrastructures as sociotechnical systems whose constellations reflect the politics and spatialities of splintering urbanism in the context of a highly contested city. It takes smart digital technologies and infrastructure initiatives as artefacts that are affected by everyday political repercussions and conflicting rationalities.

For example, Chapter 3 draws us to new modes of user technopolitics through the case of Jisomee Mita in Soweto-Kayole. These user technopolitics materialise in the different appropriations of new technologies that often cause urban infrastructures to develop in unforeseen ways. Jisomee Mita reveals how the attempt to expand centralised networks through the deployment of digital meters in Soweto-Kayole led to hybrid infrastructural constellations. Here, users can be seen as playing an active role in sabotaging the utility company's efforts in creative and innovative ways. These different appropriations in the case of Jisomee Mita offer important understandings to contemporary planning practice and draw us towards the importance of other ways of seeing the urban through dynamic processes of infrastructure change and remaking in the digital age. These processes demonstrate ways through which politics are

inscribed into technological devices, and how they may work toward, or against urban socio-spatial cohesion. As such, Chapter 3 is important for explaining how socio-technical infrastructures are shaped by a wide range of countervailing actors and dynamics. The technopolitical relations revealed in Chapter 3 highlight different forms of power dynamics and politics of technology which are necessarily embedded in the development of Jisomee Mita, and where political action is expressed through the very technological design and appropriation. They reveal a way of seeing new and emergent Jisomee Mita's constellations as inherently political; and where the politics displayed in the project's development and appropriation fall outside the explicit terrain of the traditional political. In this chapter, the apparent technopolitics become important as a basis for interpreting Jisomee Mita not only as a technological artefact, but also as inherently political artefact. It prompts a critical re-reading of the politics of Jisomee Mita as a centralised infrastructural system. In this regard, this chapter highlights locally based political contestations through technology use and appropriation where ultimately, inequalities in access to basic services that are inscribed into Jisomee Mita as a smart urban project are revealed.

Chapters 4 draws us to the different rationalities that underlie an electrification project in the context of Kibera as a contested urban sphere. As portrayed in the chapter, the dynamics of the deployment, use and appropriation of prepaid meters demonstrate how different rationalities lead to conflicts between service providers, urban residents, and a wide range of other actors involved in the deployment and appropriation of urban infrastructure. They offer a more differentiated view of the different actors and stakeholders involved. The chapter acknowledges the need to move beyond a binary view of state versus citizen. It indicates the extent to which the deployment of prepaid systems is also sometimes informed by precipitants from elsewhere, such as through a search for best practices, and consultancies from global firms and external agencies. Secondly, this chapter demonstrates how international donors, telecommunication firms, community-level actors and urban residents contest and negotiate artefacts through different and sometimes contesting rationalities. Chapter 4 shows that in the case of Nairobi's slum areas, new technologies have led to the repositioning of some of these actors. These actors include, for instance, the informal power distributers who shifted from redistributing illegal electricity in the slums to become employees of Kenya Power to deploy electricity meters, only to end up subverting the very systems they had helped to deploy. The chapter shows that these processes portray slum areas as terrains that are increasingly contested and within which different political actors collide and political confrontations emerge.

In sum, my theoretical contribution herein lies in connecting existing infrastructure scholarship in the global South with wider academic discourses through the conceptual notions of technopolitics and conflicting rationalities in the context of the digital age. The dissertation contributes a grounded framework and analytical view of technical infrastructures as domains of negotiation and political struggles. It demonstrates the complexity of power dynamics that surround the deployment, use and appropriations of new technologies in a splintered city. In so doing, the dissertation adds to infrastructure studies that go beyond technological determinist predispositions and demonstrates how deployment and appropriation processes of infrastructure affect and are affected by social, political and cultural contexts (Treré and Carretero, 2018). Thus, it emphasizes the imperative of rethinking smart urbanism in a manner that engages with the politics of infrastructure and the contradictory visions and rationalities of development interventions within the context of a contested urban sphere. It achieves this goal by showing that technopolitics and actors' rationalities in city making processes are not to be understood through simplistic framings of the state–citizen dichotomy. Instead, these processes are to be understood through a more nuanced and differentiated understanding of the multiple stakeholders involved in the planning and appropriation of infrastructure interventions. Only such an understanding would adequately reflect the various embedded politics and rationalities at play within contested urban contexts.

6.2.4 Rethinking smart urbanism: toward a situated understanding

Ultimately, this dissertation rethinks smart urbanism (Luque-Ayala and Marvin, 2015; Kitchin, 2015; Marvin et al., 2016) by applying and combining different conceptual notions for the study of city making and infrastructure development in the digital age. The dissertation employs the postcolonial paradigm as an essential perspective for reading cities and infrastructures in an African context. It applies the concepts of conflicting rationalities and technopolitics to inform and advance the discourse on smart cities and smart urbanism. However, most importantly, the dissertation emphasizes the imperative of employing a fluid and diverse understanding of the concept of smart urbanism in a manner that critically considers the ordinary, place-based contexts and realities of everyday life (see e.g. Slavova and Okwechine, 2016; McFarlane and Söderström, 2017).

While urban studies have attempted to examine the "actually existing smart city" in North America and Western Europe (Shelton et al., 2015), this dissertation contributes a nuanced empirical account that captures the smart city as it actually exists in an African context from the viewpoint of ICT-driven urban water and energy

infrastructure development projects. Through the case studies examined in Chapters 3 and 4, the dissertation demonstrates smart technologies and initiatives that extend service delivery to low-income areas through cost-effective mechanisms and tailor services to the needs of the urban poor. In so doing, the dissertation challenges implicit notions of universality and the aspirational desire of the different city planners to achieve urban smartness through top-down solutions, toward recognizing the unique historic complexities of emerging cities. Chapters 2 and 3 discussed largely less sophisticated and small-scale projects that precisely rely on both pre- and post-paid mobile phone modes of billing and payment; innovative applications and systems that rely on simple mobile-phone texts and short codes; and applications that facilitate everyday purchases and transactions, such as M-Pesa. Chapter 2 shows that these developments, which facilitate access to water and energy, are operationalised through incremental structures such as ephemeral stalls or kiosks at strategic locations in the city. These developments are counterbalanced by informal and small-scale entrepreneurial modes of practice, as well as contestation and politicization. As such, they exemplify actual realities of smart urbanism within a splintered and fragmented city. They demonstrate that rather than being directed exclusively by the city's articulated plans (Chapter 2), smart urbanism emerges, develops and evolves endogenously, and manifests itself in more diverse ways (Chapters 3–5). When considered, these developments draw us towards the imperative of rethinking smart urbanism and demonstrating its plurality as shaped by diverse publics in diverse locations, as opposed to it being a monolithic or placeless ideal form.

In sum, this dissertation's crucial contribution lies in advancing a more critical research agenda and theoretical dialogue that stimulates an understanding of the notion of 'smartness' through a perspective that exceeds notions of modernity common for the North. It adds new insights to contemporary debates in urban studies on appropriations of the smart city ideal in the context of an African city. By so doing, this dissertation speaks back to theory on the subject of smart urbanism through the lens of ICT-driven urban infrastructures by presenting a way framing city making that clearly puts urban settings, lived experiences and power dynamics at the forefront of theorizing infrastructure.

The projects examined between chapters 2 and 5 offer new perspectives on urban infrastructure and planning in the digital age in the global South. These projects, especially in fragmented and heterogeneous urban settings, draw us to place-based constellations of technologies that draw from a hegemonic model of city making. When seen through their realisation within the context of an urban settlement (such as in

chapter 3 and 4), these projects can be seen to incubate new modes of smart urbanism that is informed by poor urban areas. Moreover, it goes even further by showing how smart city projects and initiatives are mediated and counterbalanced by their different environments that present ambivalent outcomes (i.e. Chapter 5). In showing how the smart city in selected urban and peri urban areas in Nairobi is shaped by varied social, cultural, political and historical contexts, this dissertation makes the case that the advent of the smart city in Nairobi ought to be viewed as neither a decontextualized incident nor an entirely top-down phenomenon. Rather, it is part of institutional patterns, built environments and everyday situated practices. This case is clearly evidenced in Chapters 3 and 4 by situating the co-evolution of infrastructures and cities in the digital age, and the "multiple rationalities" of formal city planning vis-à-vis urban informality at work in African cities (Watson 2009: 2267). This contribution is particularly pertinent to substantiating emergent calls in urban studies to move beyond limited conceptions of smart urbanism towards conceptions that illuminate situated and more inclusive approaches (Watson, 2014; Odendaal, 2011; Odendaal and Aurigi, 2020; Aurigi and Odendaal, 2020; Datta, 2015). Ultimately, this conceptual extension is fundamental for expanding our analytical outlook of smart urbanism in critical urban studies, particularly regarding how it is understood and interpreted in its different variants.

6.3 Recommendations

Thus far, the main empirical findings and theoretical reflections have been summarized. The summary of empirical findings provides evidence of new configurations of infrastructure development and expands our understanding of digitalization processes and infrastructure dynamics in the context of a splintered city. The theoretical reflections highlight some of the most critical issues of infrastructure studies in the digital age, postcolonial critiques of urban studies of technology, technopolitical relations and conflicting rationalities, and smart urbanism in a situated context. However, beyond the empirical findings and theoretical reflections, the purpose of this dissertation is also to further discuss recommendations for future research and policy development.

6.3.1 Recommendations for future research

The results presented in this dissertation disclose possible future research directions. This dissertation builds on qualitative research of predominantly low-income and lower middle class urban areas within a single large city. It seeks to better understand the situatedness of smart urbanism, as well as to contextualise the nature of

technopolitics and conflicting rationalities within the context of splintering and fragmented urbanism. Methodologically, the focus on low-income and lower middle class urban areas was warranted to offer an empirical undertaking and presentation of smart city making and technology development processes through the lens of STS and postcolonial critique with the aim of speaking back to theories of smart urbanism. However, the limitation of this study has to do with the inability to reflect, in a more balanced way, the potentially variegated and relational forms of smart urbanism in the context of a splintered and fragmented city. This means that my focus of low-income and lower middle class urban areas within a single large city, leaves room for more for further extensive research in this area to better reflect the diverse and variegated digital and infrastructure landscapes of postcolonial cities in the global South.

A complementary contribution in future research would be to further broaden the spatial scope of smart city analysis beyond this study's individual low-income and lower middle class urban areas. Firstly, there is still need to examine wealthy enclaves, including higher middle class urban areas, as the core of empirical study of digitalisation processes. Given the ubiquity of digital technologies such as digital meters, mobile-based apps, and pre-payment systems for utility services such as water and electricity, there remains an opportunity for studying how residents in higher middle class urban areas access and pay for utility services. Thus, further research is needed to bring into dialogue the varied politics and dynamics involved within such areas.

Secondly, there is need for targeted studies of a type of premium network spaces such as city extensions in urbanizing hinterlands, wealthy enclaves, satellite cities, industrial zones and business districts. Given this dissertation's focus of mostly on the frugal and mundane technologies in low-income and lower middle class urban areas, future research needs to examine enclave infrastructure developments in the form of private investments by international ventures and real estate developers. These developments and investments include range from smart grids to multimodal transport networks that seek to supplement existing systems. In examining these spaces, a more critical portrayal of the reality in which smart city initiatives are being executed on the ground becomes imperative. Studies thus far have mostly focused on smart city plans (i.e. Watson 2015, 2014; van Noorloos and Kloosterboer, 2018) rather than on actually existing forms of smart urbanism. Hence, it becomes important to examine how wealthy enclaves, satellite cities and business districts shape and are shaped by ongoing infrastructure development and digitalisation processes.

Thirdly, specific attention is needed to examine the metropolitan scale. Here, studies need to examine city-regions with the goal to expand the scope of smart urbanism beyond the city-centred focus. Such an examination would enhance our understanding of the nature of politics at this territorial level in the context of contemporary urban governance. In Nairobi for instance, the splintered nature of urban governance poses several challenges for urban plans and initiatives at the greater metropolitan level. A more explicit study is thus needed to better grasp how both large-scale and small-scale urban digitalisation processes enact (or re-enact extant) spatial inequalities and conditions of segregation and polarization at a regional-level in the context of urban splintering and fragmentation. Such a study needs to enhance our knowledge of the wider metropolitan and city-regional politics and dynamics and enrich our understanding of the notion of smart urbanism through a perspective that exceeds conventional city-centred representations and manifestations.

A spatial scope of smart city analysis that goes beyond the study of individual low-income and lower middle class urban areas toward the study of wealthy enclaves, satellite cities and business districts would be imperative for allowing broader comparisons within a city and metropolitan region. These comparisons would go a long way in providing better insights about how variegated city and urban developments relate to each other. Within this context, comparisons would be imperative in foregrounding daily engagements and relations that tend to comprise smart urban projects, and highlighting the splintered and fragmented character of cities, urban areas and metropolitan regions. Moreover, they would be key for producing new conceptions and considerations in our theoretical outlook, re-framing smart city debates, and operationalizing theoretical pluralism.

However, beyond this focus, there are opportunities for even further comparisons and relationships. For example, since cities are considered as relational, it would be imperative to examine how smart urbanism is embedded in vertical relations (e.g. to national governments, supranational organizations), in relations with international donors, but also in horizontal relations with other cities (nationally and internationally, e.g. how ideas and technologies travel, how cities learn from each other, etc.). Moreover, a better understanding of **s**patial relations and comparisons within cities (i.e. intraurban comparison) (McFarlane, et al 2017), and between municipalities of a single country or different countries (i.e. interurban comparisons) would be necessary for further operationalising comparative case study research within, across and beyond cities of the global South. Such a contribution would advance varied and extensive understandings of smart urbanism.

Lastly, and as an additional avenue for rethinking smart urbanism, a particular focus on small and medium sized cities in the hinterlands of low-income countries in Africa and other parts of the global South would provide additional insight. Small and medium sized cities have the potential to offer different perspectives, lessons and experiences, as well as to highlight the diversity of urban patterns and infrastructural configurations in the digital age. This focus would lead to a better understanding of the situated aspects of smart city making in contexts where socio-spatial dimensions and compositions might defer from large central cities. Moreover, it would serve to counter the indifference in urban research of marginal areas and urbanising hinterlands, and to broaden further our understanding of smart urbanism (McFarlane, 2010).

At the heart of the above recommendations for future research is both an empirical and a conceptual mandate to add more insights to contemporary debates around smart urbanism in ways that further widens theoretical pluralism in urban studies. This means widening our focus of smart urbanism and paying specific attention to the variegated configurations and the situatedness of ICT-based urban and infrastructure developments in the global South. Such a contribution is important for purposes of offering a meticulous reconceptualization concept of smart urbanism, and not taking the concept simply at face value or as a universal model that can be generalised across regions, as this would directly counter the very arguments that support Southern and postcolonial theorizing. As de Satgé and Watson (2018: 25) argue, such concepts in urban planning and urban studies "need to be thoroughly tested, critiqued and refined through in-depth research in many different contexts, and even then, can only claim the status of provisional and meso-level theorizing – always subject to (and asking for) further challenge and change". Doing so requires proper acknowledgement of the nature and scope of the empirical and conceptual demands and challenges in studying smart urbanism within contexts of urban splintering and fragmentation in the global South.

6.3.2 Recommendations for policy and practice

In addition to the above recommendations for future research, this dissertation offers a lens onto main recommendations for policymaking and practice in innovation and appropriation digital infrastructure in the context of urban splintering and fragmentation. To begin with, my research results reveal the need for city governments and the technology firms to consider social aspects in smart city making and technology development processes respectively. For example, this dissertation has revealed the complexity of smart city plans and infrastructure development initiatives on the ground, and the reality of alternative digital infrastructures in disenfranchised urban

areas. The dissertation has also revealed the nature in which smart city initiatives are highly technology-centred, and how they exacerbate socio-economic divisions through their intended and unintended corporate dominance and top-down planning. Thus, a recommendation for policy and practice is for city governments and technology developers to foster user-centred designs, bearing in mind the need to benefit all inhabitants in the city including the poor, underprivileged and marginalised. This becomes even more imperative within the context of urban splintering and fragmentation where the need for inclusivity and social sustainability becomes even more imperative. In this context, the effectiveness of smart city initiatives depends on the ability to respond not only to the politics dictated from global economic institutions and formal state buildings (including bureaucratic and decision-makers, governments and regulators, and municipal authorities), but also local actors and institutions (including improvised governance arrangements to be commonly found in low income and lower middle class urban areas).

Furthermore, and following on from the aforementioned, smart city initiatives need to build more strongly on endogenous innovation capabilities and the actually existing innovations that are evident on the ground. This dissertation has demonstrated the role of urban plans in putting ICT innovations on the political agenda to stimulate entrepreneurial spirit and favourable business environment in the city region. However, there is need to further capitalize on and promote endogenous innovations shaped by informal and small-scale entrepreneurial practices, and operationalized through incremental and fragmentary structures such as ephemeral stalls and kiosks. In Nairobi, these innovations include small to medium-scale start-up ventures, digital metering initiatives, mobile-based apps, and everyday mobile payment systems. Urban planners and practitioners need to consider these kinds of digital technological initiatives and transformations, since they not only offer technological solutions and economic potentials for urban development, but also a market potential for cities in the context of smart and sustainable urban development. Obviously, this is exceptionally complex for planners and practitioners since these innovations thrive on informality and lack of regulation, and their development does not materialise in a politically neutral and culturally undifferentiated space. However, it would be important for planners and practitioners to consider endogenous innovation potentials and the context-specific realities which tend to drive these innovations in the digital age.

At the utility level, this dissertation has demonstrated how the deployment and appropriation of prepaid electricity systems and digital water meters in low-income and lower middle class urban areas respectively, are exposed to wide-ranging technopolitics and

conflicting rationalities. What is further demonstrated in both of these cases is that the users are constantly in pursuit of room to manoeuvre and act in unscripted ways with regard to the use and appropriation of public infrastructures. In Nairobi, the pragmatic approach that water and electricity utility providers have adopted in low-income and lower middle class urban areas has taken the form of engaging more productively with different locally-based actors to minimise possible tensions. This approach can take different forms depending on context-specific realities in which services are being provided, but essentially, it underscores the imperative of dealing with the reality of place-based contexts and fostering interest among local actors to support utility projects. Thus, a fair and feasible arrangement must be found that allows local actors to take part in the activities of public utilities. Here, a necessary measure would be to minimise administrative complexities that might hinder the involvement of local actors and stakeholders.

Pursuing a pragmatic approach may require utility providers to go even further and integrate locally based strategies into their initiatives. For example, Kenya Power, the main electricity utility provider in Nairobi, has integrated locally based strategies by employing informal power providers and incorporating significant subsidies and lifeline tariffs to enhance its formal supply of and access to electricity in the settlement. Of course, it has encountered obstacles including institutional hurdles at the utility level, as well as conflicting rationalities within and across different urban locations, and these cannot be downplayed. However, the case of Kenya Power highlights the need for utility providers to find better ways of engaging different actors more productively in order to minimise possible tensions that may be emerge due to manifold place-based dynamics and contestations. These actors, who may vary in different sociospatial settings, include intermediaries such as community development officers in the case of water utility provision in Soweto-Kayole, and informal power distributors in the case of electricity utility provision in Kibera. While such strategies may come at a cost for utilities in terms of adjusting their approaches to service provision, hybrid approaches that may result are likely to be more effective for improving the access to essential infrastructure services particularly within poor urban areas.

At the municipal level, urban planners need to take a more pluralistic approach that acknowledges the nature in which cities in the global South are highly splintered and fragmented. Rather than trying to realise coherence through a centralised and standardised model of urban and infrastructure development, planners need to seek to represent the interests of various constituencies within the city by ensuring that different populations are equitably served. This recommendation aligns with Cartwright's (2015) call for operative pluralism that highlights the "importance of institutional hybrids as the most

likely form of urban governance in developing countries" (ibid: 29). It supports what Akubue (2000) has referred to as a "diversified technological approach" which emphasises the principle that technologies "are embedded and differentiated according to territories and their idiosyncrasies and to the people using and affected [them]" (Bolay and Kern, 2011: 34). Jaglin has argued how such an approach requires "a radical change in perspective" (2014: 434). Thus, my recommendation for utility providers is that they need to be willing to co-exist with private co-providers instead of trying to outcompete them. Accepting the inequalities of splintered and fragmented cities to some degree is necessary for purposes of administering the differentiation approach of service delivery. City planners and regulators need to think of better ways to enable co-existence of service providers and differentiation amidst contexts of urban splintering and fragmentation. They need to create appropriate regulations as well as a suitable environment for both heterogeneous, private and public utility providers to operate equitably.

In sum, this dissertation sought to study smart city making, add knowledge to smart urban projects and derive secondary measures and outcomes to countervailing processes and rationalities of ICT innovation and appropriation in the context of urban splintering and fragmentation. In view of that, the above recommendations are primarily based on my findings from a single case of Nairobi, Kenya. Thus, they are not to be taken as a blueprint for other cities. This is because these cities might differ from Nairobi regarding, for instance, the nature of urbanization, governance, infrastructure development and digitalisation processes. As such, policy demands for facilitating these developments may vary. However, the key implications of my research, especially with regard to the need for people-centred smart city initiatives, a diversified technological approach, a pragmatic understanding of the ordinary politics and realities, operative pluralism, and diversity in service provision and access to networked infrastructure, may have valuable relevance to many Southern cities that are struggling to realise smart and sustainable service delivery. These implications have the potential to counter political and economic challenges that may limit basic infrastructure supply, as well as technical and institutional challenges that may affect the organisation and governance of infrastructure networks with the context of a splintered city. Beyond this, it is important to add that these implications are also relevant to contexts and realities in the global North where the contradictions of smart urbanism and ICT-driven infrastructure development might not necessarily be as acute as in poorer regions of the world, but might nevertheless be apparent. This insight notwithstanding, the differences between and within cities, have to be taken into consideration, as the effectiveness of approaches to urban and infrastructural sustainability will depend mostly on place-based and context-specific realities.

6.4 References

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APPENDICES

Appendix 1 Guiding Interview Questions

Utility Companies

1. How do you describe the current arrangement of the utility in Nairobi?
2. How do you describe the state of water/electricity service delivery in Nairobi?
3. What can you say about the performance of the utility over the last 10 years?
4. What are the challenges that you face in delivering services in Nairobi? Which of these challenges are specific to low-income areas? What role do new technologies play in tackling these challenges?
5. What are the other sources or modes of water/electricity service delivery and access in Nairobi? How do these modes function?
6. How would you describe the policy environment in which you operate?
7. How do you describe the interface between your company with telecommunication and other ICT companies?
8. What are the metering and billing systems in place today, and how have they changed in recent years?
9. What kinds of models of mobile payment are being incorporated for water/electricity access in Nairobi? How are these models being integrated in your company's processes? How is this process being managed? What are your interests and motivations in (1) the uptake of these models and innovations, and (2) employing them for relatively new areas/territories of low-income residents (i.e. is the motivation based on expanding your market base, out of a government directive, prevention of theft, or a preference of international donor agencies?
10. What other ICT interventions have you initiated to facilitate water/electricity service delivery? Which one of these are oriented towards the urban poor? How have they evolved over the last 10 years? What has been the reception of urban residents to these interventions? Is there any resistance against these interventions?
11. How did you encourage your customers to adopt these technologies and what was the reception? How many customers in Nairobi have so far benefited from these projects? Are you satisfied with the projects' performance? Why?
12. What factors do you consider when deploying ICT interventions in low-income areas? What are the guidelines on how water/electricity utilities should deploy ICTs for service delivery in such areas?

13. What new business models have emerged as a result incorporating of ICT innovations?
14. What new trends are emerging as a result of these deployments beyond your company?
15. What have been the unintended (mis)uses of the ICTs or their features for your company (or the end users)? How do you deal with this unintended (mis)use? What strategies are you using to ensure the success of these ICT projects?
16. What factors are affecting the deployment of ICTs in the delivery of water/electricity services to low-income areas in Nairobi?

Experts

1. Who initiated these technological interventions? Did you finance the interventions? If not who did?
2. Which actors/stakeholders (private and public) are involved in the deployment ICT-led interventions for the urban poor and what role do they play in their implementation?
3. To what extent do you engage local communities (i.e. NGOs, CBOs) in your activities; what role do they play; and what is the nature of this engagement.
4. Who is involved in the implementation of these project? How are these actors involved?
5. What challenges do you face in the implementation of this project? What are the attempts underway to address these challenges?
6. What are your views on the way forward of ICTs for the delivery of water/electricity services in Nairobi? What ICT models do you consider (more) appropriate for delivering services to low-income areas in Nairobi? Why?

Planners and Bureaucrats

1. How would you explain infrastructure service delivery in the digital age in Nairobi?
2. What ICT-driven projects/interventions in Nairobi are you aware of? What are the most common among low-income urban livelihoods in Nairobi?
3. What are your views about ICT-driven infrastructure delivery and access?
4. How do these mobile innovations affect planning and service delivery models in Nairobi?
5. How do they facilitate urban access and use of basic services in the city?
6. How do they shape user practices in urban livelihoods?
7. What are their expectations and strategies in the uptake of mobile payment innovations?

8. How do these innovations affect production, cost-recovery, and the (hitherto unequal) delivery and provision of urban critical services?
9. In which ways do you think investment in and promotion of ICT innovations fosters infrastructure investment?
10. How does mobile technology shape the city's spatial structures, technological arrangements (beyond physical networks)?
11. What factors do you think need to be considered when planning and implementing ICT interventions for low-income areas in the city?

Urban Residents

1. My first question would be to ask you to introduce yourself. Could you say a bit about who you are and where you live?
2. Could you say something about your living situation?
3. How long have you lived here?
4. Do you use mobile payments?
5. Do you own or use a prepaid/digital meter? Who introduced you to it?
6. Do you use mobile applications to access water and electricity? What was your first contact of it / How did you learn about the service?
7. Could you describe to me for what purpose or activities you use these applications? What exactly do you use them for?
8. What is the most common mobile-based technology that you have incorporated into your daily routines? Can you describe how you use the service during an average work day? With examples?
9. What other technologies and options do you have at your disposal.
10. How do you experience the technologies?
11. What roles do these technologies play in your lives?
12. How do ICTs shape relationships with urban water and electricity service providers?
13. How have these technologies changed over time? Please give me examples.
14. What does the service mean to you?
15. Does the service play an important role in your life? Can you give some examples?
16. Do you ever talk with others about the service provided by these technologies? What do you talk about?
17. Do you think it is possible to manage without the service applications? Why?
18. What is your preference between the old and new system; and why?
19. What is it that you would want improved about the system?

Appendix 2 Observation Guide

1. How people relate to the mobile payment service in their everyday contexts.
2. The different types of mobile payment systems being adopted in urban and peri-urban settlements for access to water and electricity.
3. The most common mobile payment systems in use in the city.
4. How they are being integrated in everyday life.
5. New and emerging trends, practices and expectations relating to their use in making payment for water and electricity.
6. The appeal for mobile payment systems to consumers of water and electricity in urban areas.
7. How mobile payments systems become situated and simplified for daily living in urban areas.
8. The current purpose of mobile payment systems in urban areas.
9. How these systems affect how people connect and how they operate on day-to-day and moment-by-moment basis.
10. The contemporary reality today that explains the nature of mobile technological systems in Nairobi's communities.

Appendix 3 Cited Interviews

Chapter 2

1. Executive for ICT and Social Services, Nairobi City County, Kenya. 2016 (1 April).
2. Expert, urban planner, Nairobi, Kenya. 2017 (10 January).
3. City planning official, Nairobi City County, Kenya. 2016 (7 December).
4. Communications, Nairobi City County, Kenya. 2016 (1 April).
5. ICT, education and social services official, Nairobi City County (NCC), Kenya. 2016 (7 December).
6. Official, Nairobi City Planning Department, Nairobi, Kenya. 2016 (8 December).
7. World Bank official, Country Office, World Bank Nairobi, Kenya. 2017 (9 January).
8. Engineer and technical officer, Nairobi City Water and Sewerage Company (NCWSC), Nairobi, Kenya. 2016 (4 April).
9. Expert, urban planner, Nairobi, Kenya. 2016 (26 February).

Chapter 3

1. Communications officer, Nairobi City County, 2016 (1 April).
2. Officer, ICT department, NCWSC, 2016 (6 April).
3. Field Assistant I Soweto-Kayole, NCWSC, 2016 (19 February).
4. Community Development Officer I, NCWSC, 2016 (28 March).
5. Field Assistant II Soweto-Kayole, NCWSC, 2016 (22 February).
6. Officer, Pro-poor department, NCWSC, 2016 (4 April).
7. World Bank official, Country Office, World Bank Nairobi, Kenya, 2017 (9 January).
8. Communications officer, Regional Offices, NCWSC, 2016 (28 March).
9. Soweto-Kayole resident I, Soweto-Kayole, Nairobi, 2016 (14 February).
10. Soweto-Kayole resident II, Soweto-Kayole, Nairobi, 2016 (12 March).
11. Soweto-Kayole resident III, Soweto-Kayole, Nairobi, 2016 (2 April).
12. Soweto-Kayole resident IV, Soweto-Kayole, Nairobi, 2016 (26 March).

Chapter 4

1. Kenya Power Official, Kenya Power, Nairobi, Kenya, 2017 (July 18).
2. Scholar, Institute for Development Studies, University of Nairobi. Nairobi, Kenya. 2017 (January 10).
3. World Bank official. World Bank, Nairobi, Kenya. 2017 (July 20).

4. World Bank official and consultant, Country Office, World Bank, Nairobi, Kenya. 2017 (January 9).
5. Regional Manager. Kenya Power, Nairobi, Kenya. 2017 (July 18)
6. Proprietor and Resident. 2016 (March 21).
7. Jua-kali Casual Laborer and Resident, Kibera Nairobi, Kenya. 2016 (November 26).
8. Vehicle mechanic and resident. 2016 (March 25).
9. Engineer, technician and supervisor. Kenya Power, Stima Plaza, Nairobi, Kenya. 2016 (November 24).
10. Community Representative and resident. 2016 (March 19).
11. Sociologist, planner by profession and resident, Nairobi, Kenya. 2016 (December 26).
12. Engineer, Kenya Power, Nairobi, Kenya. 2017 (July 19)
13. Communications Officer, Kenya Power. 2015 (March 13)

Chapter 5

1. Director, Programs and Standards. ICT Authority, Nairobi, Kenya, 2016 (24 November).
2. Communications and Public Relations, Safaricom, Nairobi, Kenya, 2016 (30 March).
3. Communications Officer, Kenya Power, 2015 (13 March).
4. Customer Service Desk, Nairobi City Water and Sewerage Company (NCWSC), 2016 (4 April).
5. Communications, Nairobi City County (NCC), 2016, (1 April).
6. Supervisor (Mathare-Nairobi), Kenya Power, 2016 (25 March).
7. Project Officer, Nairobi City Water and Sewerage Company (NCWSC), 2016, (4 April).
8. Customer Service Officer, Nairobi City Water and Sewerage Company (NCWSC), 2016 (4 April).
9. Communications, World Bank, Nairobi, Kenya, 2017 (9 January).
10. Programs Manager, Umande Trust, Kibera-Nairobi, 2016 (4 March).
11. Head of Business Intelligence, M-Kopa Kenya Limited, Nairobi, 2016 (5 April).

SUMMARY

Studies of technical infrastructure are on the cusp of a "digital turn". In recent years, both policy and research circles have shown much interest in ICTs and their role in infrastructure development in cities. Consequently, urban infrastructures are increasingly providing a focal point for research on digitalization processes within human geography and spatial planning disciplines. This development has prompted notions of the "digital city", "smart city", "smart urbanism" and the "smart urban age". However, these notions are mostly examined in North American, European and Asian cities, and less in African contexts. Moreover, in the age of these developments, there has still not been sufficient and complete treatment of the complex and dynamic interface between ICTs, the development of technical infrastructure and urbanization.

The main goal of this dissertation is therefore to empirically explore and understand the multiple ways in which cities and infrastructures are constructed and reconstructed through ICT innovation and appropriation, and to explain existing infrastructure constellations through countervailing processes and rationalities in the context of splintered urbanism. Drawing on the case of Kenya's capital, Nairobi, the dissertation examines the relationship between urban plans and digital infrastructure development, the place-based sociospatial contexts that shape digital infrastructures, and the extent to which these infrastructures facilitate utility companies' ambitions of extending centralized networks to new territories. The main goal and research objectives have been translated into the following research questions:

1. What is the relationship between urban plans and the ICT-driven development of technical infrastructures? And to what extent is the implementation of plans and policies contingent upon politicization, contestation and context-specific realities?

2. What are the place-based contexts shaping the deployment and appropriation of ICT-driven water and energy projects, and which technopolitical relations does the project implementation reveal?

3. How and with what impact does the proliferation of ICTs in urban water and energy supply facilitate utility companies' ambition to universalize and homogenize service provision in the splintered city?

4. What lessons can be drawn from ICT-driven urban and infrastructure development projects in present processes of city-making, and how could they more effectively contribute to the sustainability of cities and infrastructures?

In developing an analytical framework for answering these questions, the dissertation draws on the theoretical and empirical base of urban and infrastructure studies, particularly in the fields of smart urbanism, postcolonial urbanism, and science and technology studies (STS). The analytical framework employed primarily views infrastructures as socio-technical systems, and as always relational to specific environments, populations and actors. It views the city as a site of infrastructure development and digitalization processes amidst countervailing rationalities. Finally, it goes beyond a focus on individual domains towards the examination of interfaces between digital technologies and infrastructure systems within urban contexts. Methodologically, the dissertation adopts a qualitative research design and presents in-depth case studies that combine ethnographic methods with a thorough investigation of written sources. Consequently, I take the cases of Kibera and Soweto-Kayole as two individual neighbourhoods where infrastructure development projects, shaped by their integration of ICTs, have been deployed with the aim of dealing with the challenges of infrastructure service provision in Nairobi. These projects are designed as pilot projects, and marketed as community-based initiatives. The projects have become common in Nairobi, a city which while possessing centrally planned water and electricity networks, is also associated with severe socio-spatial disparities in service provision. The deployment of digital infrastructures has thus become central to the operations of utility providers in their desire to improve service delivery in the splintered city.

Chapter 2 interrogates the approach and reliance of urban planners in Nairobi on the modernizing power of technology. In doing so, this chapter draws on STS and urban studies as well as on observations, interviews, and policy analyses to examine processes of city-making and the spread of ICT-driven infrastructures, and juxtaposes ambitious visions of emergent plans with ordinary realities of the African city. The chapter reveals that while processes of city-making in the digital age are inclined towards technocratic and deterministic appeals, this inclination is highly deceptive. The empirical case study on Nairobi suggests that rather than being deterministic, these

processes are fundamentally politicized, contested and shaped by local practices and context-specific realties.

Chapter 3 examines a Nairobi's water supply project called Jisomee Mita ("Read your Meter"), which combines a new piped water network with digital technologies. The chapter reviews Jisomee Mita as a hybrid infrastructure designed to enable self-meter reading and mobile-phone-based billing, payment and querying systems in Soweto-Kayole, a low-income urban area in Nairobi. It draws on science and technology studies to illustrate how hybrid and dynamic infrastructure constellations emerge through practices directed towards reconfiguring the centralized system of water supply. The chapter demonstrates how various actors continually reassemble Jisomee Mita beyond its original design in unforeseen and partly subversive ways.

Chapter 4 examines an electricity digital metering project in Kibera, Nairobi, which allows prepayment and the use of mobile telephony for billing, payment, recharging and querying purposes. This chapter builds on scholarship on prepaid meters and debates on conflicting rationalities within urban studies to provide a more nuanced examination of the ways in which different actors contribute to the deployment, appropriation and use of prepaid systems. The chapter considers the politicians, donors, residents of the slum Kibera and informal power distributors to show how these actors' different rationalities conflict within contexts in which actors have radically different understandings of an infrastructure development intervention in question.

Chapter 5 examines interfaces between telecommunications and urban water and electricity utility systems in Nairobi, drawing particularly on the degree to which ICT deployments for urban water and electricity supply shape and are shaped by their urban context. The chapter demonstrates that in light of Nairobi's condition as a splintered city, service providers have employed spatial targeting, strategically deploying "pro-poor" services. The chapter further demonstrates that while framed through narratives of spatial justice and pro-poor deployment, these deployments essentially demonstrate the desire of utility providers to maximize their returns on investment, scale centrally planned networks, expand their market share and monopolize service provision.

In the concluding chapter, the key findings are summarized and reflected upon to provide insights into new constellations of infrastructure development and to diversify our understanding of infrastructure dynamics and digitalization processes within the context of an African city. Herein, an overarching contribution of the dissertation

is provided. The dissertation offers a critical and pragmatic understanding of the ordinary politics and practices of urban administrations, utility companies and donors for planning and developing appropriate urban infrastructures in the digital age. It calls for operative pluralism in the provision of services in the age of smart urbanism. It emphasizes that these proposals are of valuable relevance to many Southern cities struggling to realize smart and sustainable service delivery, and to Northern contexts as well where contradictions of smartness and sustainability of service delivery might not necessarily be equally acute as in other regions of the world but nevertheless apparent.

SAMENVATTING

Onderzoek naar technische infrastructuur bevindt zich op een 'digitaal keerpunt'. Sinds enkele jaren is er in zowel beleids- als onderzoekskringen veel belangstelling voor ICT en de rol daarvan bij de ontwikkeling van infrastructuur in steden. Stedelijke infrastructurele voorzieningen komen dan ook steeds meer onder de aandacht bij onderzoek naar digitaliseringsprocessen binnen de vakgebieden sociale geografie en ruimtelijke ordening. Deze ontwikkeling heeft geleid tot begrippen als 'digitale stad', 'slimme stad' en 'slimme stedelijke ontwikkeling'. Deze begrippen worden echter vooral in Noord-Amerikaanse, Europese en Aziatische steden onderzocht, en minder in Afrikaanse contexten. Bovendien is er bij deze ontwikkelingen nog onvoldoende aandacht voor het complexe en dynamische snijvlak tussen ICT-systemen, de ontwikkeling van technische infrastructuur en verstedelijking.

Het hoofddoel van dit proefschrift is dus het empirisch onderzoeken en begrijpen van de vele manieren waarop steden en infrastructurele voorzieningen worden geconstrueerd en gereconstrueerd door middel van ICT-innovatie en hoe mensen hiermee omgaan, en een verklaring van bestaande infrastructuurconstellaties door middel van tegengestelde processen en beweegredenen in de context van versplinterde stedenbouw. Op basis van de casus van de Keniaanse hoofdstad Nairobi onderzoeken we in dit proefschrift de relatie tussen stedenbouwkundige plannen en de ontwikkeling van digitale infrastructuur, de plaatsgebonden sociaal-ruimtelijke contexten waar digitale infrastructurele voorzieningen door worden bepaald, en de mate waarin deze voorzieningen het mogelijk maken dat nutsbedrijven bestaande gecentraliseerde netwerken naar nieuwe gebieden kunnen uitbreiden. Het hoofddoel en de onderzoeksdoelstellingen zijn vertaald naar de volgende onderzoeksvragen:

1. Wat is de relatie tussen stedenbouwkundige plannen en op ICT gebaseerde ontwikkeling van technische infrastructurele voorzieningen? En in hoeverre is de uitvoering van plannen en beleid afhankelijk van politisering, geschillen en contextspecifieke realiteiten?

2. Welke plaatsgebonden contexten bepalen de uitvoering van op ICT gebaseerde water- en energieprojecten en de mate waarin mensen het gaan gebruiken? En

welke techno-politieke relaties worden door de implementatie van een project blootgelegd?

3. Hoe en met welke impact maakt de toenemende rol van ICT-systemen in de stedelijke water- en energievoorziening het mogelijk dat nutsbedrijven de dienstverlening in de versplinterde stad kunnen uniformeren en homogeniseren?

4. Welke lessen kunnen worden getrokken uit op ICT gebaseerde ontwikkelingsprojecten voor stad en infrastructuur in de huidige processen van stadsontwikkeling, en hoe kunnen deze effectiever bijdragen aan de duurzaamheid van steden en infrastructurele voorzieningen?

Voor de ontwikkeling van een analytisch kader voor het beantwoorden van deze vragen baseer ik me in dit proefschrift op theoretisch en empirisch onderzoek naar stad en infrastructuur, met name op het gebied van slimme stedelijke ontwikkeling, postkoloniale stedelijke ontwikkeling en wetenschap- en techniekstudies (STS). Het gebruikte analytische kader ziet infrastructurele voorzieningen vooral als sociaal-technische systemen, die altijd in relatie staan tot specifieke omgevingen, populaties en actoren. Het kader beschouwt de stad als omgeving voor infrastructuurontwikkeling en digitalisering in een context van tegengestelde beweegredenen. Niet alleen afzonderlijke domeinen worden beschouwd, maar ook worden de snijvlakken tussen digitale technologieën en infrastructuursystemen binnen stedelijke contexten onderzocht. Methodologisch gezien hanteer ik in het proefschrift een kwalitatieve onderzoeksopzet en presenteer ik diepgaande casestudies waarin ik etnografische methoden combineer met grondig onderzoek van schriftelijke bronnen. Ik gebruik de casussen van Kibera en Soweto-Kayole: twee wijken waar infrastructuurontwikkelingsprojecten met geïntegreerde ICT zijn gebruikt om de uitdagingen van de infrastructurele dienstverlening in Nairobi het hoofd te bieden. De projecten zijn opgezet als pilot, en gepresenteerd als initiatieven vanuit de gemeenschap. Dergelijke projecten zijn gemeengoed geworden in Nairobi, een stad die weliswaar beschikt over centraal geplande water- en elektriciteitsnetwerken, maar ook te maken heeft met grote sociaal-ruimtelijke verschillen in de dienstverlening. De inzet van digitale infrastructurele voorzieningen is daarom centraal komen te staan in de activiteiten waarmee nutsbedrijven proberen de dienstverlening in de versplinterde stad te verbeteren.

Hoofdstuk 2 gaat over de manier waarop stadsplanners in Nairobi omgaan met de moderniserende kracht van de technologie en in hoeverre ze hiervan afhankelijk zijn. Vanuit STS en stedenbouwkunde en door middel van observaties, interviews en

beleidsanalyses onderzoek ik processen van stadsontwikkeling en de verspreiding van op ICT gebaseerde infrastructurele voorzieningen, en vergelijk ik de ambitieuze visies van nieuwe plannen met de alledaagse werkelijkheid van de Afrikaanse stad. In dit hoofdstuk blijkt dat stadsontwikkelingsprocessen in het digitale tijdperk weliswaar vaak gekenmerkt lijken te worden door een technocratische en deterministische invalshoek, maar dat schijn bedriegt. Uit empirische casestudies van Nairobi blijkt dat deze processen niet deterministisch zijn, maar ten diepste gepolitiseerd, betwist en bepaald door lokale praktijken en contextspecifieke realiteiten.

In hoofdstuk 3 wordt Jisomee Mita ('Lees uw meter') onderzocht, een watervoorzieningsproject in Nairobi, waarin een nieuw waterleidingnetwerk wordt gecombineerd met digitale technologieën. Jisomee Mita – een project in Soweto-Kayole, een lage-inkomenswijk in Nairobi – is een hybride infrastructuur, ontworpen voor het zelf aflezen van meterstanden en voor facturering, betaling en gegevens opvragen met de mobiele telefoon. Vanuit STS wordt geïllustreerd hoe er hybride en dynamische infrastructuurconstellaties ontstaan door praktijken die gericht zijn op herinrichting van het gecentraliseerde systeem van watervoorziening. Dit hoofdstuk laat zien hoe verschillende actoren het project Jisomee Mita voortdurend omvormen, op onvoorziene en soms subversieve manieren die buiten de grenzen van het oorspronkelijke ontwerp gaan.

In hoofdstuk 4 wordt gekeken naar een project voor digitale elektriciteitsmeting in Kibera (een sloppenwijk in Nairobi), met de mogelijkheid van prepaid elektriciteit, en het gebruik van mobiele telefoon voor facturatie, betaling, opladen en gegevens opvragen. Voortbouwend op onderzoek naar prepaid meters en op stedenbouwkundige discussie over tegenstrijdige beweegredenen, presenteert dit hoofdstuk een genuanceerder onderzoek naar de wijze waarop verschillende actoren bijdragen aan invoering, acceptatie en gebruik van prepaid systemen. Ik bekijk de rol van politici, sponsoren, bewoners van Kibera en informele energieleveranciers en laat zien hoe de verschillende beweegredenen van deze actoren met elkaar in conflict komen, binnen contexten waarin de actoren radicaal andere opvattingen hebben over de desbetreffende interventie voor infrastructuurontwikkeling.

In hoofdstuk 5 wordt gekeken naar snijvlakken tussen telecommunicatie-, water- en elektriciteitssystemen in Nairobi, waarbij met name aandacht wordt besteed aan de mate waarin ICT-toepassingen voor water- en elektriciteitsvoorziening de stedelijke context bepalen en er zelf door worden bepaald. Het hoofdstuk laat zien dat dienstverleners in het kader van het versplinterde karakter van Nairobi gebruik hebben

gemaakt van een ruimtelijke benadering, waarbij ze speciale 'diensten voor de armen' strategisch hebben ingezet. Verder laat dit hoofdstuk zien dat deze toepassingen weliswaar geframed zijn als ruimtelijk rechtvaardig en goed voor arme mensen, maar in wezen demonstreren hoe leveranciers naar maximaal rendement streven, centraal geplande netwerken op hun gewenste schaal brengen, hun marktaandeel uitbreiden en dienstverlening monopoliseren.

In het slothoofdstuk vat ik de belangrijkste bevindingen samen en reflecteer ik hierop, om inzicht te verschaffen in nieuwe constellaties van infrastructuurontwikkeling en om meer reliëf te geven aan ons inzicht in infrastructuurdynamiek en digitaliseringsprocessen binnen de context van een Afrikaanse stad. Ook wordt hier uiteengezet hoe het proefschrift kan bijdragen aan de behandelde kwesties. Het proefschrift biedt een kritisch en pragmatisch inzicht in de alledaagse politiek en praktijken van stedelijke overheden, nutsbedrijven en sponsoren bij de planning en ontwikkeling van passende stedelijke infrastructurele voorzieningen in het digitale tijdperk. Het roept op tot een doeltreffend pluralisme bij dienstverlening in het tijdperk van slimme stedelijke ontwikkeling. Deze voorstellen zijn relevant en waardevol voor veel steden op het zuidelijk halfrond die moeite hebben om slimme en duurzame dienstverlening te realiseren, en ook in contexten op het noordelijk halfrond waar de tegenstrijdigheid tussen 'slimheid' en duurzaamheid van dienstverlening misschien minder sterk is, maar wel degelijk een rol speelt.

BIOGRAPHICAL NOTE

Prince K Guma was born on 16 February, 1985 in Rakai, Uganda. He obtained his BA in Social Sciences in 2008 and MA. in Public Administration and Management in 2010 from Makerere University, and an MBA from Amity University in 2011, before starting his Ph.D. in December, 2014. Prince started his Ph.D at the Graduate School for Urban Studies (URBANgrad) at Technische Universät Darmstadt before moving to Utrecht University in July, 2017. Since 2020 he is Research Fellow and Assistant Country Director at the British Institute in Eastern Africa (BIEA) in Nairobi. His research work is situated at the intersection of STS, Urban Studies and Postcolonial Studies, and explores the multiple ways through which domains are constructed and reconstructed through the diffusion and uptake of digital technologies. Since 2012, Prince has actively engaged in academic work on the urban informal economy, civic governance and engagement, urban planning and development, public-sector reform, organisational management, e-government, smart urbanism and infrastructure development in east Africa's cities of Kampala, Dar es Salaam and Nairobi. Prince's latest research concerns the aspect of infrastructural vulnerabilities and inadequacies in poor, small, and fragile cities in Uganda, the Democratic Republic of Congo and South Sudan. His findings are hoped to provide a menu for new explorations, enhance our understanding of urban and digital possibilities, and add new insights to debates on technology and urbanity in Africa and beyond.

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