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Smart urbanism? ICTs for water and electricity supply in Nairobi

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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 maximise returns on investment, expand centralised 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.

Keywords
electricity, ICT, Nairobi, telecommunications, urban infrastructure, water

摘要
近年来，对城市基础设施的研究已成为研究非洲城市的核心。本文是对这一研究的贡献。特别值得关注的是电信与城市水电公用事业系统之间的交互。我研究了肯尼亚内罗毕的城市环境与城市供水和供电的信息通信技术部署之间的作用与反作用关系。我展示了服务提供商如何认识到城市的分裂和隔离，并采用空间定位策略性地部署"扶贫"服务。我认为，虽然"扶贫"部署采用了空间正义的叙述框架，但其表明的是公用事业提供商的市场化优先考虑因素，他们希望最大化投资回报、扩大集中网络、增加市场份额、以及应对来自私人和公私合营提供商的竞争。我还表明，这些部署必须应对微观政治动态和影响。最终，本文的目的是提供一个关于以下问题的认识：城市关系的有效性，以及智能或信息通信技术主导的城市化的政治和空间的争夺性质（特别是在非洲城市的背景下）。

关键词
电力、ICT、内罗毕、电信、城市基础设施、水

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 characterised 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, 2017), Nairobi has been recognised by critics and scholars alike as a sphere of smart technologies, innovations and approaches (Graham and Mann, 2013; Omwansa and Sullivan, 2012; Poggiali, 2017). Moreover, as Kenya's capital, and political and economic hub, with a population of over 3 million, Nairobi represents some of the most salient transformations with regard to infrastructural development and

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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 realising the service delivery goals (Government of Kenya 2007; Poggiali, 2017). Moreover, the ICT Transformation Roadmap 2015–2020 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 prioritised 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 data set 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 data set 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 organisations including the World Bank and UN-Habitat in Nairobi. Snowball 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 universalising supply, maximising returns on investment and expanding centralised 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.

Framing the debate

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 specialised studies covering a wide range of sub-themes and perspectives (i.e. Graham and Marvin, 2002; Jackson et al., 2007; Wheeler et al., 2000). 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 subdiscipline within urban studies (Luque-Ayala and Marvin, 2105). As a rising discourse at the interface of technological and urban networks, smart urbanism envisages ICT-driven societies. It characterises 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, computerised networks and centralised control responses, to big-data analytics and data-driven governance, fixed and wireless telecommunications networks, digitally controlled utility services and innovations, etc. (Kitchin, 2014, 2018; Luque-Ayala and Marvin, 2015).

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; Odendaal, 2011; Watson, 2014).

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. Foster et al., 2012; Krolikowski, 2014) and electricity (i.e. Baptista, 2015, 2016), 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 pre-eminent 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 materialised. 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 neoliberal 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.

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; Lawhon et al., 2018; Monstadt and Schramm, 2017; Nilsson, 2016). This literature has scrutinised 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 characterised 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' (Lawhon et al., 2018; Jaglin, 2014; Monstadt and Schramm, 2017: 6).

The above insights offer a basis for conceptualising 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.

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 (Charton-Bigot and Rodriguez-Torres, 2006; K'akumu and Olima, 2007). Nairobi later became an administrative centre, and in 1907, the capital of British East Africa (Guma, 2016; Owuor and Mbatia, 2012). 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 as 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 prioritised by the 2010 Constitution (Government of Kenya, 2010) and identified as critical to the government's realisation 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. Johnson, 2009; KPLC, 2006; NCWSC, 2011). 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 neoliberal 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 unserviced for prolonged periods, or face persistent power blackouts and water rationing. For instance, only about 50% of urban residents in Nairobi receive piped water from NCWSC, and of these, only about 40% have 24-hour access to water (NCWSC, 2017). Likewise, although KP reports that it is now supplying over 80% of Nairobi's households with electricity, this figure is often politicised 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 vandalising, bypassing or tampering with water pipes and electricity transformers.

In the midst of these complexities, in situ incremental and self-organised 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 centralised 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 prioritised sectoral and organisational 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.

Deploying ICTs for urban water and electricity supply

Since its formal liberalisation 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, 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 digitalise 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, 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.

The beginnings of mobile payments

The late 2000s saw water and energy providers in Nairobi begin to look beyond basic tools that enabled the computerisation 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 computerising and mobilising 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* lies 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 standardised 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 Table 1.

As Table 1 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 realisation of efficiency and

Table 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 Maximise 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 utilisation 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

Source: The result of researcher's compilation from field research, 2018.

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 centralised control, sometimes at the expense of the needs of recipients. Moreover, these utility providers also sought to further marketise 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. Specialised 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 optimised 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 prioritise corporate and technocratic goals – such as increasing sales and revenue collection, expanding the market share, maximising returns on investment, and guaranteeing cost recovery – more than contextual and socio-political dimensions. In the following subsection, I show how utility providers, in their attempt to connect more to contextual and socio-political realities, began to emphasise a kind of bottom-driven and socially

organised pro-poor initiative, largely shaped by the spatial diversity of Nairobi.

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' (Wheeler et al., 2000). Table 2 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 centralised 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.

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 2000 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, materialising in the form of Okoa Stima.

Table 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.

(continued)

Table 2. Continued

Operation	ICT solution	Scope	Launch	Modality	Typology	Key actors	Focus	Particularities
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.

(continued)

Table 2. Continued

Operation	ICT solution	Scope	Launch	Modality	Typology	Key actors	Focus	Particularities
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.

Source: The result of researcher's compilation from field research and review of secondary sources.

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 realising 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 1. Also, as Table 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 (NCWSC, 2011, 2016; World Bank – WSP, 2015). 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 politicised. The 'token water initiative' listed in Table 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 vandalised 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. Organised 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 digitalisation 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 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 because of 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 – because of 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 stabilisation, expansion and monopoly for large-scale centralised 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.

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; Poggiali, 2017; Watson, 2014). 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 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 standardised 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' (Kitchin, 2018: 20). As this paper has shown, utility providers in their motives exploit the process of universalisation through diversification. For example, they are essentially driven by the desire to expand their market share, recover costs, generate revenue, universalise supply, realise monopolies, push heterogeneous service constellations such as 'informal' service providers and 'cartels' out of the market, and by design, universalise 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 realise 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 aimed at 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 politicisation 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 characterised 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 digitalisation 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 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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Appendix: List of cited interviews

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