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Hybrid Constellations of Water Access in the Digital Age: The Case of Jisomee Mita in Soweto-Kayole, Nairobi

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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 meter 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.

KEYWORDS: Water infrastructure, digital technologies, urban planning, African cities, Nairobi, Kenya

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.

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.

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.

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.

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 evolvment 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.

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.

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.

Innovation typology and system architecture

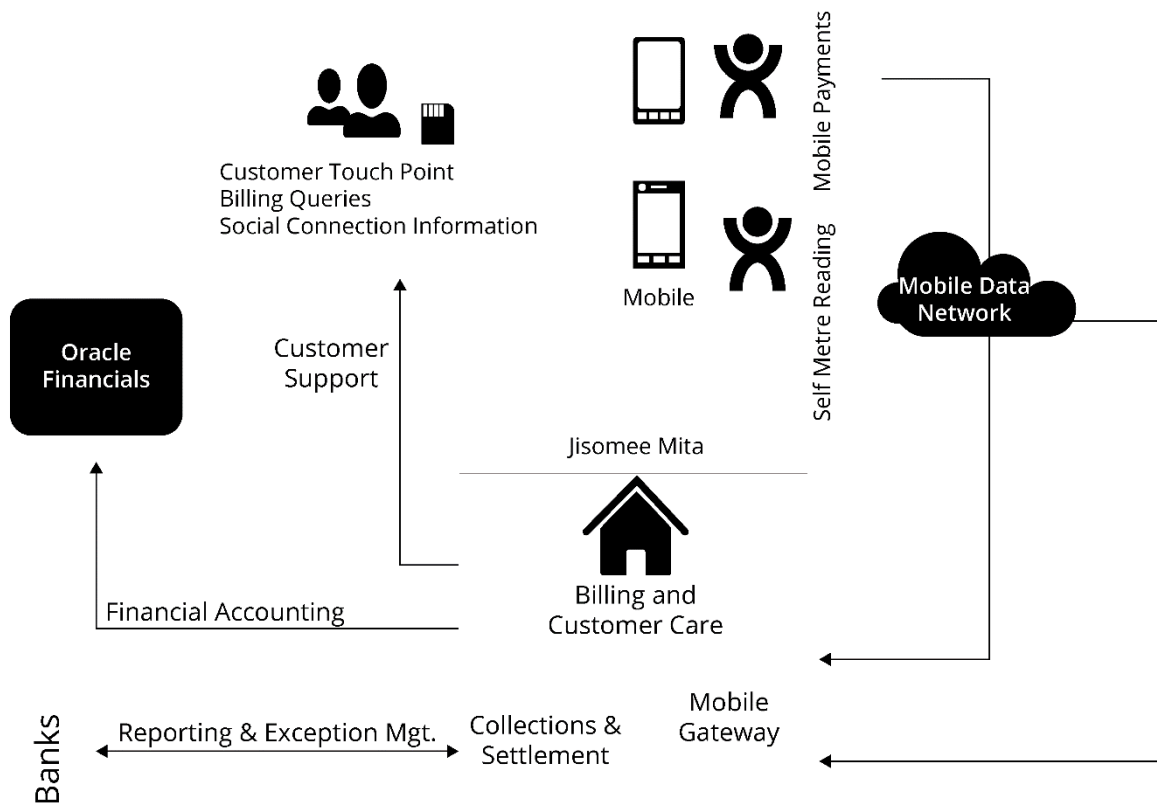
Jisomee Mita was launched in May 2014 by NCWSC. It is an infrastructure development project that is designed to provide access to networked water services in Soweto-Kayole. It is based on a hybrid technological constellation which combines ICT tools with an expansion of a network of water pipes. Jisomee 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 meter 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 I 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 meter reading, mobile-based invoice acquisition, system-related querying, water billing, and payment making. Jisomee Mita incorporates prepaid crediting mechanisms, self meter 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.

Figure 1. Jisomee Mita system architecture.



Source: Mwangi et al. (2015).

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 meter 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.

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 aimed at 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).

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 meter 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.

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 pre-designed 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 aimed at 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 meter 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 2 below), in part to prevent theft, but also to prevent constant monitoring and supervision by the CDAs.

Figure 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: Lead author (2016).

To encapsulate Jisomee Mita's evolution 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 pre-designed 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 meter 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.

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 meter 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 technopolitical 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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REFERENCES

- Amin, A. and N. Thrift, 2017. *Seeing like a city*. John Wiley and Sons.
- Anand, N. 2017. *Hydraulic city: Water and the infrastructures of citizenship in Mumbai*. Durham: Duke University Press.
- Baptista, I. 2015. 'We live on estimates': Everyday practices of prepaid electricity and the urban condition in Maputo, Mozambique. *International Journal of Urban and Regional Research* 39(5): 1004-1019.
- Baptista, I. 2013. Everyday practices of prepaid electricity in Maputo, Mozambique. InSIS Working Paper Series. Institute for Science, Innovation and Society. University of Oxford.
- Behrends A.; Park, S.-J. and Rottenburg, R. 2014. Travelling models. Introducing an analytical concept to globalisation studies. In Behrends, A.; Park, S.J. and Rottenburg, R. (Eds), *Travelling models in African conflict management. Translating technologies of social ordering*, pp. 1-40. Brill: Leiden and Boston: Brill.
- Braadbart, O. 2009. North-south transfer of the paradigm of piped water: The role of the public sector in water and sanitation services. In Castro, J.E. and Heller, L. (Eds), *Water and sanitation services. Public policy and management*, pp. 71-85. London: Earthscan.
- Charton-Bigot H. and Rodriguez-Torres, D. (Eds). 2010. *Nairobi today: The paradox of a fragmented city*. African Books Collective.
- Coutard, O. 2008. Placing splintering urbanism: Introduction. *Geoforum* 39(6): 1815-1820.
- Coutard, O. and Guy, S. 2007. STS and the city: Politics and practices of hope. *Science, Technology, and Human Values* 32(6): 713-734.
- de Bercegol, R. and Monstadt, J. 2018. The Kenya Slum Electrification Program. Local politics of electricity networks in Kibera. *Energy Research and Social Science* 41: 249-258.
- Edgerton, D. 2006. *The shock of the old. Technology and global history since 1900*. Oxford University Press: Oxford.
- Egyedi, T.M.; Mehos, D.C. and Vreeth, W.G. 2012. Introducing inverse infrastructures. In Egyedi, T.M. and Mehos, D.C. (Eds), *Inverse infrastructures: Disrupting networks from below*, pp. 1-14. Cheltenham, UK/Northampton MA, USA: Edward Elgar Publishing.
- Foster, T.; Hope, R.; Krolkowski, A. and Cohen, I. 2012. Mobile water payments in urban Africa: Adoption, implications and opportunities. In Grafton, Q.; Wyrwoll, P.; White, C. and Allendes, D. (Eds), *Global water: Issues and insights*, pp. 101-106. Oxford, UK: Oxford University.
- Gandy M. 2004. Rethinking urban metabolism: Water, space, and the modern city. *City* 8(3): 363-379.
- Gandy M. 2006. Planning, anti-planning, and the infrastructure crisis facing metropolitan Lagos. *Urban Studies* 43(2): 63-75.
- Graham, S. and Simon, M. 2001. *Splintering urbanism: Networked infrastructures, technological mobilities and the urban condition*. London: Routledge.
- GSMA. 2016. Mobile for development utilities mobile-enabled solutions for improved water service delivery in Nigeria.
- Guma, P.K. 2019. Smart urbanism? The rise of ICTs for water and electric supply in Nairobi, *Urban Studies*. In Monstadt, J. and Coutard, O. (Eds), *Interfacing infrastructures in cities: Politics and spatialities of the urban nexus*, pp. 1-20.

- GW, 2016. Africa's mobile revolution: Calibrating the role of mobile technology in Africa's water future. www.emiliefilou.com/wp-content/uploads/2016/05/Mobile-tech-in-African-water-utilities.pdf (accessed on August 2018)
- Hope, R.A.; Foster, T.; Krolikowski, A. and Cohen, I. 2011. *Mobile water payment innovations in urban Africa*. School of Geography and the Environment and Skoll Centre for Social Entrepreneurship at Saïd Business School, Oxford University, UK.
- Jaglin, S. 2014. Rethinking urban heterogeneity. In Parnell, S. and Oldfield, S. (Eds), *The Routledge Handbook of Cities of the Global South*, pp. 434-447. London: Routledge.
- Kariuki, M.; Collignon, B.; Taisne, R.; Valfrey, B. and Plummer, J. 2003. Better water and sanitation for the urban poor. In Plummer, J. (Ed), *Water utility partnership for capacity building (WUP) Africa*, pp. 1-105. Abidjan, Côte d'Ivoire: Union of African Water Suppliers (Union Africaine des Distributeurs d'Eau).
- Kjellen, M. 2000. Complementary water systems in Dar es Salaam, Tanzania: The case of water vending. *International Journal of Water Resources Development* 16(1): 143-154.
- Kirsch, T.G. 2006. Illegal connections: Conflicts over electricity, Soweto. *Soziale Welt* 16: 193-208.
- Koehler, J.; Thomson, P. and Hope, R. 2016. Mobilizing payments for water service sustainability. In Evan, T.A. (Eds), *Broken pumps and promises*, pp. 57-76. Springer International Publishing.
- Kyessi, A.G., 2005. Community-based urban water management in fringe neighbourhoods: The case of Dar es Salaam, Tanzania. *Habitat International* 29(1): 1-25.
- Lawhon, M.; Nilsson, D.; Silver, J.; Ernstson, H. and Lwasa, S. 2017. Thinking through heterogeneous infrastructure configurations. *Urban Studies* 55(4): 720-732.
- Majale, M.M. 2002. Tenure regularization in Informal settlements in Nairobi, Kenya. In Kreibich, V. and Olima, W.H.A. (Eds), *Urban land management in Africa*, pp. 267-283. Dortmund: Spring Centre.
- Monstadt, J. and Schramm, S. 2017. Toward the networked city? Translating technological ideals and planning models in water and sanitation systems in Dar Es Salaam. *International Journal of Urban and Regional Research* 41(1): 104-125.
- Mwangi, P.; Nduati, O.L. and Ndakorerwa, C. 2015. Innovation in scaling up access to water and sanitation services in Kenya. Briefing note to support innovation in scaling up access of water and sanitation services to urban low-income areas. Water and Sanitation Program, World Bank.
- Nganga, N.G. 2012. Information and communication technology and customer service delivery at Nairobi City Water and Sewerage Company. PhD Dissertation, University of Nairobi, Nairobi, Kenya.
- NCWSC, 2014. Nairobi City Water and Sewerage Company Limited Strategic Plan 2014/15-2018/19. NCWSC, Nairobi, Kenya.
- Ndaw, M.F. August, 2015. Unlocking the potential of information communications technology to improve water and sanitation services: Kenya Case Study. World Bank/WSP.
- Odendaal, N. 2014. Space matters: The relational power of mobile technologies. *Urbe. Revista Brasileira de Gestão Urbana* 6(1): 31-45.
- Republic of Kenya, 2010. Constitution of Kenya. Government Printer. Nairobi, Kenya.
- Republic of Kenya, 2007. Vision, Kenya. 2030. A globally competitive and prosperous Kenya. Nairobi, Kenya.
- Robinson, J. 2014. New geographies of theorizing the urban: Putting comparison to work for global urban studies. In Parnell, S. and Oldfield, S. (Eds), *The Routledge handbook on cities of the global South*, pp. 79-92. London: Routledge.
- Schramm, S. and Wright-Contreras, L. 2017. Beyond passive consumption: Dis/ordering water supply and sanitation at Hanoi's urban edge. *Geoforum* 85: 299-310.
- Simone, A. and Pieterse, E. 2018. *New urban worlds: Inhabiting dissonant times*. John Wiley and Sons.
- Thuo, J.J. 2013. ICT Outsourcing at Nairobi City Water and Sewerage Company. PhD thesis, School of Business, University of Nairobi, Nairobi, Kenya.
- van Heusden, P. 2009. Discipline and the new "logic of delivery": Prepaid electricity in South Africa and beyond. In McDonald, D.A. (Eds), *Electric capitalism: Recolonizing Africa on the power grid*, pp. 229-247. Cape Town, South Africa: HSRC Press.

- von Heland, F.; Nyberg, M.; Bondesson, A. and Westerberg, P. 2015. The citizen field engineer: Crowdsourced maintenance of connected water infrastructure. Scenarios for smart and sustainable water futures in Nairobi, Kenya. In von Heland, F. (Ed), *EnvirolInfo and ICT for Sustainability*. Atlantis Press.
- von Schnitzler, A. 2016. *Democracy's infrastructure: Techno-politics and protest after apartheid*. Princeton University Press.
- von Schnitzler, A. 2013. Traveling technologies: Infrastructure, ethical regimes, and the materiality of politics in South Africa. *Cultural Anthropology* 28(4): 670-693.
- Wamuchiru, E.K. 2017. Rethinking the networked city: The (co-)production of heterogeneous water supply infrastructure in Nairobi, Kenya. PhD thesis, Technische Universität, Darmstadt, Germany.
- World Bank. 2015. Leveraging water global practice knowledge and lending: Improving services for the Nairobi water and sewerage utility to reach the urban poor in Kenya. International Bank for reconstruction and development, and the World Bank.
- Zérah, M.H. 2008. Splintering urbanism in Mumbai: Contrasting trends in a multilayered society. *Geoforum* 39(6): 1922-1932.

APPENDIX: LIST OF CITED INTERVIEWS

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)

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