



Fluidities and Fixities: Examining the Alignment of Digital Platforms Within Nairobi's Heterogeneous Infrastructural Configurations

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Across the Global South, digital platforms have become increasingly present in the understanding, management, and operation of cities and their infrastructures. In examining the impact of digital platforms within urban infrastructures however, the experiences of cities of the South, and especially informal urban settlements, remains significantly overlooked when considering the impact of digital technologies on urban processes. With digital technologies and associated platforms becoming ever more embedded within the infrastructures of informal settlements, the lack in understanding around the consequences of this insertion for one billion of the world's population, is something that urgently needs to be addressed. This paper attends to this deficit by examining how digital platforms are being designed in respect of the socio-technical setting of informal settlement infrastructures and the consequences for infrastructural change of their insertion. Focussing on four digital platforms deployed within Nairobi's water and energy infrastructures, the paper builds on the theoretical efforts of urban political ecology framing infrastructures as power laden socio-environmental constructions and goes on to utilize the analytical entry points provided by the notion of heterogeneous infrastructural configurations. The findings identify that, although the digital platforms developed new avenues for infrastructural change via opportunities for utilizing data as leverage, they also created fixities for users that caused disjuncture with the natural fluidity that existed within the informal settlements. The findings note that not only do digital platforms reconfigure dynamics of power within heterogeneous infrastructural configurations but they also create opportunities for learning around the intersection of infrastructural flexibility and digital fixities.

Keywords: Nairobi (Kenya), data, informal settlement, digital platforms, infrastructure

INTRODUCTION

For the one billion of the world's population residing within informal settlements (UN Habitat, 2016), their infrastructural reality is one that often differs markedly from the networked and uniform versions of infrastructures that most of the Global North experiences. In Kenya's capital Nairobi, 60% of the population live within the city's informal settlements which means that daily engagements with infrastructures are the norm rather than the exception for the city (*ibid*). For Nairobi and many other cities in the Global South, the infrastructures serving informal urban

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areas and their vital labor force are often either non-existent or suffer from a multitude of issues (World Health Organization and United Nations and Human Settlements Programme, 2010). With ongoing rates of urbanization and informal urban settlements predicted to absorb large portions of the build out of urban populations (UN Habitat, 2016), understanding the infrastructural dynamics of these areas is key in efforts to develop sustainable and equitable cities in the future.

For informal settlements, areas traditionally defined as sites of insecure land tenure and a lack of adherence to planning and building regulations (UN Habitat, 2003), uneven urban geographies, a lack of governmental oversight and inadequate infrastructural provision have resulted in communities within these areas establishing alternative arrangements of infrastructures so as to enable their survival. In developing alternative and often informal establishments of infrastructures, these communities can create infrastructures that are highly fragmented, susceptible to shocks, costly and potentially dangerous to human health (Simone, 2004). With increased academic attention regarding the emergence, dynamics and growth of informal urban settlements (Dovey and King, 2011), it emerges that although these areas vary in their manifestation, many share similar infrastructural challenges (McFarlane, 2008). Over the last few years however, information communication technologies (ICTs) have increasingly been positioned as solutions that can be plugged into the infrastructures of informal settlements in order to solve or mitigate many of the challenges they face. Initiated and led by various actors such as governments, charities, and technology companies, cities across the Global South are witnessing an increasing convergence between digital and physical spheres at points of infrastructure (Datta, 2015, 2018).

In recent years Nairobi has become a key node within global ICT networks and, as evidenced by the Nairobi Integrated Urban Development Master Plan (NIUPLAN) and the Nairobi Metro 2030 Vision, ICT and smart technologies are key both in improving the infrastructure of the city and pushing the country toward a knowledge based economy (Hanna, 2016; Guma, 2019). With the landing of fiber optic cabling (Waema and Ndung'u, 2012), the establishment of supportive open data initiatives (Ndemo, 2015), the development of the mobile banking phenomenon *M-Pesa* (Jack and Suri, 2011) and an emergence of innovation hubs across the country (Mwaniki, 2017), Nairobi has become a hotspot of digital innovation and implementation. Although academic and media attention often focuses on ICT's infrastructural implementation within wealthier areas of the city (Guma, 2019), advanced digital technologies such as those of the Internet of Things (IoT) are increasingly becoming embedded within informal urban settlements such as Mathare, Mukuru Kwa Njenga, and Kibera and the infrastructures that serve them (Guma, 2019; Chambers and Evans, forthcoming). As a consequence of ICTs integration within the infrastructures of Nairobi's informal urban settlements and against a backdrop of rapid uptake of mobile payment services such as *m-pesa*, digital platforms have begun to emerge as new points of engagement between citizens and infrastructures in the city.

Traditionally, digital platforms refer to the computational and coding elements of data and associated networks (Gillespie, 2010), which form the visible interfaces common in content sharing websites and social media applications (Plantin et al., 2018). In addition to having broader architectural, figurative and political implications (Gillespie, 2010), digital platforms such as Uber, AirBnB, and Facebook have become so central within urban life and its processes that "their related code and content are becoming nearly as important as a city's bricks and mortar" (Shaw and Graham, 2017, p. 908). Termed "platform urbanism," this notion positions platforms as "new, complex multi-stakeholder ecosystems [which] bring together private and public organizations" that respond to and shape the urban processes which create cities (van der Graaf and Ballon, 2019, p. 368). Furthermore, whilst digital platforms have been noted as enabling a greater understanding of urban flows, reducing costs, helping achieve sustainability goals, spurring innovation and accessing new markets (Esposito De Falco et al., 2017), they also present challenges and tensions. As Morozov (2015) suggests, the reliance on digital platforms for solving urban challenges constitutes a push toward solutionism, whereby the integration of digital technologies solves singular issues, rather than engaging in broader political or societal discourses about what causes these challenges in the first place. Furthermore, both Morozov (2013a) and Hill (2014) suggest that many digital platforms represent what can be termed a "parasitic relationship" whereby these tools extract profit from infrastructural inefficiencies whilst simultaneously offering little in the way of improving these underlying infrastructures, and if anything, benefitting from these configurations remaining in this state. Ultimately, digital platforms can prey on urban challenges, but rather than solve these, offer ways out for those with access to technology or who are willing to pay.

Despite a global proliferation of digital platforms and their integration within numerous urban operations, much of the examination around these tools has tended to focus on their implementation within cities of the Global North, thereby overlooking their manifestation within the Global South (van der Graaf and Ballon, 2019). In challenging this deficit in understanding, work examining the proliferation of ride hailing apps in Africa by (Hema and Sifolo, 2017), the rise of M-health in the Global South (Aker and Ray, 2010) and the impacts of digital labor platforms across Africa and Asia (Graham et al., 2017) provides some examples of critical examination around the manifestation of digital platforms in these areas. Increasingly however, and as noted earlier in the case of Nairobi, the physical infrastructures that hold together many cities of the South, are becoming interwoven at various points by digital platforms, something that has yet to be critically examined, especially within the context of informal urban settlements.

Building on theories framing infrastructure as power laden socio-material systems such as urban political ecology (Heynen et al., 2006; Njeru, 2006; Silver, 2015) and in echoing calls for situated understanding of the infrastructural realities faced by many in the Global South (Jaglin, 2015; Coutard and Rutherford, 2016). Lawhon et al. (2018) present the notion of heterogeneous infrastructural configurations (HICs) as an

analytical tool for examining these socio-material arrangements. In doing so, Lawhon et al., push thinking around infrastructures to better accommodate the numerous visible and hidden complexities embedded within these arrangements, the dynamics of power they hold, their spread and diffuse geographies and the difficulties in neatly distinguishing or separating infrastructural artifacts from one another. HICs represent the infrastructural realities of many informal settlements, noting the array of options available for citizens, the exchanges that differ from a traditional “system,” the socio-material relations between people and objects and the lack of a universal official observer. Drawing on empirical work of others on infrastructures of the Global South, the notion of HICs encompasses wider thinking of the dynamic, changing and continuously reconfiguring nature of many of these infrastructures (Silver, 2014) and challenges the binary notion of these infrastructures existing as purely informal or formal configurations (Lawhon et al., 2014). This notion of infrastructural reconfiguration and infrastructural change is noted as both a symptom of the lack of capital investment within informal urban settlement and something that has enabled these areas to survive and adapt (Maringanti and Jonnalagadda, 2015). By being able to adapt to infrastructural shocks, shifts in power and resource disruptions, the changing, fluid nature of HICs has allowed populations relying on them, often located on socio-economic margins, to navigate everyday urban challenges (Thekdi and Chatterjee, 2019).

The analytical lens provided by HICs, allows exploration of how infrastructures fit into complex “socio-political urban geographies” (Lawhon et al., 2018, p. 722) and provides openings for understanding the impact that infrastructural interventions can make in these dynamic configurations. In addition, understanding how these configurations play out, enables examination of the power relationships embedded within these socio-material constructions. When we consider the integration of ICTs within the infrastructures of informal settlements therefore, HICs emerges as a key analytical framing that enables in-depth examination around the impact of digital technologies within these configurations. Given the heterogeneous realities that exist in the infrastructural configurations of many informal settlements, it becomes evident that in order to understand the consequences of digital platforms within these areas, examination must be led by an understanding situated within local dynamics.

In the case of Nairobi, a handful of efforts have examined the consequences of the digital turn for infrastructures of the city. The heterogeneous realities of Nairobi's informal settlement infrastructures has been well-identified by Wamuchiru (2017), who notes that in the case of the city's water infrastructures, the various water provisioning mechanisms involve multiple arrangements of water trucks, exposed pipes, illegal vendors, state powers, and numerous other artifacts and actors. Work by Guma (2019), identifying the dynamic, overlapping and heterogeneous infrastructures many in the city rely on, notes that ICT integrations being led by major infrastructure providers have resulted in an increasing homogenization of infrastructural configurations, resulting in a squeezing out of informal/illegal

activities and a universalization of urban space (*ibid*, 17). In other work, Guma et al. (2019) identify how users of ICT interventions within the infrastructures of informal settlements, end up adapting, adjusting and reconfiguring these top-down efforts in order to better deal with the heterogeneity of current infrastructural systems. Despite the aforementioned efforts examining the alignment between ICT interventions and Nairobi's HICs, these works have predominantly focussed on digital technologies deployed by large infrastructure providers such as Nairobi City Water and Sewerage Company and Kenya Power and Lighting Company. Although an important aspect, this focus can tend to overlook the multiple ways in which smaller ICT operations are entering into this space, specifically within the dynamics of informal urban settlements.

The integration of digital platforms within urban infrastructures, predominantly explored within cities of the Global North and formal infrastructural arrangements, is increasingly becoming common within informal urban settlements. As noted earlier however, with the alternative infrastructural realities of informal urban settlements and associated networks of power, this new space of digital platform emergence needs to be understood from an infrastructural perspective that accommodates the dynamic, heterogenous and reconfiguring nature of these socio-material arrangements. Given the deficit in current understanding, this paper aims to explore the consequences of inserting digital platforms within the HICs of informal urban settlements, examining the notion of change and reconfiguration present within these infrastructures. The paper focuses on Nairobi and draws from four case studies of digital platforms integrated within the infrastructures of its informal urban settlements. Through this examination, the paper not only provides insights around the integration of digital platforms in Nairobi, but also helps spur further examination for informal urban settlements globally. In addressing the aim of the paper, two research questions are posed;

- How are digital platforms being designed and deployed with consideration to infrastructural change, within Nairobi's informal settlements?
- What opportunities or constraints do digital platforms present for infrastructural change within Nairobi's informal settlements?

Data collection involved one user focus group (7 persons) and forty interviews with relevant stakeholders, including the platform users (20), developers (4), and managers (4). Interviews were also held with others who worked directly on digital platforms in Nairobi, including employees of global development organizations (4), community activists (2), charity workers (1), government officials (2), and experts (3). The various transcripts and notes were subsequently coded and analyzed (Strauss and Corbin, 1990). Full anonymity was offered to those taking part in the research, and the interviews and focus groups have been labeled with codes that correspond to their relevant transcript (e.g., F1). The work was undertaken during the period of September 2017 and May 2018, with the data collection primarily being undertaken by the author of this paper with the help of a Kenyan research assistant during periods

where translation and interpretation were required. The research selected four platforms in order to provide enough depth to the investigation and to allow examination of both water and energy infrastructures. The four platforms selected were as follows.

1. This digital platform was developed by a medium sized, private, for-profit company (10–20 persons), Paygo Energy, that used their smart technologies within LPG infrastructure, allowing users to top-up via mobile phones services, whilst also enabling the company to track and monitor gas consumption. This organization primarily operates within informal settlements within Nairobi, although having plans for expansion. The company was launched in 2016, and via financial funding from various capital investment firms, has been able to expand its services and technologies.
2. This digital platform was developed by MobiTech Water Solutions, a private, for-profit company (5–10 persons) that designed metering devices to be installed within various water infrastructures across informal settlements. These devices generated data, which provided information to both operators and users about water levels and consumption rates. During the research, the company was primarily operating within Nairobi but since, has developed applications for beyond the city.
3. This digital platform was developed by Grundfos a large, for-profit international company (100+ persons), which has various operations across Africa. Through working with Nairobi Water & Sewerage Company (NWSC), Grundfos created water consumption points which could be accessed via smart card top-up system. From this system, a digital platform emerged which allowed operators of water points and managers of related water infrastructure to monitor water levels, track consumption and increase financial accountability.
4. This digital platform had been created as a pilot study between the U.N, Ericsson and NWSC to allow the collection, analysis and sharing of data around water distribution. With complex arrangements for water provisions in Nairobi, this project, *Maji Wazi*, endeavored to work with local “citizen observers” to develop real-time devices for monitoring water flows within informal settlements and to create platforms that allow people’s voices to be heard by key decision makers. The project had recently ended when this research began.

In the following empirical sections, the paper identifies how many of the digital platforms examined explicitly attempted to incorporate local knowledge and infrastructural realities within their design, rather than attempting to fit infrastructures around the digital platform. The findings also demonstrate how three of the digital platforms attempted to support communities in demanding infrastructural change by enabling groups to use the data being generated as leverage against organizations such as Nairobi Water and Sewerage Company in calls for infrastructural improvements. The paper then identifies that, despite the best efforts of the digital platforms to be situated within local infrastructural realities, these digital tools create challenging fixities for systems based around flux and fluidity. Following on from this, the paper examines the findings within broader understanding around digital platforms and infrastructures of

the Global South, noting how the heterogeneity of infrastructures within informal settlements acts as a fertile ground for digital platforms but through their insertion, these data tools can end up prising open these spaces to new flows of capital and potentially making these once fluid infrastructures more fixed. The paper concludes by identifying the contributions of these findings toward broader work around platform urbanism and infrastructural theories, whilst also identifying further research areas for consideration.

ACKNOWLEDGING AND ACCOMMODATING INFRASTRUCTURAL CHANGE IN DIGITAL PLATFORMS

In answering the first research question around whether, and how digital platforms were being designed and deployed in consideration to the changing and reconfiguring nature of the infrastructures they entered, the findings indicated two dominant considerations; that platforms were being designed to navigate the blurred infrastructural binaries of informal settlements and that they were attempting to account for the fluid state of infrastructure.

Framing Binaries

As noted earlier, within both the literature on infrastructural realities in the global South (Lawhon et al., 2018) and Southern urbanism (Schindler, 2017), there is growing acknowledgment that analysis of urban life with the South needs to move away from one based on binaries such as informal/formal. If this focus remains, it is feared that the realities of many cities such as Nairobi will remain unaccounted for. During conversations with a range of stakeholders involved in the design and deployment of digital platforms within the infrastructures of Nairobi’s informal settlements, it became apparent that for many, the binaries that had often dictated previous ICT deployments were now being less attended to.

Many of the platform developers and managers, as well as associated stakeholders, often commented on what happens when digital platforms do not account for the blurred or perhaps non-existent binaries of everyday life within informal settlements. One prominent example that regularly emerged in discussions, that of BebaPay, was an attempt by Google and Equity Bank to create a prepayment card system that could replace financial transactions on Nairobi’s transport systems (Githira et al., 2019). As others have identified, the failures of this platform appeared as a combination of lack of user uptake and design issues (Mwesigwa, 2015). Stakeholders involved with designing the digital platforms researched often commented that BebaPay didn’t succeed because its creators did not understand how everyday life in Nairobi flows between different binaries, as opposed to being fixed to one (M37), with people traveling on both formal and informal forms of transport and possibly combining two jobs, one in a formal sector and one in the informal economy. Naturally, with citizens straddling these binaries, creating a digital platform that created fixed notions around cash storage meant that it was not in harmony with the everyday realities of thousands of people and hence, was bound

to fail. One global development employee working around digital platforms commented that for many people living in Nairobi, their lives “are engrained with informality” (M37), meaning that when digital platforms are developed, they need to incorporate this mode of living that influences how most of the city live, further suggesting that “if you don’t have the right framework in place... to support what [you] want technology to do, it won’t work” (M37).

Infrastructural choices available to residents within informal settlements, are often a dynamic spectrum rather than a fixed selection (Silver, 2014), meaning that a resource can often flow between alternative configurations before its final point of consumption. Whilst an awareness of this aspect was not always at the forefront of digital platform developers’ minds at the start of the design process, they soon understood the infrastructural realities that needed to be built into their system. This change in thinking was evidenced by one platform developer (M29) who noted that, having come from Europe, they had assumed a formal/informal dynamic existed, but soon realized the complex relationships between these states, noting that water would often flow between different informal and formal configurations. The end result of this realization was that they then “designed the platform to be semi-formal” (M29) in order to accommodate this nuance.

Whilst infrastructural disruption can often leave urban populations in the Global North with few other options for accessing resources, given the requirement for officials to conduct repairs and the high infrastructural coupling (Hughes, 1993), the bottom-up nature of repairing and reconfiguring infrastructure in informal settlements means that the notion of something working or not is never a simple binary. Within these areas, components of infrastructural configurations can often break down but these can be repaired quickly, even if through short-term and informal processes. For the digital platforms investigated in this research, the infrastructures they entered into were often dominated by power shortages, causing tap valves to open and not shut (M2) or boreholes not being able to pump water due to a “lack of Phase 2 power connection” (F6). Therefore, the users of these platforms noted that these digital tools needed to operate “during the event of a power blackout, so we are still able to monitor and manage water at the facilities” (F8). Platforms therefore, needed to navigate this dynamic where small components of infrastructural configurations could fail and infrastructural systems were tied to each other. Whilst this interlink between infrastructures appeared prominent within the platform related to water, it was less so for the gas in terms of the LPG related platform, where instead the complex supply chains often dominated discussions. Despite this, for the LPG platform developers, they noted the demand and interlinks between different infrastructures, which meant that they designed platforms to complement the “different speeds at which the [infrastructural] cogs go” (M18), noting how these digital platforms would undoubtedly be used to support the work and repairing of other infrastructures.

Understanding Infrastructural Fluidities

As the literature identified, infrastructures within informal settlements can be seen as fluid constructions “given their

vulnerability to physical and socio-political pressures but also in how they are nearly impossible to demarcate fully, given their continuous production, maintenance and destruction by various parts of society” (Maringanti and Jonnalagadda, 2015, p. 366). These notions around fluidity often appeared as a concern during data collection in both the minds of stakeholders associated with platform development and the users of these digital tools.

As much of the literature around Southern urbanism suggests, and here focussing on Nairobi, the provision of resources within informal settlements is often tied to notions of illegality, which subsequently impacts the materiality and fluidity of infrastructures (Birongo and Quyen Lhe, 2005; Karekezi et al., 2008). Often, illegal activities such as cartels are central across large scale infrastructural configurations. As one platform developer noted “in order to understand the cartels, you need to understand the whole value chain... and vice versa” (M21), meaning that for them, their platform needed to navigate this aspect of illegality that would always be present. For another platform developer, they noted that a similar platform that was created had been able to tackle the monopoly that gangs had on water infrastructure control, but this was soon navigated by placing a gang member at the point of access of infrastructures, “so people would just go up and pay him” (M29) rather than use the digital platform. This meant that “even when this technology was implemented, the [water access] problem wasn’t solved” (M29). As one development organization employee noted, “Policemen are the bottlenecks of technology” (M19), further commenting that when designing platforms one must accommodate the influence of all aspects of what could constitute illegality, as otherwise those with power will merely muscle out any technology. Even when digital platforms had been created, developers identified challenges when dealing with local norms, with one platform developer noting how “conspiracy theories were spread by people with vested interested... they wanted to achieve different things to us” (M33), which meant that even after the deployment of digital platforms, there was a need to work with communities to dispel any misinformation. It should be noted that for the digital platforms working around LPG, the issue of misinformation was a particular problem and whilst the other three identified similar challenges, it was not at the same level that PayGo identified. Here, infrastructural fluidity was not something purely tied to material aspects or issues of supply and demand, but was also influenced by illegality, crime, nefarious power structures and even rumor, all of which the platforms needed to manage.

This attention toward alternative components of infrastructural fluidity was also present in discussions about how specific demographics and patterns of movement influenced the design and deployment of digital platforms. Within informal settlements, women are often central in the fetching, transportation and engagement of essential infrastructures for households (Sorenson et al., 2011), meaning that any infrastructural changes often directly impact the daily activities of many women. Two of the platform developers noted this aspect as central in designing their digital platforms, commenting that “women, and sometimes children, form 95% of the queues” for water, thereby necessitating their platform to be designed with the user interactions of these groups in mind (M1). This

platform developer also noted that with women often suffering from low literacy rates due to challenges with accessing basic education, the developer needed to design the platform so that it had a voice messaging option for those who were unable to read (M1). This issue around literacy emerged in conversations with Grundfos and PayGo platforms, but did not appear with the other two platforms. With women being the primary users of the platform, one platform developer also noted that they were the ones who needed to be consulted on how these digital tools aligned with local infrastructural dynamics (M18).

Wider population movements also influenced how platform developers and associated stakeholders framed infrastructural fluidity. Mirroring other cities of the South, there is a regular migration of people between Nairobi's informal settlements and their rural family homes, with people often moving for religious, ceremonial, familial, or economic reasons (Beguy et al., 2010). For users of the digital platforms examined, predominantly those of the LPG platform, many expressed annoyance at the inability of these platforms to accommodate this pattern of movement, with one user noting that the platform developers needed to "make it possible for someone to [take] the whole... set up to the countryside too" (J7) and another user noting that, "people will need to [eventually] move to even better places" (J4), so these digital tools needed to account for this. With the emerging frustration around digital platforms' inability to account for the fluidity of infrastructures in terms of people's movement, this research posed this tension to the platform developers, with three subsequently identifying that whilst this was outside their remit at the moment, it was something they wanted to incorporate into their digital platforms in line with future expansion.

OPPORTUNITIES AND CONSTRAINTS OFFERED BY DIGITAL PLATFORMS WITHIN NAIROBI'S INFORMAL SETTLEMENTS AND THEIR INFRASTRUCTURES

In answering the second research question around the opportunities or constraints offered by digital platforms for infrastructural change, the findings demonstrate one prominent opportunity in platform users being able to use data as leverage for infrastructural improvement. The findings also presented constraints caused by digital platforms in how they created infrastructural fixities and designed out the human component of HICs.

Data as Leverage

As noted earlier, the relationship between many digital platforms and urban infrastructures across the globe, is one that could be viewed as parasitic in its nature (Morozov, 2013b; Hill, 2014), due to how platforms profit from the inefficiencies or challenges of certain infrastructures whilst simultaneously doing little to positively change these configurations. Whilst this parasitic nature is evident in nearly every major global city, the global proliferation of Uber being an example of this, the digital platforms examined

here presented an element of contradiction to this notion of parasitism by working with infrastructure users and operators to utilize the generated data to leverage larger infrastructure providers.

Throughout the research, participants commented on the Kenya wide undervaluing of data. One expert commented that nobody sees data as a resource and that people didn't understand that when you give it out, it has consequences for others (M39). In addition, many commented that the Kenyan government's data collection efforts were poor, with one global development organization employee suggesting that "[the government] are problem solving first, but not collecting the data correctly or in the right framework" (M37). One expert on data management also commented that "The government just aren't informed enough [about data collection]... they just don't understand and can't make it happen in a clear process" (M39). Through a combination of minimal holistic societal understanding about the role of data, inadequate government efforts around data education and a general skepticism from informal settlement communities about data collection (M33), there appeared initially, little in the way of the communities engaging in conversations about utilizing the data generated from the platforms.

Against this backdrop of data challenges however, three of the digital platforms being researched expressed an explicit interest in working with users and operators of infrastructures within informal settlements in relation to using the data generated from the platforms as leverage for infrastructural improvement. The developers of one digital platform that works with water monitoring, commented that their "aim is to make the water data more available for them [users]" (M1) and that they "send graphs and data back to the users...[so] they can then open up dialogue with the water service providers" (M1). Because of this approach, the platform developers noted that NWSC had indicated they were able to have a more open dialogue with informal settlements regarding possible infrastructural changes (M1). For another platform working around water infrastructures, the developers commented on the importance of "teaching the [users] about graphs, statistics and charts...so they can download from the platform" (M9) and that through this approach "two communities have been able to engage with the city authorities by using the data as leverage...those in Mukru and Mathare" (M9). For the LPG platform however, whilst data was not necessarily leveraged directly by the users as with the other three platforms, there was interest from government authorities around better understanding how transitioning energy infrastructures could align with the needs of informal settlements.

Water rationing is a prominent feature within Nairobi's water infrastructures (Maseno, 2017) and, as a practice, is tied to numerous social and political dimensions across the city. For informal settlements, many can find water not being piped on the designated days or not at the flow required, often leading to road blockades and protests from residents of these areas (M29). One platform however, working around monitoring water was able to provide data about flows of water within the informal settlement of Mathare. Through this monitoring, the platform

developers worked with local water operators so that the data generated can be used to demonstrate to NWSC that water was not being supplied and negotiate its turning on, thereby providing another facet of data as leverage. The developers of this platform noted their focus on “presenting the data back to the community” (M29) as well as aiding in the larger infrastructural negotiations with senior stakeholders on NWSC. In addition, they commented that there needed to be much more “research on how best to present data to the [slum] community, so that is understandable and accessible,” given some of the challenges around data education (M29).

Creating Fixities

For the digital platforms examined in this research, three required an aspect of time or financial investment from those utilizing these services for either the monitoring or consumption of resources. In addition, two of these platforms required users to top up via mobile phones in order to be able to access technologies and services, which, as with many other digital payment platforms, created new dynamics. For many of the users of the digital platforms, they commented that infrastructural decisions were often taken on a day-to-day and short-term basis, as opposed to longer term planning. Whilst this is not to say all decisions were taken in this matter, the data demonstrated how infrastructural decisions are related to the small temporal and financial margins which many navigate on a daily basis within informal settlements. This sentiment was reflected by one expert on urban planning in Nairobi who noted that “people in informal areas are daily planners. . . they plan [their infrastructure choices] for that day” (M26).

For the digital platforms that entered into these complex infrastructural dynamics of informal settlements, it meant they created fixities for users, either through financial top ups or through a social connection around trust (Chambers and Evans, forthcoming), but when something went wrong with the platform, users were left struggling. One user noted that the digital platform they used for accessing LPG needed to make sure “that any top-up reflects instantly so that the customer can continue using the gas. . . at times we are forced to go source other types of field and we have already paid for the gas and that could have been the only money we had” (J8). Another user also commented that “Sometimes I top up say Ksh 100 hoping to use it for 2 days but it does not reflect and I am forced to incur extra Ksh 30 for charcoal” (F5). Whilst this issue of top-up delays on platforms was noted during conversations of the LPG platform, users and developers of the two platforms related to water payments did not identify such an issue. These quotes however, identify the financial precariousness associated with infrastructural access many within informal settlements face and that when platforms enter into this mix, they create new fixed dimensions, which result in people suffering if the technology fails. By creating fixities and dependencies, the digital platforms were having adverse effects on users within informal settlements through not accounting for the daily planning around infrastructures of informal settlement residents, an important aspect that contributes to the ever-changing and dynamic infrastructural configurations of these areas.

Designing Out Humans

A final finding that emerged from the data around how platforms were engaging with the dynamic and heterogeneous nature of infrastructures of informal settlements was identified in how these digital tools were designing out the need and role of human agency within infrastructural configurations. Whilst digital platforms do not always lead to efficiencies, with some ending up creating “more complexity and bureaucracy” (M33), there was an additional danger in how these tools were potentially pushing out the human element of infrastructures within informal settlements. Often, these bureaucracies and possible inefficiencies were vital in keeping local people in employment, as reflected by one user of a platform noting concerns that these digital tools may be eliminating both inefficiencies and local jobs in equal measure (M18). For both Paygo and Grundfos, in addition to their digital platforms, they also actively employed local residents within the new infrastructural configurations, potentially lessening the tensions around local employment. Although not visible in MobiTech's platform, the role of citizen field engineers in the now-defunct UN & Ericson platform, is another potential way to gain favor from local communities.

Another human element of HICs was presented by one planning expert, who noted “people value face to face interaction, [and] these kinds of platforms are killing that warmth of exchanging concerns and ideas,” further stating removal of this element means infrastructures aren't able to deal with potential shocks as well as previously (M26). Furthermore, another interviewee, a researcher and government advisor, commented that within Kenya, “people here want to see you in person. They want to know you're the one they're talking to” (M39) and by removing this interaction, platforms can create mistrust or skepticism within these infrastructures. For many of the digital platforms, the efficiencies within infrastructures were often tied to points within these configurations that involved human interaction, such as bribes and incorrect levels of resources being given (M29; M18), and their attempt to design these aspects out of these processes was negatively impacting the human element of infrastructural configurations, an aspect which had aided the continuously shifting nature of infrastructures within these areas.

DISCUSSION

As the findings demonstrate, although the platform developers attempted to accommodate the fluidity of infrastructures and navigate the realities of blurred binaries, the digital platforms being deployed within Nairobi's informal settlements created fixities and designed out the human component of the HICs they entered. The platforms did however, offer opportunities for infrastructural change through supporting the use of data as leverage in discussions between informal settlements, the state and major infrastructure providers. The following section examines these findings within theories of urban political ecology and Southern urbanism more broadly, as well as identifying what implications these have for further thinking around HICs.

Digital Platforms, Their Support and Challenge to Nairobi's Modern Infrastructural Ideal

Over the last few decades, the modern infrastructural ideal of networked, centralized systems has been a dominant driver of urban visions and plans for many cities in the Global North (Graham and Marvin, 2002). For the Global South and cities such as Nairobi, this infrastructural ideal, often focussed by countries during the latter half of the twentieth century through international development loans, still continuing today (Onjala, 2018), has significantly shaped the form of cities today as well as their internal dynamics. Traditionally, the demarcation of infrastructure in cities of the South has been conducted by identifying those of a formal nature, networked infrastructures delivered by major infrastructure providers, and “informal” infrastructures, those existing outside of formal regulation. For many governments and urban municipalities, such as Kenya and Nairobi city council, there remains an overarching push toward pushing out the heterogenous and “informally” denoted aspects of infrastructure within the city and instead toward rolling out networked, “modern” infrastructures led by top-down structures (Wamuchiru, 2017). As this paper notes, the reality for many within Nairobi and its informal settlements is one in which these state led networked infrastructural visions clash with “actually existing urbanisms” (Shaktin, 2011) and force the creation of heterogeneous infrastructural configurations so as to support the populations and livelihoods of these areas. As this paper's findings note, digital platforms are increasingly being embedded within these HICs and in doing so, are attempting to accommodate the infrastructural fluidities and blurred binaries that exist within these configurations, as opposed to state services that explicitly attempt to homogenize (Guma, 2019). Three of the platforms researched were explicitly designed to offer avenues for users and operators to use data generated as leverage in discussions with the state and major infrastructure providers. In doing so, the platforms present new opportunities for mediating state-citizen relationships around infrastructure, whereby technologies and infrastructures aren't black-boxed and hidden from view, but are illuminated and present in discussions about rights and environmental justice within these informal settlements. Furthermore, these platforms were giving agency to users within the HICs, by allowing them to manage their resource consumption from informal vendors whilst also being able to act as part of a collective when pushing complaints and queries to larger infrastructure operators such as Nairobi Water and Sewerage Company. Through these means, the digital platforms were not immediately acting as tools toward creating new, networked systems, but instead acted as supports of the HICs and potentially, offered new avenues for discussion and examination around the role of these infrastructural configurations in a future Nairobi.

Despite the aforementioned opportunities presented by the digital platforms in navigating tensions between the realities of HICs and the infrastructures led by larger private or state forces, and in doing so opening up spaces for rethinking

the future of non-networked infrastructures, the findings did point toward what seemed an inevitability with the digital tools designing out humans and creating infrastructure fixities. By attempting to reduce inefficiencies through navigating the human components of HICs, the platforms were inadvertently removing key nodes that support the ongoing fluidity of these infrastructures. Whether now or in the near future, removing the human aspect may open up these infrastructures to greater control and ownership from top-down structures. Furthermore, the fixities the digital platforms created such as individual financial investments and a technological reliance, resulted in users becoming tied to certain infrastructures. These ties meant that when inevitable resource supply and demand fluctuations happened in the informal settlements, users were less able to navigate these due to these new infrastructural fixities the platforms created. The digital platforms therefore, whilst not intentionally pushing HICs toward becoming part of networked structures, were inadvertently increasing the passivity of users by making them reliant on single infrastructures.

Spreading and Structuring Infrastructures Through Platform Urbanism

Digital platforms, as aggregators of artifacts, people, resource flows and networks, are shaping the city of the twenty first century in ways that previous technologies hadn't. As the findings present, platform urbanism is undoubtedly present within Nairobi's informal settlements, via the insertion of these digital tools within the infrastructures of these areas and the bringing together of new arrangements of actors and artifacts of formal/informal infrastructures. Platform urbanism is identified as an urban process enabling on-demand services such as mobility and allowing flexibility to urban flows through various applications (van der Graaf and Ballon, 2019), something present within the findings of this paper. The backdrop to platform urbanism however, is one based on networked infrastructures that dominate cities in the Global North and formal urban areas in the Global South. For the developers of platforms researched within Nairobi's informal settlements, flexibility was something already identified as existing within the HICs that support these communities but was not something explicitly intended to be offered via the platforms themselves. Whilst platform developers designed these tools to accommodate the blurred binaries and infrastructural fluidities of daily life, they also created fixities via the aforementioned financial fixities and technological dependence. Although understanding whether these communities wish to see greater infrastructural fixity or require further fluidity was beyond the scope of this research, the findings present tensions for further thinking around the manifestation of platform urbanism in Nairobi's informal settlements.

If platforms are to allow new modes of governance and alternative methods for value extraction (Srnicsek, 2017), platform urbanism is to represent the embedding of these new modalities within urban processes. For the platforms researched here, the fixities they created for users within informal settlements meant that flexibility, the very thing that had allowed these

areas, communities and infrastructures to survive, was being severely limited. Over the coming months and years, it will become apparent if users and communities within Nairobi's informal settlements were able to adjust to these infrastructural fixities created by these digital platforms. It is apparent that current framings of platform urbanism have yet to fully consider how the integration of platforms within infrastructures at a global scale. Whilst the integration of platforms within cities in the Global North is primarily based on offering flexibility to users within fixed, networked infrastructures, the embedding of these digital tools within informal urban settlements offers the opposite by providing assurances and fixities within already flexible infrastructures.

Digital Platforms as Infrastructural Lubricators

As urban political ecology would suggest, infrastructure acts as a key functional lattice that enables flows and circulations of capital within cities, thereby influencing the urban conditions faced by society (Swyngedouw and Heynen, 2003). In addition, these infrastructures and the structures of power they represent are, key components in directing urban change (Heynen et al., 2006). For the digital platforms researched here, they entered into infrastructural "functional lattices" that were highly fragmented, dynamic, and overlapping, often reconfiguring in order to accommodate changes in resource demand and supply. For the infrastructures of Nairobi's informal settlements, their ongoing changes, lack of holistic understanding and numerous socio-political issues meant that capital investment was low (Wamuchiru, 2017). As the findings identified however, the insertion of the digital platforms into these heterogeneous infrastructures, such as water and LPG networks, illuminated previously unknown infrastructural dynamics to state and private organizations outside of informal settlements. As one platform developer noted, by inserting digital platforms within these infrastructures, they were accessing "low-hanging fruit" (M18) by using these tools to understand previously hidden transactions and flows. As a consequence of this illumination, and during the fieldwork, platform developers noted they had received increased interest from government officials and major infrastructure providers who were keen to utilize these new data streams (M9; M18). When digital platforms were inserted within HICs of informal settlements such as Mukuru kwa Njenga and Kibera, it caused the power and control over infrastructural change to shift, with it now becoming more available to external forces outside of these areas. With slum upgrading programmes and large scale infrastructural transformations planned for Nairobi's informal settlements (Mitra et al., 2017), the findings here would suggest that in order to control both the narrative and practicalities of urban change, state forces may begin to harness technologies such as digital platforms to facilitate this.

CONCLUSION

For informal settlements of cities in the Global South, the infrastructures that guide the daily lives of one billion operate

in stark contrast to the dominant, networked infrastructures of cities in the Global North. As scholarly efforts within Southern urbanism and theoretical framings through urban political ecology suggest, the reality for many in cities of the South, and particularly within informal settlements, is one of multiple, overlapping, dynamic and continuously reconfiguring infrastructures (Jaglin, 2015). These infrastructures respond to the numerous socio-political and environmental pressures and in their form and materiality, reflect the power embedded within these socio-material configurations. For Lawhon et al. (2018), the dynamics of these infrastructures can be viewed from a perspective that frames them as "heterogeneous infrastructural configurations" and in doing so, intends to encapsulate the different aggregations of technologies, relations, actors and capacities (*ibid*: 726).

For urban infrastructures globally, the last decade has seen an increasing involvement of ICTs and digital technologies within these various configurations and networked systems. One prominent manifestation of the increased digitization of urban fabric has been the insertion of digital platforms within infrastructures of the city. The global proliferation of digital platforms has seen these tools aggregating networks, urban flows, resources and streams of data, thereby influencing the very processes that drive the experiencing, management and planning of cities. This interrelation between urban processes and these digital tools has been termed "platform urbanism" (van der Graaf and Ballon, 2019). Whilst offering insights for future digital and physical intersections in the city, platform urbanism at present has been little examined within cities of the Global South, and notably, within informal settlements and their infrastructures.

In addressing the deficit in understanding of the consequences of digital platforms within the infrastructures of informal settlements, and building on work around infrastructures in the Global South (Lawhon et al., 2014; Silver, 2014), this paper examines how these data tools were being designed for the HICs of informal settlements in Nairobi and the impact they had on the HICs of these areas. The findings of the paper identified that in the case of four digital platforms operating within the city's informal settlements, they presented alternative avenues toward reimagining infrastructure futures. This reimagination was demonstrated by the emergence of data leveraging, where users were able to utilize data from platforms to demand greater resource provision from state and major infrastructural providers. In doing so, this data leveraging potentially gave greater power to HICs and the people within them, during a time in which national visions are orientated around efforts to push out infrastructural heterogeneity in favor of larger networked, homogeneous systems. These digital platforms therefore, became tools in which citizen-state relationships and balances of power were becoming reconfigured, if only in small amounts and in short time scales. Furthermore, platform developers were keen to accommodate the blurred binaries existing within infrastructural realities of informal settlements and their fluid nature in the design and deployment of the platforms.

Despite the aforementioned support from the digital platforms researched for heterogeneity and infrastructural

change, the findings also point to a reality where the design of these data tools was creating fixities within these infrastructural configurations. In addition to designing out the human components of HICs so as to increase infrastructural efficiency within the informal settlements, the platforms also created fixities by leading users toward financial investment and reliance on certain infrastructures. These fixities meant that users were unable to navigate infrastructural hurdles and challenges that they had been able to do before the platforms. Whether directly or indirectly therefore, the digital platforms were removing notions of infrastructural change by reducing the agency of both workers and consumers through narrowing their options. Through creating these fixities, digital platforms may prise open infrastructural configurations of informal settlements so as to allow new circulations of capital that had previously found it difficult to understand or enter into these spaces.

Over the coming decades, the digitalization of cities will result in significant changes in nearly every urban aspect, from accessing infrastructures to processes of governance. For cities in the Global South, ICTs are often an attractive route for attempting to solve various political, economic, environmental and social issues. Responding to calls for radically rethinking African urban theory (Myers, 2011), this paper suggests a closer alignment between theoretical framings that examine the power laden relationships between the social and the environment, such as urban political ecology, and the scholarly engagements that examine the role of digital technologies and data within cities. Furthermore, with an increasing interest and acknowledgment of the role digital platforms play in cities, the manifestation of platforms in Nairobi's informal settlements and its alternative dynamics around infrastructural fluidity and fixities means that platform urbanism needs to be further understood from a global perspective. This holistic and global approach to examining the manifestation and consequences of platform urbanism, it must account for the everyday realities of the one billion living within informal urban settlements. This paper has provided initial entry points into the deficit in understanding of digital platforms and informal urban settlements, but with a vast range of digital technologies entering into urban dynamics and continued calls to develop situated urban theory from the Global South however (Lawhon et al., 2014), more in-depth empirical investigations are required.

The ongoing integration of advanced digital technologies such as the Internet of Things within our urban fabric, results in the mass of data generated becoming aggregated by digital platforms. These platforms are being currently utilized by a range of urban actors and have become both key tools and lenses for experiencing, managing and planning twenty first century cities (Kitchin and Perng, 2016). Data tools such as

digital platforms are central components in efforts toward creating smart cities, where ICTs are harnessed to help solve urban inefficiencies (Hollands, 2008; Peck, 2013). As the paper identifies however, notions of urban inefficiencies within smart city discourses are predominantly derived from an understanding about urban metabolisms in the Global North, often overlooking many of the social and cultural facets tied to resource flows, particularly apparent within informal urban settlements and HICs. Furthermore, smart city discourses often note a push toward creating spaces of experimentation and flexible urbanisms to understand the role digital technologies can play within the urban fabric (Calzada, 2018). This paper would argue that many of these spaces already exist in places such as Kibera and Mukuru kwa Njenga, informal urban settlements within heterogeneous infrastructural configurations. Rather than continuing to position wealthy urban enclaves of the Global North as "urban laboratories" and sites of digital experimentation, future efforts would do well to examine how already existing dynamic, flexible, and heterogeneous infrastructural configurations within informal urban settlements are currently navigating the embedding of digital technologies. If we wish to create flexible, on-demand cities with decentralized infrastructures, informal urban settlements already provide ideal testing grounds for exploring the realities of such futures.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Manchester University Ethics and Research Committee (UREC). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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REFERENCES

- Aker, S., and Ray, P. (2010). mHealth—an ultimate platform to serve the unserved. *Yearb. Med. Inform.* 19, 94–100. doi: 10.1055/s-0038-1638697
- Beguy, D., Bocquier, P., and Zulu, E. M. (2010). Circular migration patterns and determinants in Nairobi slum settlements. *Demogr. Res.* 23, 549–586. doi: 10.4054/DemRes.2010.23.20
- Birongo, J. M., and Quyen Lhe, N. (2005). *An Analysis of Water Governance in Kibera, Kenya. Report*. Roskilde: Department of environment, technology and social studies, University of Roskilde.
- Calzada, I. (2018). "From smart cities to experimental cities?" in *Co-Designing Economies in Transition*, eds V. M. Giorgino and Z. Walsh (Cham: Palgrave Macmillan), 191–217.
- Chambers, J., and Evans, J. (forthcoming). Reconfiguring. Informal Urbanism and the Internet of Things. Reliability, trust and the

- reconfiguration of infrastructure. *Urban Stud.* doi: 10.1177/0042098019890798
- Coutard, O., and Rutherford, J. (2016). "Beyond the networked city: an introduction," in *Beyond the Networked City: Infrastructure Reconfigurations and Urban Change in the North and South*, eds O. Coutard and J. Rutherford (London: Routledge), 294.
- Datta, A. (2015). New urban utopias of postcolonial India: 'Entrepreneurial urbanization' in Dholera smart city, Gujarat. *Dialogues Hum. Geogr.* 5, 3–22. doi: 10.1177/2043820614565748
- Datta, A. (2018). Postcolonial urban futures: imagining and governing India's smart urban age. *Environ. Plann. D Soc. Space* 37:0263775818800721. doi: 10.1177/0263775818800721
- Dovey, K., and King, R. (2011). Forms of informality: morphology and visibility of informal settlements. *Built Environ.* 37, 11–29. doi: 10.2148/benv.37.1.11
- Esposito De Falco, S., Renzi, A., Orlando, B., and Cucari, N. (2017). Open collaborative innovation and digital platforms. *Prod. Plann. Control* 28, 1344–1353. doi: 10.1080/09537287.2017.1375143
- Gillespie, T. (2010). The politics of 'platforms'. *New Media Soc.* 12, 347–364. doi: 10.1177/1461444809342738
- Githira, D., Opiyo, R., and Mwaniki, D. (2019). "Achieving regional development through enhanced connectivity in the Nairobi Metropolitan region," in *Smart Metropolitan Regional Development*, eds T. M. Vinod kumar (Singapore: Springer), 759–793.
- Graham, M., Hjorth, I., and Lehdonvirta, V. (2017). Digital labour and development: impacts of global digital labour platforms and the gig economy on worker livelihoods. *Trans. Eur. Rev. Lab. Res.* 23, 135–162. doi: 10.1177/1024258916687250
- Graham, S., and Marvin, S. (2002). *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition*. London: Routledge.
- Guma, P. K. (2019). Smart urbanism? ICTs for water and electricity supply in Nairobi. *Urban Stud.* 56, 2333–2352. doi: 10.1177/0042098018813041
- Guma, P. K., Monstadt, J., and Schramm, S. (2019). Hybrid constellations of water access in the digital age: The case of Jisomee Mita in Soweto-Kayole, Nairobi. *Water Alternat.* 12, 636–654.
- Hanna, N. K. (Ed.). (2016). "Mastering digital transformation: Towards a smarter society, economy, city and nation," in *Mastering Digital Transformation: Towards a Smarter Society, Economy, City and Nation* (Bingley: Emerald Group Publishing Limited), i–xxvi.
- Henama, U., and Sifolo, P. (2017). Uber: The South Africa Experience. *Afr. J. Hosp. Tour. Leisure* 6, 1–10.
- Heynen, N., Kaika, M., and Swyngedouw, E. (Eds.) (2006). *In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism*. Routledge.
- Hill, D. (2014). "Urban parasites, data-driven urbanism, and the case for Architecture," in *Architecture and Urbanism: Data Driven Cities*, Vol. 530, 6–10.
- Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial? *City* 12, 303–320. doi: 10.1080/13604810802479126
- Hughes, T. P. (1993). *Networks of Power: Electrification in Western Society, 1880–1930*. Baltimore, MD: JHU Press.
- Jack, W., and Suri, T. (2011). *Mobile Money: The Economics of M-PESA (No. w16721)*. National Bureau of Economic Research.
- Jaglin, S. (2015). "Is the network challenged by the pragmatic turn in African cities? Urban transition and hybrid delivery configurations," in *Beyond the Networked City* (London: Routledge), 200–221.
- Karekezi, S., Kimani, J., and Onguru, O. (2008). Energy access among the urban poor in Kenya. *Energy Sustain. Dev.* 12, 38–48. doi: 10.1016/S0973-0826(09)60006-5
- Kitchin, R., and Perng, S. Y. (2016). *Code and the City*. London: Routledge.
- Lawhon, M., Ernstson, H., and Silver, J. (2014). Provincializing urban political ecology: towards a situated UPE through African urbanism. *Antipode* 46, 497–516. doi: 10.1111/anti.12051
- Lawhon, M., Nilsson, D., Silver, J., Ernstson, H., and Lwasa, S. (2018). Thinking through heterogeneous infrastructure configurations. *Urban Stud.* 55, 720–732. doi: 10.1177/0042098017720149
- Maringanti, A., and Jonnalagadda, I. (2015). Rent gap, fluid infrastructure and population excess in a gentrifying neighbourhood. *City* 19, 365–374. doi: 10.1080/13604813.2015.1016341
- Maseno, L. (2017). Prayer for rain: a pentecostal perspective from Kenya. *Ecum. Rev.* 69, 336–347. doi: 10.1111/erev.12297
- McFarlane, C. (2008). Sanitation in Mumbai's informal settlements: state, slum, and infrastructure. *Environ. Plann. A* 40, 88–107. doi: 10.1068/a39221
- Mitra, S., Mulligan, J., Schilling, J., Harper, J., Vivekananda, J., and Krause, L. (2017). Developing risk or resilience? Effects of slum upgrading on the social contract and social cohesion in Kibera, Nairobi. *Environ. Urban.* 29, 103–122. doi: 10.1177/0956247816689218
- Morozov, E. (2013a). *To Save Everything, Click Here: Technology, Solutionism, and the Urge to Fix Problems that Don't Exist*. London, UK: Penguin Books UK.
- Morozov, E. (2013b). *To Save Everything, Click Here: The Folly of Technological Solutionism*. New York, NY: Public Affairs.
- Morozov, E. (2015). *Where Uber and Amazon Rule: Welcome to the World of the Platform*. The Guardian. Available online at: <https://www.theguardian.com/technology/2015/jun/07/facebook-uber-amazon-platform-economy> (accessed June 14, 2019).
- Mwaniki, D. (2017). "Infrastructure development in Nairobi: widening the path towards a smart city and smart economic development," in *Smart Economy in Smart Cities* (Singapore: Springer), 687–711.
- Mwesigwa, D. (2015). *Here is Why Googles BebaPay was Killed*. Dignited. Available online at: <https://www.dignited.com/12301/google-backed-bepapay-killed/> (accessed May 16, 2019).
- Myers, G. (2011). *African Cities: Alternative Visions of Urban Theory and Practice*. London: Zed Books Ltd.
- Ndemo, E. B. (2015). Political entrepreneurialism: reflections of a civil servant on the role of political institutions in technology innovation and diffusion in Kenya. *Stabil. Int. J. Secur. Dev.* 4:15. doi: 10.5334/sta.fd
- Njeru, J. (2006). The urban political ecology of plastic bag waste problem in Nairobi, Kenya. *Geoforum* 37, 1046–1058. doi: 10.1016/j.geoforum.2006.03.003
- Onjala, J. (2018). China's development loans and the threat of debt crisis in Kenya. *Dev. Policy Rev.* 36, 710–728. doi: 10.1111/dpr.12328
- Peck, J. (2013). Explaining (with) neoliberalism. *Territory Polit. Govern.* 1, 132–157. doi: 10.1080/21622671.2013.785365
- Planting, J. C., Lagoze, C., Edwards, P. N., and Sandvig, C. (2018). Infrastructure studies meet platform studies in the age of Google and Facebook. *New Media Soc.* 20, 293–310. doi: 10.1177/1461444816661553
- Schindler, S. (2017). Towards a paradigm of Southern urbanism. *City* 21, 47–64. doi: 10.1080/13604813.2016.1263494
- Shaktin, G. (2011). "Planning privatopolis: representation and contestation in the development of urban integrated mega-projects," in *Worlding Cities: Asian Experiments and the Art of Being Global*, eds A. Roy and A. Ong (Oxford: Blackwell Publishing), 77–97.
- Shaw, J., and Graham, M. (2017). An informational right to the city? Code, content, control, and the urbanization of information. *Antipode* 49, 907–927. doi: 10.1111/anti.12312
- Silver, J. (2014). Incremental infrastructures: material improvisation and social collaboration across post-colonial Accra. *Urban Geogr.* 35, 788–804. doi: 10.1080/02723638.2014.933605
- Silver, J. (2015). Disrupted infrastructures: an urban political ecology of interrupted electricity in Accra. *Int. J. Urban Reg. Res.* 39, 984–1003. doi: 10.1111/1468-2427.12317
- Simone, A. (2004). People as infrastructure: intersecting fragments in Johannesburg. *Public Cult.* 16, 407–429. doi: 10.1215/08992363-16-3-407
- Sorenson, S. B., Morssink, C., and Campos, P. A. (2011). Safe access to safe water in low income countries: water fetching in current times. *Soc. Sci. Med.* 72, 1522–1526. doi: 10.1016/j.socscimed.2011.03.010
- Srnicek, N. (2017). The challenges of platform capitalism: understanding the logic of a new business model. *Juncture* 23, 254–257. doi: 10.1111/newe.12023
- Strauss, A., and Corbin, J. (1990). *Basics of Qualitative Research*. Newbury Park, CA: Sage publications.
- Swyngedouw, E., and Heynen, N. C. (2003). Urban political ecology, justice and the politics of scale. *Antipode* 35, 898–918. doi: 10.1111/j.1467-8330.2003.0364.x
- Thekdi, S. A., and Chatterjee, S. (2019). Toward adaptive decision support for assessing infrastructure system resilience using hidden performance

- measures. *J. Risk Res.* 22, 1020–1043. doi: 10.1080/13669877.2018.1440412
- UN Habitat (2003). *The Challenge of Slums*. London: Earthscan.
- UN Habitat (2016). *Slum Almanac 2015–2016: Tracking Improvement in the Lives of Slum Dwellers. Participatory Slum Upgrading Programme*.
- van der Graaf, S., and Ballon, P. (2019). Navigating platform urbanism. *Technol. Forecast. Soc. Change* 142, 364–372. doi: 10.1016/j.techfore.2018.07.027
- Waema, T. M., and Ndung'u, M. N. (2012). *Understanding what is Happening in ICT in Kenya: A Supply-and Demand-side Analysis of the ICT Sector. Evidence for ICT Policy Action*. Available online at: http://www.researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_9_ (accessed November 3, 2019).
- Wamuchiru, E. K. (2017). *Rethinking the networked city: the (co-) production of heterogeneous water supply infrastructure in Nairobi, Kenya* (Doctoral dissertation). Technische Universität, Berlin.
- World Health Organization and United Nations and Human Settlements Programme. (2010). *Hidden Cities: Unmasking and Overcoming Health Inequities in Urban Settings*. World Health Organization.
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