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Tinkering with malleable grassroots infrastructures: Kenyan local currencies in informal settlements

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ABSTRACT

The article examines how dwellers in Kenya's informal settlements engage in continuous tinkering of a particular grassroots infrastructure: local currencies. The article argues that the malleability of these grassroots infrastructures enables grassroots networks to actively and creatively engage in reclaiming and reorganizing money, a critical infrastructure. The argument is built in three steps. First, it presents the notion of money as an infrastructure and local currencies as grassroots infrastructures. Second, it follows the development of the Kenyan local currencies from paper- to blockchain-based, and identifies malleability as a key trait of small-scale grassroots infrastructures. Third, it highlights the extent to which malleability enables grassroots networks to engage proactively and creatively with the city through tinkering practices that continuously adapt these local infrastructures to the community using them. The article ends with a discussion of the implications of grassroots monetary infrastructures for the understanding of urban politics within urban studies.

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Think of "infrastructure" and images of large, complex and financially demanding projects come to mind: Water provision and sewage systems, IT and optical grids or electricity and power structures – Networks of lines, pipes, tunnels, conducts and viaducts criss-crossing the city. These images exude a uniform, centralized and modernist ideal of urban infrastructure (Graham & Marvin, 2001) that informs much of urban planning beyond its birthplace – colonial Europe – and into post-colonial times (Nilsson, 2006). Not surprisingly, large and composite urban infrastructures have received increased scholarly attention from the social sciences for the way they enable, shape and reproduce life in the city (Alda-Vidal et al., 2018; Coutard, 1999).

"The infrastructure turn" in urban studies has not only brought much needed attention to the way large urban infrastructures shape the economic (Torrance, 2008), social (Graham, 2000), and cultural (Kaika & Swyngedouw, 2000) fabric of our cities; it has also recognized the heterogenous nature of urban infrastructures (Lawhon et al., 2018; Sseviiri et al., 2022). Often building on concepts from Science and Technology Studies, urban

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infrastructures are increasingly conceived as socio-technical networks (Furlong, 2010), assemblages of material objects, social practices and cultural meanings (McFarlane, 2011), in which people's activities in the city are co-constitutive of infrastructural conjunctions (Simone, 2004). This approach has come with a close empirical attention to the way the activities of marginalized communities are implicated in the creation, ongoing maintenance, extension and continuous adaptation of infrastructure (Addie, 2021). In highlighting the under-recognized human labor required to maintain and extend infrastructures to the urban poor, theory and analysis of urban infrastructures have become genuinely political.

At the heart of the politization of urban infrastructure, there is a recognition of infrastructure as "a relational property" that is "part of human organisation" (Star, 1999, p. 380) and, with it, an awareness of the spatiotemporal reach and fractures of infrastructures (Star & Ruhleder, 1996). Infrastructures connect citizens at the nodes of the network, while also disconnecting others from its benefits. Examples of "disconnecting" are how water supply lines bypass residents of many informal settlements (Graham, 2000). As Latour (1993) puts it, we can "die right next to a phone line if we aren't plugged into an outlet and a receiver" (p.115). Dwellers of informal settlements excluded from access to large infrastructure systems struggle either to be "switched eon" (Graham, 2005) or to, themselves, developing the infrastructure through continuous improvization and ad-hoc incremental socio-technical adjustment (Silver, 2014). This "connecting work" requires human labor (Addie, 2021; Chelcea & Pulay, 2015) and the participation of people as part of the infrastructuring process (Simone, 2004).

Ignored by private and public actors that are increasingly constrained by the demands of financialized global networks (O'Neill, 2018), residents in marginalized city areas are finding new ways of organizing critical infrastructures for their communities – from water and sanitation (McFarlane et al., 2017) to waste management (Sseviiri et al., 2022). A recent line of research refers to these grassroots-driven small-scale projects as "grassroots innovations" (Smith et al., 2017). Two ideas central to grassroots innovation studies are particularly relevant for the study of infrastructures at the margins of the city: 1, the location of creative agency in grassroots networks; and 2, a focus on the continuous work of these networks to adapt, locally, knowledges and practices that circulate globally. In this way, grassroots innovation studies have the potential to shed light on the ways in which city dwellers actively engage in the creation of their own infrastructures.

More specifically, grassroots innovation studies focus on the ways networks of community groups, activists, social entrepreneurs, and researchers (henceforth, "grassroots networks") develop and implement bottom-up solutions in efforts to bring about more just, inclusive and sustainable cities (Smith et al., 2017). While this research field borrows the vocabulary of innovation and entrepreneurship, it also builds on the literature on social movements. The result is a conceptualization of the piecemeal, everyday, relentless tinkering of grassroots networks with small scale solutions as the political practices of the grassroots (Barinaga, 2017). In this doing, grassroots innovation studies highlight that the entrepreneurial and political agency of the grassroots is not merely against dominant institutional arrangements. Rather, through everyday tinkering, these grassroots innovation initiatives are suggesting new ways to reorganize the city.

That is, while the infrastructural turn in urban studies has brought much needed attention to the political dimension of infrastructures and infrastructural processes,

bridging grassroots innovations studies with infrastructure studies has the potential to highlight the practical politics of grassroots-driven infrastructures. Our argument develops from the experiences with the contemporary complementary local currencies in Kenya and builds on desk-work, interview, and ethnographic data generated by the authors in 2017, 2018 and 2019. The paper argues that these monetary grassroots innovations are not only suggesting a new way to do sustainable development work (Bendell et al., 2015). They are, above all, infrastructural developments through which grassroots networks are reimagining and reorganizing a critical urban infrastructure; namely, the monetary infrastructure that enables other critical infrastructures. The first contribution of this article is thus to conceive local currencies as grassroots urban infrastructures. Bringing together monetary studies, urban studies and grassroots innovation studies, the paper builds its argument in three steps. First, it argues that money can be seen as an infrastructure, and local currencies as small, relatively simple and affordable economic grassroots infrastructures. It then presents the case of the Kenyan local currencies and follows the grassroots' continuous tinkering with the design of the local monetary infrastructure. Such tinkering practices bring to the fore the malleable character of these grassroots infrastructures. This is the second contribution of the article, to suggest the notion of malleability to capture the possibility of continuous adaptation characteristic of grassroots infrastructures. It is the malleable character of these small-scale frugal infrastructures that enable grassroots networks to engage in creative, productive and relentless tinkering practices. The paper ends considering the role grassroots networks play in the development of critical urban infrastructures as well as the political dimension of this form of engagement with the city.

Money as a socio-material infrastructure …

Money is seldom considered as an object of study within urban studies. When considered, it is to emphasize the role global financial networks play in shaping large urban infrastructures and, through these, life in the city (see O'Brien et al., 2019). Important as it is to understand how capital flows shape infrastructures and govern urban social relations from afar (Torrance, 2008), such studies fall short of understanding money, itself, as a heterogeneous infrastructure, as a socio-technical assemblage that mediates flows, movement, and exchange (Graham & Marvin, 2001), as a "complex combination of objects, spaces, persons, and practices" (Simone, 2004).

And yet, as many an economist (Ricks, 2018), sociologist of money (Ingham, 2004), and economic anthropologist (Graeber, 2011) contend, money is "arguably one of the most important developments in humanity's organizational or infrastructural powers" (Ingham, 2001, p. 312). Conceptualized as representing a debt–credit relation, at once a "promise to pay" (Innes, 1913) and a "claim upon society" (Simmel, 1976/1900), an "obligation, which exists between human beings and cannot be identified independently of its institutional usage" (Bell, 2001), analysts agree on approaching money as a socio-material infrastructure for record-keeping of debits and credits through which monetary societies achieve the allocation of resources and organize economic life (Bell, 2001). The practice of recording debts and credits in a ledger inscribes a social relation between buyers and sellers and creates the monetary units that become the material expression of that relationship. A two-sided balance-sheet phenomenon (Keynes, 1930;

Wray, 1998), at once an asset (the creditor's claim upon the debtor) and a liability (the debtor's promise to pay), money as a heterogeneous infrastructure enables resources to flow between people, various forms of capital moving through networks of humans and institutions (for a more detailed development of this perspective on money, see Barinaga, Forthcoming).

Three traits of this characterization of money are particularly relevant for an urban studies approach to it. One, contrary to popular misconceptions, analysts argue, money is not merely the material stuff it is made of or it is assumed to be a representation of. Rather, for money to be able to connect economic activities and organize movement and exchange, a money-of-account needs to be in place. In Geoffrey Ingham's own terms, "these *promises* [to pay] are constituted by *the means of accounting for value (money of account)* and *the various means or forms of the representation of abstract value*" (Ingham, 2001, p. 307, emphasis in the original). Money, that is, has an ideational/social component (abstract means to measure economic value that needs to be agreed upon) *and* a material component (the money-stuff – commodity, paper, or digital). Two, money is relational (Ingham, 1996) since a promise to pay requires a buyer that promises and a seller that accepts that promise, – or, symmetrically, since a "claim upon society" requires a creditor that claims the debtor's promise to pay. And three, it hinges on the general acceptability of those promises to pay (Kiyotaki & Wright, 1992) – or, symmetrically again, of those claims upon society –, a general recognition of the value of the promise-claim. Only then can the "promises to pay"/"claims upon society" (coins, paper bills, or digital bits) be transferable and circulate across (connect) economic actors. In other words, money can be conceived as a socio-material arrangement connecting economic actors and organizing resource flows in our societies, a heterogeneous assemblage where people's activities and debt–credit relations are co-constitutive of the monetary infrastructure.

… and local currencies as grassroots monetary infrastructures

As other infrastructures, money not only connects. It also disconnects. Let us illustrate with the informal settlements in Mombasa and Nairobi. While conventional money – shillings in Kenya – *enters* these settlements scarcely through those few residents that earn an income outside the area, it quickly *leaves* the settlement for goods produced and exchanged outside of it. Called "leakage" (Ward & Lewis, 2002), this dynamic leaves the community without a medium of exchange with which to connect buyers and sellers; residents and micro-entrepreneurs in these settlements thus excluded from the monetary infrastructure (Dissaux, 2023). This, in turn, further exacerbates unemployment and poverty in the area. "Leakage" is the monetary expression of "splintered networks" (Kooy & Bakker, 2008), the monetary infrastructure contributing to the "uneven development" of the city (Grant & Nijman, 2004) that further fragments the economy, discriminates social interactions, and provides for distinct experiences of the city.

For those areas at the margins of established financial networks and disconnected from global, and local flows of money, their position at the periphery of the monetary infrastructure is doubly harmful. One, because scarcity of money excludes residents from the established economy. Two, because a position at the margins of the monetary

and financial infrastructures is constitutive of the lack (and cracks) of other critical infrastructures. Indeed, although informal settlements are "anything but homogeneous" (Gilbert, 2007, p. 69), their residents frequently live overcrowded in poor housing, with food insecurity, inadequate access to safe water and sanitation, and deficient access to the power grid.

To tackle the monetary leakage at the root of other infrastructural cracks, grassroots networks are designing and introducing local currencies as small-scale frugal infrastructures to facilitate exchange, organize the flow of critical goods and services, and assemble people and resources into geographically delimited circuits (Collom, 2005; Pacione, 1998). Similar to other small-scale infrastructural innovations (Ambole et al., 2019), the "grassroots" in the Kenyan local monetary infrastructures here studied included, depending on the currency model, various dweller organizations, youth groups, local business hubs and micro-entrepreneurs, non-profit organizations, and the social entrepreneur. Instead of the normative ideal of a uniform money, these grassroots networks are contributing to enact monetary infrastructures that are intentionally situated, develop through continuous experimentation and adjustment, and build on people's everyday relational work (Zelizer, 2001). In the case of the Kenyan contemporary local currencies at the center of this paper, these grassroots infrastructures are designed to support the build-up of other critical infrastructures (waste collection and food security infrastructures) by actively connecting the myriad micro-entrepreneurs that make up the informal settlement towards the collective development of those two infrastructures. In this doing, we will see, they draw from knowledges and experiences in other cities and from other times, ceaselessly tinker with the monetary designs as they learn through continuous experimentation, and are adapted to the particular challenges and resources of the urban poor that are to use the currencies.

In sum, conceiving money as a critical infrastructure necessarily entails looking at local, grassroots monies as "grassroots infrastructures": heterogeneous socio-technical arrangements developed by networks of community groups, residents, activists and entrepreneurs to facilitate the flow of goods and services and organize people and resources in a local circuit. Further, we argue that these grassroots networks are not only developing novel local infrastructures. They are also suggesting a form of "politics of urban fragments" (McFarlane, 2018), one characterized by relentless tinkering practices that take advantage of the possibilities enabled by the malleability of small-scale frugal grassroots infrastructures.

Empirical material presented in the following three sections comes from business logs as well as baseline and inline surveys conducted along the life of the first two currency models by the social entrepreneur designing and setting up these currencies (reported in Ruddick et al., 2015) as well as from previous studies carried by independent researchers (e.g., Cauvet, 2018; Dissaux, 2018, 2023). Empirical material also comes from fieldwork carried by the two authors during four three week-long field visits and from thirty individual and group interviews ranging between 25 min to 2 h with residents in informal settlements that both had used, currently used, or had never used these currencies, as well as with community leaders, youth groups, and the non-profit organization's field officers. Interviews focused on the use, challenges and benefits currency users and organizers experienced as well as on their aspirations as they went about continuously

rearranging the currency schemes. Further interviews and phone conversations were held with the social entrepreneur as part of a two years-long research collaboration.

Eco-pesa: first contemporary Kenyan local currency infrastructure

Eco-pesa is the forerunner of today's local currencies in Kenya. Although no longer in place, a history of the Kenyan currencies necessarily begins with Eco-pesa, for the experience of setting and running it taught the social entrepreneur coordinating it lessons that would shape the infrastructuring of later currencies.

Starting in May 2010 and running throughout three months, the social entrepreneur engaged in a series of community discussions in Kongowea – an informal settlement in Mombasa where local trade is low, unemployment high, the population live under the poverty line, have no access to bank-loans, and lack critical infrastructures such as waste management and piped water. Community groups, local leaders, individual traders, and residents were invited to assess the neighborhood's most urgent needs. Community discussions highlighted two priority areas: (1) the need to tackle the amounts of waste in the settlement, and (2) residents' need to access paid work.

Ecology and employment came therefore to be central guidelines in the subsequent design of the Eco-pesa monetary infrastructure. "Eco" stood for the ecological ambition. "Pesa" is the Swahili word for money. Inspiration for the monetary design came from the Berkshares, a prominent local currency in Massachusetts, which is issued in exchange for dollars, to localize production, boosting the local economy. Relying on the same principle, the Eco-pesa was designed and assembled as a local currency backed by the national currency.

While the currency was designed by the social entrepreneur, implementation was coordinated by the Kenyan chapter of Eco-Ethics International Union, an international environmental NGO, which provided a program officer, a local office and 50% salaries to run the grassroots monetary assemblage from August to November 2010. To encourage adoption, local micro-entrepreneurs and youth were given a 20% discount upon purchasing Eco-pesa for Kenyan shillings (KSh). Because only local businesses accepted Eco-pesas, the possibility of spending the currency was geographically limited, thus preventing it from leaking out of the informal settlement. To further prevent leakage, the program charged a 20% fee upon redeeming the Eco-pesa for shillings. That is, Eco-pesas were convertible to Kenyan shillings at a significant fee and up to 500 Eco-pesa per day per business.

After one month, once the community had gained familiarity with the new money, both the discount and the fee were removed. Yet community groups, the local NGO and the social entrepreneur wanted to further generate jobs in the settlement while taking care of the lived environment. For this, they managed to get a US$ 4,000 donation from the Kenyan chapter of Eco-Ethics International Union, which were put to back the issuance of new Eco-pesas. These donation-backed Eco-Pesas were used to pay the local unemployed youth and other residents for the waste collected during community-wide waste collection events. Connecting waste collection work to the distribution of the currency was a feature in the grassroots monetary infrastructure inspired by the local currency in Curitiba, Brazil.

Connecting

The economic connections infrastructured by the local currency were soon visible in the surge of local trade and youth employment. After one month, 8 of 31 businesses (26%) monitored noticed positive increases in the number of customers and monthly income. This figure went up to 32 of the 41 businesses (80%) monitored two months later, with an average of 22% increase in monthly income. This was partly a result of increased awareness among local residents/businesses which soon realized that, thanks to a higher number of transactions, the Eco-pesas they used returned swiftly. Or, as they put it, "I am happy because the Eco-pesa I spend comes back to me".

This was mirrored in improved local employment, as businesses started to spend their Eco-pesas in waste collection and other infrastructural services for which they hired youths. Indeed, in surveys, the local youth reported getting more work and expressed enhanced morale due to the Eco-pesa. Apart from increased local trade and employment, residents avowed a new-found capacity to save. As one resident put it, "I use Eco-pesa and save my shillings. I have never saved before now".

The connecting capacity of the new grassroots monetary infrastructure was also visible in how it extended the waste collection infrastructure it was designed to support. Four tons of waste were gathered during the first waste collection event on September 17th; 16 tons on the second event one month later. These events were organized in coordination with the Mombasa Municipal Council, who then hauled the waste to a local landfill. Such events helped raise awareness on the functioning of the new money. They also further generated jobs for the local youth as local businesses, benefiting from cleaner access to their shops, increasingly used their Eco-pesas to pay for assorted environmental services, from waste collection to tree seedling and planting. In this way, the local currency acted as an infrastructure contributing to organize other critical infrastructures – that is, an "infrastructure of infrastructure" (Cerny, 1993), a "pervasive infrastructure" (Amin & Thrift, 2017, p. 55) that enables other infrastructures to continue doing their work (Zapata Campos et al., 2023).

Disconnecting

The donated Kenyan shillings, as well as those residents exchanged for their Eco-pesas, were kept at the Eco-Ethics office. These served as backing for the grassroots currency and local businesses could redeem their accumulated Eco-pesas for shillings. Although the possibility to redeem Eco-pesas guaranteed trust in the new currency, it also clogged up the grassroots monetary infrastructure. Foremost, a few businesses were actively spreading false information, telling other businesses that Eco-pesas couldn't be used. These businesses were simultaneously hoarding the local currency in order to redeem them for shillings. Other businesses hoarded Eco-Pesas simply due to a lack of understanding of the local currency. Whatever the reason, hoarding took currency units out of circulation in the community, hampering infrastructural flow and thus weakening the capacity of the new currency to strengthen local trade, foster local employment, and underwrite other critical infrastructures.

A second challenge was dependence on donors. With a donation of US$ 4,000, the local currency had reached over 75 businesses and 20,000 residents. Yet, despite its

effectiveness in improving environmental and economic indicators, the program was necessarily limited in time. While products such as water, firewood, eggs, soap or alcohol, and services such as laundry, hair-styling and cooked food were produced locally, 62% of the goods exchanged in Eco-pesas came from outside the informal settlement. These businesses redeemed the local currency for shillings to restock products originating outside the community. Once all backing of the Eco-pesa had been redeemed, there were no funds left to uphold the local currency, the connections the monetary infrastructure had assembled ceasing to be in place.

Finally, because the national currency was too valuable to exchange for a more restricted local currency, many local businesses were reluctant to purchase the Eco-pesa for Kenyan shillings. This resulted in a relatively low number of businesses joining the grassroots monetary infrastructure, which in turn limited the variety and number of goods and services moving through the locality.

That is, a main trait of the new local monetary infrastructure – that it was backed by and redeemable for the national currency – resulted in a number of challenges that limited the capacity of the grassroots infrastructure to connect economic actors and organize economic life in the informal settlement. This is why, as we will see, the nature of the backing as well as the possibility to redeem were to be changed in the local currencies that followed.

Bangla-pesa: second contemporary Kenyan local currency infrastructure

Bangla-pesa circulated in the Bangladesh settlement, in Mombasa with an estimated population of 20,000. From November 2013 to December 2017, Grassroots Economics (GE) – a non-profit organization founded in 2013 by the social entrepreneur behind Eco-pesa – facilitated the design, issuance and management of the Bangla-pesa currency.

To address the disconnections following from the Eco-pesa model, in early 2013 the social entrepreneur started tinkering with the currency design. In this work, he was inspired by the WIR (*Wirtschaftsring*, German for "economic circle") credit clearing network in Switzerland – a local currency circulating among a national network of SMEs since 1934. The donation and fee-based backing in conventional money of the Eco-pesa was substituted by a cooperative credit system backed by the businesses' excess capacity (Bendell et al., 2015). Independence from external donors was made possible by making the currency neither backed by, nor redeemable to, conventional money.

With the support of local youth groups, community health workers, elders, and local businesses, GE assisted in the formation of the Bangladesh Business Network (BBN), a cooperative – or economic circle – assembling about 200 micro-enterprises in the settlement that agreed to accept and trade in the local currency. The economic activities the members conducted stood for the value of the new local currency. 400 Bangla-pesas (at a parity of one with the Kenyan shilling) were issued per registered member, 200 of which (equal the average budget for the daily needs of a family of five) were distributed directly to each member and the other 200 put into a Community Fund. Through assembly democracy, the BBN decided what community services to spend their Community Fund on, in this way distributing Bangla-pesas to residents outside the BBN. Typically, such services included waste collection and tree planting by the local youth; the

grassroots monetary infrastructure thus assembling the human dimension of the waste infrastructure (Simone, 2004).

Along the design of the currency, priorities and risks were discussed at various community meetings, resulting in two key monetary rearrangements: guarantors and community liaisons. One, to avoid the risk of members spending all their credit without accepting Bangla-pesas for purchases in their shops, the BBN required each business member to have four guarantors. Guarantors promised to both spend and receive pesas from the guaranteed business, as well as accept them from customers if the business refused. Two, to avoid businesses hoarding pesas, thus taking them out of circulation and limiting infrastructural flow, the BBN selected community liaisons from among its members. Community liaisons went from business to business, discussed the challenges they may be having, educated them on the implications of hoarding and encouraged them to spend the local currency on a daily basis. The system of guarantors as well as that of community liaisons developed the people dimension of the local monetary infrastructure, helping to embed market exchange in extant communal relations. This made the grassroots monetary infrastructure more decidedly local; its embeddedness in community structures aimed at assuring more rapid and wider connectivity (and thus increased circulation of the currency).

Further, to accelerate the flow of Bangla-pesas within the community, and learning from the experiences in Wörgl – an Austrian city, which mayor introduced a stamp scrip currency in 1932 (Barinaga, Forthcoming) –, an expiration date was printed on the paper bills. On that date, and after one year of circulation, members of the cooperative met to return the 200 Bangla-pesas initially distributed to each. While the event was organized by the BBN, GE facilitated the collection, stamping and redistribution of the bills. Without the stamp, the bills were no longer accepted.

Connecting

According to baseline and inline surveying (Ruddick et al., 2015), within one week of launching, 109 local micro-businesses had registered to the BBN and were reporting 22% of daily trade was carried in Bangla-pesa, the currency circulating two to three times faster than the official Kenyan shilling. Women in particular benefitted as many of them set up their businesses in front of their homes. Indeed, 75% of the businesses in the economic circle were women□□□s and their revenues grew by 37%. This resulted in a reported increase of 77% in families' access to food. Three years after launch the BBN had 223 registered businesses. At this point in time, active Bp users reported a larger capacity to save in Kenyan shillings, increased access to food, and growth in business activity (Dissaux, 2018).

Surveys revealed other impacts: 23% increase in school attendance (which reportedly increased once various schools started to accept payment of fees in Bp); 25% reduction in crime; and 57% increase in environmental activities in the informal settlement. Businesses and residents were spending their pesas on the unemployed youth and putting them into work for the environment of the area. This meant 17% more jobs created in the settlement. When asked "How much over the last month did you give (in money, professional services, and time) to support people or groups without expecting compensation?" residents not using Bp reported an average equivalent 191 KSh

monthly, while currency users reported an average equivalent 855 KSh monthly. That is, over 347% more gifting for those using than not using the local currency.

On top of the social and economic connections developed, Bangla-pesa also bore significant political consequences. In May 2013, a tendentious local newspaper article portrayed the BBN and Bp as a secessionist plot, after which followed a police raid in the informal settlement, 6 grassroots members placed in jail for 3 days in charge of forgery, and months of legal wrangles. In August 2013 charges were dropped and the Central Bank of Kenya's Currency Dpt. acknowledged the currency as a development tool. The events gained the grassroots network much visibility and a newfound sense of empowerment. In interviews, residents in Bangladesh reasoned that, in the run-up to the 2017 election, this visibility and sense of empowerment led to their collective demand for pavement and threats to withhold their votes being heard, demands and threats that the City and Council had previously ignored. Before election date, Bangladesh had its main thoroughfare paved.

Disconnecting

Everyday governance of Bangla-pesa was onerous. People often forgot the paper bills at home, which introduced a degree of disconnection into the monetary infrastructure thus slowing down circulation of the currency. Community liaisons and GE officers had to spend a good deal of time going from one business to the next, finding out where the currency accumulated, explaining the importance of spending, connecting businesses that didn't know where to spend with those that couldn't get Bp, or suggesting new possibilities to spend and earn the local money. The task was made all the more strenuous because the paper-based nature of the currency made it difficult to trace its flow paths.

Governance of the cooperative was also taxing. Either for lack of time or because of personal conflicts, or for low levels of trust among a few community members (Dissaux, 2018), BBN meetings were poorly attended and decision-making was slow. This was to the detriment of quick adaptation of the currency's governance rules. For business networks where the seasonality of the products sold affects the economic well-being of the community, the inability to continuously and promptly adapt a currency's governance rules to the challenges of the community resulted in the web of debts throughout the community not being balanced, disconnection of economic actors, and thus poor currency circulation.

These challenges not withstanding, neighboring communities were showing interest in introducing a currency of their own. By late 2017, and with support from GE, similar currencies had been introduced in two other informal settlements in Mombasa as well as in three informal settlements in the capital, Nairobi. Within each of these communities, their local currency was extensively used. Schools accepted it for school fees, churches for the Sunday alms, and a larger number and variety of businesses traded in it. Yet, the geographical delimitation of the currencies inhibited the expansion of trade across settlement boundaries, something that could further infrastructure the economy of the areas. All these challenges prompted yet another round of redesigning, rearranging and tinkering with the grassroots monetary infrastructure.

Sarafu: crypto-ing the Kenyan local currency infrastructures

Making the local currencies digital provided one answer to some of the disconnections the Kenyan currencies were experiencing. 98% of Kenyans use M-pesa – a mobile currency driven by Kenya's biggest telecom operator. Kenyans, that is, were already used to digital money and digitalizing the local currencies would allow to track their circulation, set currency governance rules into the code, and facilitate trade across communities.

Blockchain technology seemed to offer possibilities to address the challenges and disconnections the Kenyan local currencies were facing. In mid-2018, GE teamed up with Bancor – the blockchain startup celebrated for its record-breaking ICO (Initial Currency Offering) in 2017 –, and went on to redesign and reassemble the local monetary infrastructure. Bancor had developed a protocol that facilitated connecting currency systems, thus enabling transactions across blockchain-based currencies. GE took the technology as the basis from which to redesign the Kenyan currencies along the communities' demand for connectivity across them. This led to the Sarafu Model, a network of local currencies allowing users to exchange monetary units directly through the wallets in their phones. As in the previous monetary assemblage, issuance of currency units resided in GE. Tokens were then distributed to those residents that agreed to trade in the local currency. After transactions were carried out, a SMS was sent to the user's phone showing the money sent/received and the balance remaining in one's wallet. The Sarafu model also involved partial backing of the local currency, individual users being able to redeem weekly 10% of their account balance, and business hubs and groups up to 50% of their monthly balance.

Gatina, an area of Kawangware (Nairobi) informal settlement, and Miyani, a rural and coastal community north of Mombasa, became two of the first testing grounds. Both communities had used the earlier paper-version of the currency and understood the benefits of local money. In mid-December 2018, Sarafu was rolled out, GE officers walking around the communities and registering residents – a process that took about ten-fifteen minutes – and thus quickly connected micro-businesses within each community. Upon registration, users received 400 pesas – worth 400 Kenyan shillings – straight into their phones, which they could start spending directly.

By June 2019, six communities in Mombasa and Nairobi had gone blockchain. The Sarafu model opened up the possibility of easily trading across all six currencies, extending the monetary system's geographical reach.

Connecting

While the first Kenyan community cryptocurrencies had been in place for barely six months, their capacity to connect across economic actors was already discernible. By mid-June 2019, transactions in all communities totaled 65,835, amounting to 5,190,602 Kenyan Shillings. Word of mouth spread quickly and about 100 businesses were enrolling weekly. A mobile currency increases connectivity because, as one resident put it, "you forget the paper bills but you never forget your phone".

Further, by keeping transaction records in the blockchain, the circulation of the currency and the speed, paths and clogs of circulation could easily be traced. This facilitated

GE officers' work who could walk directly to those users who seemed to have troubles spending, help them find businesses that accepted the currency or educate them in the use, benefits, and challenges of local monies.

The possibilities brought by the new technology also became evident in terms of governance rules of the currency. The transparency of blockchain technology gave GE access to live-data, thus enabling to continuously oversee the stream of data, identify circulation challenges on the spot, design rules to tackle such challenges, and rapidly code the rule into smart-contracts. To illustrate, on January 20, 2019 seeing that some businesses were accumulating a disproportionate amount of Sarafu, GE coded a time-based fee into the smart-contract. A SMS was then sent twice a week to all currency users: "If you don't spend, your community doesn't benefit. If you don't spend by the end of the week, 1% of your balance will be withdrawn from your account". That is, GE directly implemented a time-based fee like that in Wörgl's stamp scrip of the 1930s. Based on up to date data on the circulation of the currency, GE was able to promptly bring issues to community groups, tinker with the governance rules of the currency and quickly implement them. This opened up the possibility to swiftly adapt the governance rules of the monetary infrastructure to the idiosyncrasies and immediate needs (as those emerging at the onset of the pandemic) of each community.

Disconnecting

While businesses were rapidly registering to the currency system and instantly using their newly-acquired money, the digital nature of the new currency made connection of non-registered residents more difficult. In paper currencies, residents and businesses outside the economic circle could still be paid with Bangla-pesa notes and then use them for their own purchases. This was a natural and intuitive way of showing reluctant dwellers the benefits of a local currency as well as an easy way for residents to enlist other residents. Payment to non-registered users is however not possible in the digital currencies, thus inhibiting the connection of skeptical residents and of those with no phone. To cope with this potential disconnection, the transition from paper to blockchain was done gradually, both technologies co-existing for about one year.

As with the original Eco-pesa, the possibility to redeem designed into the initial Sarafu model animated users to hoard the local currency to later exchange them for Kenyan shillings. Such an individual behavior disengaged people from acting as elements of the momentary infrastructure that had been meant to incentivize the flow of money. Instead, as people hoarded to redeem, the flow of currency units slowed down. To attend this infrastructural challenge, the social entrepreneur would tinker with redemption rates and ultimately, in late 2020, tinker them away (Barinaga, 2020).

A malleable grassroots monetary infrastructure

The Kenyan local currencies are not a phenomenon isolated in time and space. As we have seen, they are instances of monetary knowledges and grassroots practices that circulate at a global scale. To name, the Eco-pesa was inspired by the experiences in Berkshire (US) and Curitiba (Brazil); the Bangla-pesa built on the lessons from the Eco-pesa

while bringing in those from the WIR (Switzerland) and Wörgl (Austria). It is this capacity to learn from global networks while adapting to local conditions that make grassroots innovations for community infrastructure particularly potent. They remain embedded into the peculiarities of local relations and cultures, yet build on a myriad of other local experiences that are shared globally. This, the tension between attending to local specificities whilst simultaneously seeking wide-scale diffusion, has been identified as one of the key challenges for grassroots innovations (Smith et al., 2017). How do monetary grassroots infrastructures manage this tension? What traits allow them to move back and forth between global networks and situated localities? How do grassroots networks manage the contradictory simultaneity of standardizing global knowledges on monetary infrastructure and particularizing practices to the needs and priorities of the community that is to use the grassroots infrastructure? Or, how do the margins of the city practice everyday urban politics?

Malleability. That is the argument we want to put forward in this section. It is the malleable nature of grassroots innovations that allows grassroots networks to adapt global knowledges and practices into local small-scale and frugal community infrastructures. The malleability of these grassroots infrastructures opens up the possibility for active and creative tinkering with them. It allows grassroots networks to continuously and gradually adapt these infrastructures to fit to their needs and priorities. The relentless, piecemeal and unfaltering work of adjusting the grassroots infrastructure to the community that is to use it, we also argue, can be conceived of as a form of "politics at the margins of the city" (McFarlane, 2018). In the case of grassroots monetary infrastructures such as local currencies, malleability, and with it the possibility of tinkering practices, manifests in four dimensions.

One, local currencies are simultaneously material and immaterial; a thing and an abstraction; a commodity and an accounting tool. As discussed in the section on money as an infrastructure, money has both a material and an ideational component, the money-stuff and the money-of-account. This dual ontology of money has given rise to two main positions within monetary theory concerning the nature of money. Metallists argue that money developed from barter, currencies becoming the *thing* all agreed to barter with. In this view, currencies have value per se, the gold and silver content of the first coins standing for that intrinsic, material, value of money. Chartalists, on the other hand, argue that money is based on debt–credit *relationships*. This position views units of currency as units of measurement and monetary tokens as debt records, IOUs. For Metallists, that is, money is a commodity; for Chartalists, it is an accounting tool (Graeber, 2011; Ingham, 2004; Wray, 1998).

We see aspects of both views in the development of the Kenyan local currencies. Backed by donor funds, Eco-pesas were the physical representation of the Kenyan shillings held as reserves at the Eco-Ethics office. This aligns to the Metallist view, the local currency being the local translation of a thing (Kenyan bills) that is given value per se. But, because shillings are given value per se, local businesses were reticent to purchase the local currency with the more widely accepted national currency. Further, material things are finite and so as Eco-pesas were redeemed into shillings, the donor funds that backed the local currency ended. As the Kenyan local currency met the challenges of finitude proper of material things, and inspired by other local experiences shared in global flows of knowledge, the promoters of Kenya's pesa-programs were able to

reimagine the grassroots monetary infrastructure from a commodity with inherent value (that is, directly redeemable into Kenyan shillings) into a voucher registering a member's debt to the community (the Bangla-pesa model) and again into a token with value given by both partial backing and its acceptability in the local community (the Sarafu model). The malleability of the grassroots infrastructure allowed the grassroots network to experiment and tinker with the monetary design of the local currency and rearrange community relations.

The second malleable aspect of the grassroots monetary infrastructure refers to the dual set of moral principles that ground the economic relationships they inscribe and organize. On the one hand, a moral principle of communism based, as Graeber (2011) describes it, not on the notion of property but on that of human sociality. Communism defined as "any human relationship that operates on the principles of 'from each according to their abilities, to each according to their needs'", a definition that acknowledges the inequality that pervades human relations. This turns local currencies into an infrastructure based on solidarity and mutual aid. On the other hand, the moral principle proper of exchange, one that assumes equality of relations, builds on a notion of equivalence, and therefore demands reciprocal tic-for-tac, independent of individual abilities and needs.

That local currencies are simultaneously based on a principle of communal solidarity that assumes inequality of relations *and* on a principle of reciprocity of exchange that assumes equal relations is best seen in the confusion that seems to pervade among scholars of local currencies. Some describe local currencies as driven by an ethos of reciprocity (Werner, 2015), others as enabling economies of solidarity (Collom & Lasker, 2012). Our argument is that they are both, simultaneously assuming equal and unequal relationships, asking for reciprocity while nonetheless demanding different efforts from different members. To illustrate: Some local businesses bought Eco-pesa with their hard-won Kenyan shillings, others paid their Eco-pesa with time in waste collection events. And while not all businesses in the Bangladesh Business Network were equally strong – some being a mere mat by the road with only a couple of products, others having a proper shop offering a wide range of goods –, each and every member was handed 200 Bangla-pesas in initial credit. Similar in the first version of the Sarafu currencies, members received the same amount of tokens independently of their productive capacity; that is, the introduction of monetary units was based on a principle of equivalent reciprocity. And yet, once the local currency was issued and distributed, stronger members were expected to hire the services of others, solidarily contributing to widen the circulation of the local currency.

Three, local currencies have to be immobilized geographically in order to facilitate greater movement in that space. As they are fixed to the informal settlement yet their movement accelerated through the promotion of local networks of exchange, these forms of monetary grassroots infrastructures are gradually embedded within the fabric of the settlement. It is the very crippling of the currency to strict geographical boundaries that is the necessary condition for the vitality of the economic relations the grassroots infrastructure is to support. In the process, existing relations of exchange are strengthened (ex. organizing local micro-businesses into the BBN cooperative), and new ones are formed (ex. creation of waste collecting youth groups, new local customers), thus articulating new types of social relations and producing novel territorial configurations.

Economic relations of trade, that is, are progressively tinkered with and embedded into the local community through continuously adapting the socio-technical arrangements that constitute the grassroots infrastructure.

To specify the malleable dimensions of the monetary infrastructure the Kenyan grassroots monetary networks slowly but relentlessly remade to immobilize yet accelerate its circulation in the territory: (1) issuance form of the local money (backed, mutual credit, fiat); (2) introduction method of the currency into the settlement (users buying it at a discount, through payment for work, as credit granted to cooperative members, free distribution to willing residents); (3) usage fees (none, expiration date, broker redemption fees); and (4) relation to national currency (no possibility to redeem, 100% redemption, partial redemption possible). These design traits involved deciding on what community actors to build the infrastructure on as well as on how to rearrange social and economic relations in the community. With the notion of "circuits of commerce", Viviana Zelizer (2001) highlights the coexistence of intimate social relations and impersonal economic ties in a variety of market transactions, those organized by local currencies among others. It is, we argue, the malleability of these grassroots innovations that facilitates such coexistence, as malleable infrastructures open up the possibility for grassroots networks to tinker with its elements and embed the monetary infrastructure in communal relations of solidarity and mutual aid.

Four and last, although local currencies may be introduced as tools to articulate the local economy, their tight connection to the territory and to its social networks generates new structures of feeling (Larkin, 2013). Because geographical immobilization of the currency prevents its leakage outside of the community, because it demands from each according to their capacity yet expects that all equally reciprocate in its use, and because the community becomes aware of a new-found ability to create their own money, local currencies shape how residents experience their settlement and, by extension, the city. Indeed, repeatedly, the aspect that residents valued the most about Bangla-pesa was an increased sense of collective identity, a pride about their cooperative ability to manage their own currency (Dissaux, 2018). New structures of feeling are the seeds of new formations of thought and action: From an increase in gift-giving practices and a newfound capacity to mobilize residents to demand pavement of the informal settlement's main road, to exclamations of desire ("Bangla-pesa is the mother of all pesas") that ignite the imagination ("Because we wanted to be international!"). By making the monetary infrastructure more easily accessible, local currencies shape how residents experience their neighborhood. Their design and organization is not only conditioned by the geographical locality, but also condition the social organization of that locality (Dourish & Bell, 2007).

In this sense, local currencies serve as vehicles of pride and desire that trigger the imagination. The malleability of the grassroots infrastructure enables the network of settlement dwellers, community groups, local businesses and socially engaged entrepreneurs to act on those desires and on those images of a common, more-connected future. Because the shaping and reshaping of these infrastructures is done slowly, piecemeal, through continuous tinkering with the infrastructure's various socio-monetary elements, grassroots actors see possibility in it. Money ceases to be inaccessible and difficult to grasp and becomes understandable and attainable through one's own everyday practices. Herein resides a form of agency that is pro-active and creative, opening up for novel political possibilities in the informal settlement and in residents' relation to the city.

The malleable nature of grassroots monetary innovations – as both commodity and accounting tools, based on moral principles of both equality and inequality, both immobilized and accelerated, and structuring relations of both trade and affect –, enables their adaptability to the objects, spaces, persons and practices particular to each place. Grassroots networks governing local monies could thus experiment with various infrastructural designs, adapt the currency to the circumstances and assets of the local community, and tinker with various "combinations of objects, spaces, persons and practices" (Simone, 2004) to adjust the urban infrastructure to them. This, in turn, generates a renewed sense of agency and a political engagement in the settlement imbued with hope, desire, and possibility.

Concluding discussion

The article is a response to recent calls in urban studies to study "fragment urbanism" (McFarlane, 2018), to look at the ways through which the urban poor and activists deal with the lacks of the city, actively developing their own infrastructures, and politicizing the city. It does so by studying the ways in which grassroots networks – therein marginalized communities – in Kenya's informal settlements engage in the creation, maintenance and continuous adaptation of a particular grassroots infrastructure: Local currencies. The article argues that it is the *malleability* of these grassroots infrastructures that enables the urban poor to actively and creatively engage in reclaiming and reorganizing money, a critical and heterogeneous infrastructure. This argument builds upon two notions from two distinct fields – 1, the notion of infrastructures as socio-technical arrangements that has prompted the "infrastructural turn" in urban studies; and 2, the idea of grassroots innovations that delineates the emergent field of grassroots innovation studies – to develop the notion of "grassroots infrastructures". The literature on grassroots innovations focuses on small, simple, and financially humble innovations driven by a collaboration of grassroots actors. While local in nature, grassroots innovations do however build on the experiences of grassroots innovations from other places and times that circulate through global networks of knowledges and practices (Smith et al., 2017). The article shows the way in which the interplay between local grassroots innovations and global knowledges and practices translates into possibilities for networks of residents and social entrepreneurs to actively engage in developing grassroots infrastructures.

The article's first contribution is thus to bridge urban infrastructure studies and grassroots innovation studies in order to conceptualize local currencies as grassroots infrastructures. In this light, local currencies become heterogeneous socio-technical arrangements developed by networks of community groups, residents and social entrepreneurs to facilitate the movement of goods and services and organize people and resources in a locality. The article's second contribution is to identify malleability as a key trait of grassroots infrastructures. In the case at hand – Kenyan local currencies – we identified four malleable dimensions: 1. the ontology of the infrastructure (thing and abstraction), 2. the moral principle grounding the infrastructure (communism of access and reciprocal equivalence), 3. the degree of fixedness of the infrastructure (immobilized yet accelerated), and 4. its relational reach (economic and affective). While the first two dimensions of malleability are specifically connected to the monetary nature of the grassroots infrastructure analysed, the last two could be generalized to other

grassroots infrastructures. Indeed, both the degree of mobility and the affective and material dimensions of infrastructures have been pointed out as relevant for how infrastructures shape life in the city (see, for instance, Anand, 2011; Graham & McFarlane, 2014; Larkin, 2013).

But malleable grassroots infrastructures are per se not enough. The case showed the extent to which the malleability of grassroots infrastructures necessarily comes with practices of continuous tinkering by the grassroots network (Barinaga, 2017). The article's third contribution is to highlight the relationship between infrastructural malleability and the tinkering practices of the grassroots. Translating global knowledges to local idiosyncrasies, adapting localized practices to constantly changing circumstances, and continuously adjusting combinations of objects, spaces, persons and practices is possible thanks to both the grassroots' immersive presence in the communities for which they innovate and their tireless reorganizing of the infrastructures they suggest. In this way, grassroots infrastructures are far from the uniform modernist ideal informing grand urban infrastructures. Herein, in the relentless, ongoing, piecemeal adaptation of global knowledges and practices to local circumstances and needs lies an active form of fragment politics, one that attends to the agency of the grassroots and their capacity not only to react and resist but to enact and create. The final contribution of the article is to highlight this form of creative and proactive engagement with the city as a form of urban grassroots politics. In this sense, the Kenyan local currencies are suggesting one way to sketch "new urban imaginaries capable of inspiring more democratic urban politics" (Graham & Marvin, 2001).

At this moment in the research project, we can but speculate on the long-term implications of such grassroots monetary infrastructures. One argument could be that, as they develop differentiated infrastructures in the city, they are able to adapt to the needs of diverse population groups, thus facilitating the integration of the city. There is also the possibility to argue in the opposite direction. Because monetary grassroots infrastructures create separate economic, social and affective spaces, they risk contributing to further fragmenting the city, to reinforce "cities within cities" (McFarlane et al., 2017). To answer this question, research that takes a long-term perspective is needed. At any rate, the guiding question should be, what socio-financial relationships develop in the city as those at its margins reclaim and reorganize the monetary infrastructure?

Answering such urban development questions calls for interdisciplinary research that builds on urban and grassroots innovation studies for the study of local infrastructures. Depending on the nature of the infrastructure investigated, it also calls for bringing other specialized fields of research; in our case, that of monetary studies.

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