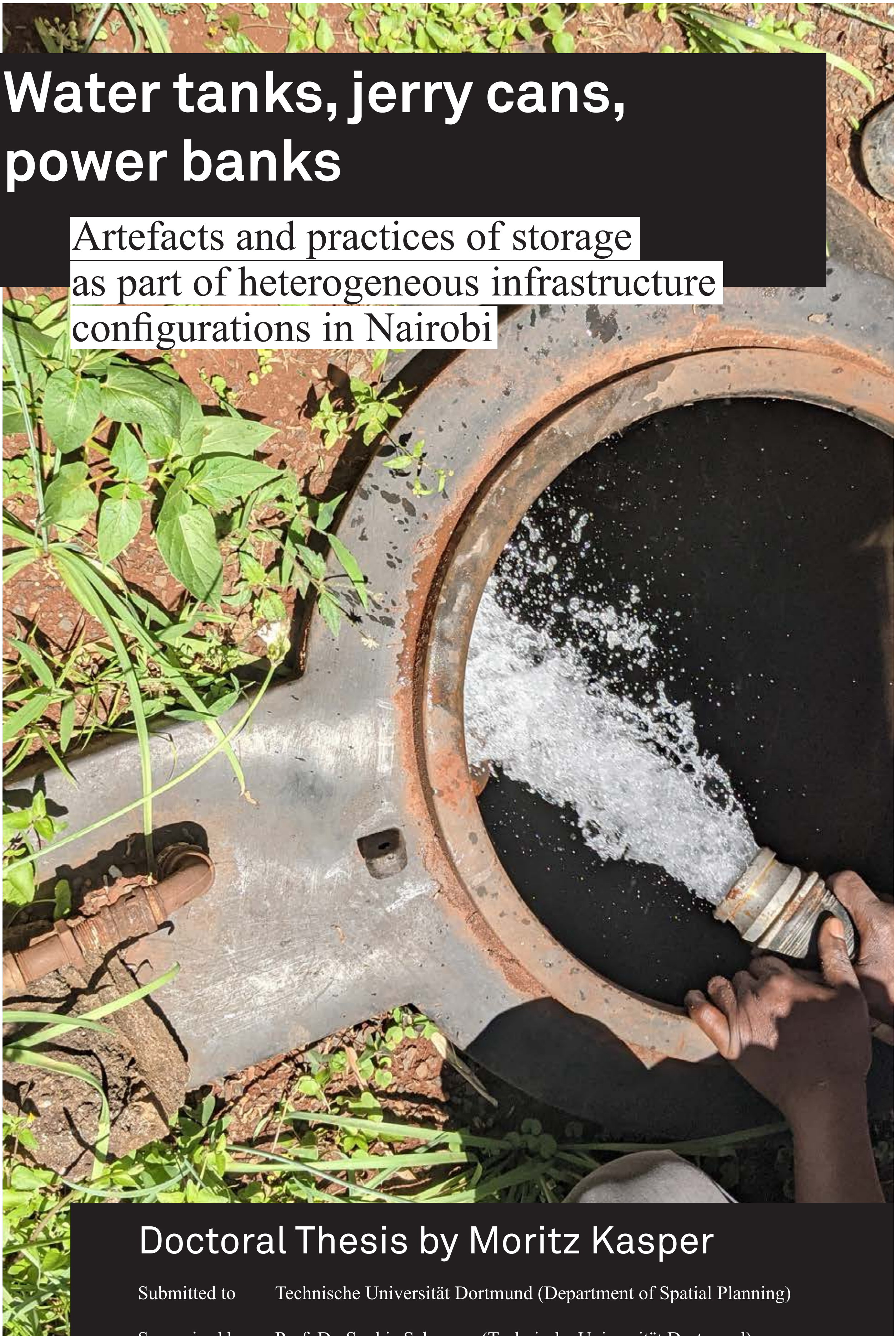
Water tanks, jerry cans, power banks

Artefacts and practices of storage as part of heterogeneous infrastructure configurations in Nairobi



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ABSTRACT Seemingly mundane and inconspicuous 'tools' such as water tanks, jerry cans, power banks and other battery devices – often seen as nothing more than household appliances – are constitutive elements of Nairobi's infrastructure space. This cumulative dissertation is rooted in an exploration of these artefacts, the human practices around and for them, and the broader phenomenon of (domestic) storage as a vital and influential part of the supply of and access to basic resources. Specifically, by exploring and discussing the role and significance of domestic water and electricity storage for situated and heterogeneous infrastructure configurations, as well as for individualized experiences and efforts in everyday infrastructuring, the study uncovers patterns and logics that can be found throughout the fragmented realities of Nairobi, albeit in variegated articulations.

Nairobi – Kenya's capital city of approximately 5 million people – has struggled since its founding in 1899 to provide universal, reliable, and equitable access to basic resources for all its residents. Its contemporary infrastructures are built on colonial, often deliberately discriminatory, planning legacies that, since Kenya's independence in 1963, have mutated into place-specific expressions and geographies of infrastructural heterogeneity, fragmentation, and intermittency. As a result, and at the same time as a co-producer of these conditions, domestic storage, in the form of idiosyncratic household dispositifs, enables urban residents to adapt to the shortcomings of the networked infrastructures of the state and its proxies, while also allowing them to tap into a variety of other, non-networked modes of supply, such as boreholes and solar power. Understanding infrastructures, as well as any storage arrangement, as sociotechnical and socioecological assemblages, this study examines household dispositifs of supply and storage and discusses them in multi-scalar relation to their respective infrastructure configurations, urban geographies and inequalities, and networks of flows and circulations.

Drawing on critical and postcolonial urban studies, STS-inspired infrastructure research, and planning literature as key disciplines and debates, the empirical research for exploring and analyzing domestic storage as part of heterogeneous infrastructure configurations in Nairobi is largely qualitative. Following an inductive and iterative research approach, the main modes of inquiry are 39 'enriched' household interviews with residents from diverse, purposively selected neighborhoods, 36 interviews with thematic experts, several go-alongs and urban explorations, and complementary forms of (secondary) data collection. Building on empirical findings and larger theoretical debates, four cumulative papers – each focusing on different aspects or perspectives – analyze and discuss how storage and its artefacts mediate relationships between residents, other urban actors, their infrastructural environments, and the broader city.

Several new concepts are introduced throughout the papers – such as the 'storage city,' the 'batteryscape' or 'storage as a multi-scalar analytic' – and a key argument of this dissertation is that domestic storage has an ambiguous tool power, enabling households to adapt to infrastructural heterogeneity and intermittency, while at the same time enabling, stabilizing and sometimes even exacerbating these larger infrastructural conditions and their injustices. However, in considering 'storage as a propositional space' also, the findings suggest that future interventions into Nairobi's infrastructure space must incorporate domestic and communal forms of water and electricity storage into the plans, mandates, and imaginaries of various urban actors, from municipal planning offices to state regulators, from real estate developers to informal neighbor groups. Ultimately, the study argues for more (multi-scalar) research on the storage of different resources to challenge and extend the empirical, theoretical, and practical insights presented.

ZUSAMMENFASSUNG Scheinbar vernachlässigbare und unauffällige „Geräte“ wie Wassertanks, Kanister, Powerbanks und andere Batterieanwendungen, die oft nur als Haushaltsgegenstände angesehen werden, sind in Wirklichkeit konstitutive Elemente des infrastrukturellen Raums in Nairobi. Diese kumulative Dissertation beschäftigte sich mit diesen technischen Artefakten, den menschlichen Praktiken um sie herum und für sie sowie dem umfassenderen Phänomen der (häuslichen) Speicherung als unabdingbarer und einflussreicher Teil der Versorgung mit und des Zugangs zu grundlegenden Ressourcen. Insbesondere durch die Untersuchung und Diskussion der Rolle und Bedeutung der häuslichen Wasser- und Stromspeicherung für situierte und heterogene Infrastrukturkonfigurationen sowie für individuelle Erfahrungen und Bemühungen bei der alltäglichen Infrastrukturgestaltung deckt die Studie Muster und Logiken auf, die in der fragmentierten Realität von Nairobi überall zu finden sind, wenn auch in unterschiedlichen Ausprägungen.

Nairobi – Kenias Hauptstadt mit rund 5 Millionen Einwohnern – hat seit Gründung im Jahr 1899 damit Schwierigkeiten, allen Einwohnern einen universellen, zuverlässigen und gerechten Zugang zu grundlegenden Ressourcen zu bieten. Die heutigen Infrastrukturen basieren auf kolonialem, oft bewusst diskriminierendem planerischem Erben, das sich seitdem zu ortsspezifischen Ausprägungen und Geografien infrastruktureller Heterogenität, Fragmentierung und Unstetigkeit entwickelt hat. Infolgedessen und gleichzeitig als Mitverursacher dieser Bedingungen ermöglicht die häusliche Speicherung von Ressourcen wie Wasser und Strom in Form von haushaltspezifischen Konstellationen (*Dispositifs*), sich an die Unzulänglichkeiten der Netzinfrastrukturen des Staates und seiner Vertreter anzupassen, während sie gleichzeitig eine Vielzahl anderer, nicht vernetzter Versorgungsarten wie Bohrlöcher und Solarenergie nutzen können. Mit einen Verständnis von Infrastrukturen und Speicher-Arrangements als soziotechnische und sozioökologische Gebilde untersucht die Studie die Versorgungs- und Speicher-Dispositifs von diversen Haushalten und diskutiert diese in einer multiskalaren Relation zu Infrastrukturkonfigurationen, städtischen Geografien und Ungleichheiten sowie Strömen und Zirkulation.

Mit Bezug zu kritischer und postkolonialer Stadtforschung, STS-inspirierter Infrastrukturforschung und Planungsliteratur als Schlüsseldisziplinen und -debatten ist die empirische Forschung der Arbeit weitgehend qualitativ. Einem induktiven und iterativen Forschungsansatz folgend, bestehen die Hauptuntersuchungsmethoden aus 39 „angereicherten“ Haushaltsinterviews mit Bewohnern verschiedener, gezielt ausgewählter Stadtteile, 36 Interviews mit thematischen Experten, mehreren Begehungen und Stadterkundungen sowie ergänzenden Formen der (sekundären) Datensammlung. Aufbauend auf den empirischen Ergebnissen und größeren theoretischen Debatten wird in vier kumulativen Beiträgen, die sich jeweils auf unterschiedliche Aspekte oder Perspektiven konzentrieren, analysiert und diskutiert, wie Speicherung und die jeweiligen Artefakte die Beziehungen zwischen den Bewohnern, anderen städtischen Akteuren, ihren infrastrukturellen Umgebungen und der Stadt im Allgemeinen mitgestallten.

Ein zentrales Argument dieser Dissertation ist, dass die häusliche Speicherung einem ambivalenten Einfluss hat, die es den Haushalten ermöglicht, sich an infrastrukturelle Heterogenität und Unstetigkeit anzupassen, während gleichzeitig solch größere infrastrukturelle Bedingungen und deren Ungerechtigkeiten ermöglicht, stabilisiert und manchmal sogar verschärft werden. Die Ergebnisse der Studie legen jedoch auch nahe, dass künftige Interventionen in Nairobis Infrastrukturraum häusliche und kommunale Formen der Wasser- und Stromspeicherung in die Pläne, Mandate und Vorstellungen verschiedener städtischer Akteure – von städtischen Planungsdepartments bis zu staatlichen Regulierungsbehörden, von Immobilienunternehmen bis zu informellen Nachbarschaftsgruppen – einbeziehen müssen. Letztlich plädiert die Studie für weitere (multiskalare) Forschung zur Speicherung verschiedener Ressourcen, um die vorgestellten empirischen, theoretischen und praktischen Erkenntnisse zu hinterfragen und zu erweitern.

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Abbreviations

AWWDA	Athi Water Works Development Agency
BMS	Battery managements system
CBD	Central Business District
CBO	Community based organization
EPRA	Energy and Petroleum Regulatory Authority
EV	Electric vehicle
EWIK	E-Waste Initiative Kenya
HIC	Heterogeneous infrastructure configuration
ICT	Information and communications technology
IPP	Independent power provider
IPS	International Planning Studies research group
KARA	Kenya Alliance of Resident Associations
KEBS	Kenya Bureau of Standards
KenGen	Kenya Electricity Generating Company
KEREA	Kenya Renewable Energy Association
KES	Kenyan shilling
KETRACO	Kenya Electricity Transmission Company
KNBS	Kenya National Bureau of Statistics
KPLC	Kenya Power & Lighting Company
KWAHO	Kenya Water for Health Organization
LIB	Lithium-ion battery
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MoE	Ministry of Energy
NAS	Nairobi Aquifer System
NCC	Nairobi City County
NCT	Northern Collector Tunnel
NCWSC	Nairobi County Water & Sewerage Company
NEMA	National Environment Management Agency
NGO	Non-governmental organization

NMS	Nairobi Metropolitan Services
NWHSA	National Water Harvesting & Storage Authority
PhD	Doctor of philosophy
PV	Photovoltaic
SDG	Sustainable development goal
SHS	Solar home system
STS	Science and technology studies
TUD	Technische Universität Dortmund
UoN	University of Nairobi
UPE	Urban political ecology
UPS	Uninterruptible power supply
VAT	Value added tax
WRA	Water Resource Authority

⚡	Electricity
💧	Water

1. Setting

A prologue

Figure 1: Underground water tank in Mila‘s front yard being filled by a water bowser *crew; photo by author (2022).*

Sometime in early 2022, I am standing in the front yard of a small, aged townhouse on Rhapta Road, where Mila[1] has lived for the past few years. Located in the rather affluent Westlands area of Nairobi – Kenya's capital city of about 5 million people – Rhapta Road has seen its fair share of the city's transformation into a 'world-class metropolis.' Upscale and vertically rising real estate, both residential and office, has sprung up to replace the single-family homes, townhouses, and dated apartment buildings of the twentieth century. And just two streets north of Mila's, parallel to Rhapta Road, the massive and controversial, elevated Nairobi Expressway is being constructed. Since construction started in 2020, many properties on and around Rhapta Road have been repeatedly cut off from the water supply of the municipal utility, the Nairobi County Water and Sewerage Company (NCWSC), or just Nairobi Water. Sometimes planned and communicated, but often accidental and without warning, Nairobi Water's already intermittent and unreliable supply has worsened on Rhapta Road due to the physical disruption of main lines by construction activities, forcing property owners and tenants to seek non-networked water supply options at unprecedented rates.

And so, I stand in Mila's front yard as the crew of a water tanker, known in Nairobi as a *bowser*, fills her underground water storage, a simple polyethylene tank of a few thousand liters dug in to the top (‣ Figure 1). Mila shares the bowser water with a neighbor and their own tank to get them both through the next week or two. From Mila's tank, into which the piped utility water would also flow, water is electrically, but not automatically, pumped up to another, albeit smaller, tank in the attic to provide pressure throughout the house. Without these two tanks, as well as some smaller water storage in her kitchen areas, Mila would not really be able to use any water, ever. Unfortunately, because power outages are also a fairly common phenomenon, Mila and many others in Nairobi sometimes have water available but cannot pump it up to fill the pipes in the house. Yet, electricity disruptions do not only disrupt water use, but more importantly, with their unpredictable regularity, they affect a wide range of household activities and uses of electricity in Nairobi; from simple lighting to cooking to Internet access to work and more. To ensure that at least some basic needs and conveniences are met during a blackout, especially at night, Mila has a headlamp and some battery-operated lights, as well as a power bank that is always charged, 'because you never know.'

[1] All names of interviewees in this thesis have been replaced with pseudonyms.

‘Because you never know.’ ‘Just to be prepared.’ ‘Because my country is like this.’ In the last few years, I heard these and many similar phrases in virtually every conversation I had with Nairobians when I asked why they actually store water in various containers, from large tanks to small buckets. And the same goes, increasingly so, for storing electricity in devices with built-in batteries or stand-alone batteries such as power banks. Often people would look confused, probably wondering why I was asking such a banal, borderline stupid question with such obvious answers. But more often than not, over the course of our conversations, my interviewees developed their own curiosity and fascination with the banality and simultaneous importance of all their containers and their efforts to use them. Some contacted me months after our conversations to tell me that they could not stop seeing all the water tanks and jerry cans that dotted Nairobi‘s urban landscape, after having tended to ignore them all their lives. Some began to think more about their energy consumption and how to dispose of their dead batteries. Others were now inspired in their creative work by the audio-visual aesthetics of domestic storage. I could tell little side stories like these from across Nairobi‘s large and multiple urban space, just as I could have started this prologue with many other ‘cases’ or households that I visited and interviewed during my research on ‘artefacts and practices of storage as part of heterogeneous infrastructure configurations (HICs) in Nairobi.’ However, not only does the brief vignette from Mila‘s front yard foreshadow many of the aspects discussed in this cumulative thesis, but the deliberate start on Rhapta Road in the arguably upscale area of Westlands connects with two important points that warrant clarification early on: my own positionality towards Nairobi, and the importance of avoiding, as much as that is actually possible, the ‘danger of a single story’ – to borrow a phrase from writer Chimamanda Ngozi Adichie[2] – when researching and writing about an African city.

Positioning myself

The inspiration for much of this thesis may have started with a small spark, a tiny moment of witnessing an incredibly mundane activity – the carrying of jerry cans across a street – as mentioned in a bit more detail in Chapter 5. However, much of what will be described and discussed, the everyday activities of storing resources and thus the everyday *infrastructuring* of the city named Nairobi, has been part of my life for several years too: checking water levels in tanks, keeping jerry cans as a water backup, constantly making sure my power bank is charged, etc. All this started

[2] See her respective TED Talk from 2009 on YouTube: www.youtube.com/watch?v=D9Ihs241zeg.

in 2009 with my first stay in Nairobi, where I got a short internship in a German-led project on reforming Kenya‘s water sector and – as I vividly remember – where I saw an alkaline-battery-powered TV for the first and last time in my life in a small shack in Nairobi’s outskirts; both strangely foreshadowing the topics of my dissertation research about 15 years later. Then I worked for the German cultural institute and lived in Nairobi for almost three years, from 2012 to 2014; and again, as an employed researcher in the development/ humanitarian sector for about two years, from 2017 to 2019, during which time I also lived on Rhapta Road, just a few hundred meters away from Mila‘s place. In addition, there have been countless visits, strong relationships, and many friendships that to this day define how I relate to Kenya’s capital; as a place of belonging, as a place that has shaped my life more than almost any other, and as a place through which I often see and compare many other urban worlds.

I am compelled to disclose my somewhat strong attachment to the city of Nairobi, which has probably its own pitfalls and risks of bias, due to the legitimate, longstanding but renewed discussions and critiques of the extractive nature of many empirical research projects, especially by Euro-American foreigners such as myself in formerly colonized countries, e.g. Kenya (Lewis 1973; Mwangi N 2019; Tilley 2017). In the wake of ongoing attempts to decenter and decolonize such research – including urban studies and planning research (Ahmed Na et al. 2022; Vasudevan and Novoa E. 2022) – and the academy more broadly, the positionality and reflexivity of a researcher has become an important topic of debate. Here, I would never claim to have sought to specifically challenge the inherent, historically grown but systemically cemented inequalities and power imbalances that persist between academics, between institutions, and between a (foreign) researcher and some of their interlocutors. For example, by inadvertently ‘wielding class and educational privileges over research participants’ (Mwangi N 2019: 25), not to mention my racial and passport privileges, such imbalances have most likely also impacted my empirical research in Nairobi. Furthermore, as many of my interlocutors are read as female, gender is another dimension that likely influenced my empirical interactions as well as my interpretation of data, especially since infrastructural labor of households, such as water fetching and storing, is often a highly gendered domain in Nairobi (Sarkar 2022). Throughout the research process, I have tried to reflect on and address my position and potential biases, for example by adopting a highly exploratory and open-minded approach to empirical work such as interviews, where I always prioritize the narrative preferences of the interviewees, or by deliberately asking female and/ or Kenyan friends and colleagues for their perspective on certain findings. Still, I am under no illusion that I have legitimately addressed all the biases and inequalities that even come with a dissertation project on such mundane things as 'water tanks, jerry cans, power banks.' However, based on my longstanding connections to Nairobi and my respective positions as what might be called a 'hybrid insider-outsider researcher' (van Hooft 2019) for research on everyday urban and infrastructural experiences in the city, I may have had both the privilege and the obligation to build and expand various relationships with colleagues, friends, and new contacts in Kenya and beyond (see *Acknowledgements* for some examples). Not only do I hope and plan to extend these relationships collaboratively beyond the timeframe of this project, but some have already been linked to further research projects, collaborative proposals, and other opportunities that may be beneficial to some of the people I have met along my PhD journey; a journey that – by deliberately choosing Nairobi as my 'field' – has been 'not a one-off event but a series of interactions and relationship building' (Mwangi N 2019: 26) that began in 2009 and to which I am committed into the distant future.

Positioning Nairobi

By starting off in a front yard in Westlands – rather than, say, at a water point in an informalized settlement or in the darkened stairwells of a low-income apartment building during a nightly power cut – I also hope to have set the right tone and expectations for this thesis. Since its colonial beginnings, Nairobi has always been a space of urban-infrastructural and socio-spatial multiplicity, sometimes experienced as highly fragmented and segregated, sometimes as overwhelmingly simultaneous (Fontein et al. 2024; wa Mungai 2019). Nevertheless, as has been criticized for urban Africa in general for decades now (Mbembe and Nuttall 2004; Myers 2011), academic and public discourse still tends to write largely problematizing, singular stories about Nairobi. Despite the important work of urban scholars inspired by postcolonial critique (e.g. Bhan 2019; Roy 2009; Yeoh 2001) and the carefully constructed scholarly interventions of many who have researched in and on African cities (e.g. Silver J 2023; Simone 2001; Watson V 2009), African cities are still often portrayed as the 'Other,' the chaotic, the unruly. Simple dichotomies tend to dominate, for example between the perennially-informalized landscapes of the urban poor and techno-utopian imaginaries of the so-called *Silicon Savannah*, between total chaos or failure and soon-to-be 'world class city' status, between pity for the hardship of its inhabitants and romanticizing their resilience (cf. Watson V 2014). While none of these notions and imaginaries are entirely unwarranted, they flatten and simplify the urban realities experienced not only in informalized settlements like Kibera and Mathare, or behind the glittering windows of luxury high-rises that signify a cosmopolitan narrative of 'Africa Rising,' but even more so in the everyday realm of the wider yet heterogeneous Nairobi, which can hardly be reduced to a single city, a single story.

However, describing and positioning Nairobi as a city of many stories, as 'a space of many urban worlds' (McFarlane et al. 2017), has clear limitations in terms of analytical value and corresponding practical implications. In particular, for our understanding of the conditions, production and politics of urban infrastructures, 'there is a danger that an emphasis on plurality and complexity obscures the more structural patterning' (Ahlers et al. 2014: 8). Thus, in order to account for both dangers, the single story and the obscurity of multiplicity, I have deliberately chosen a conceptual framework and examined an issue that relates to and occurs in different but ubiquitous ways in the many urban worlds of Nairobi: the everyday storage of water and electricity by households of virtually all classes and geographies. By using 'storage as an analytic' (▸ Chapter 7), I hope not only to provide another, albeit plural, story and focused analysis of the urban-infrastructural condition of Nairobi in the early twentifirst century, but by examining a somewhat mundane and 'boring' aspect of everyday life – one that almost every Nairobian can relate to in their own idiosyncratic ways – it is also my attempt to position and describe Nairobi in a unifying and ordinary perspective. This perspective or lens, i.e. the storage of basic resources at home, refers not just to one kind of urban reality, not just to Westlands, not just to Kibera, not just to *mabati* (iron sheet) shacks or townhouses or *ghorofa* (multistorey) apartment buildings, but basically everywhere; albeit in situated variations. Ultimately, this helps to uncover patterns and processes that challenge, nuance, and advance the classic descriptions of Nairobi and its infrastructural articulations as full of fragmented, chaotic, and unruly contradictions only.

2. Framing

Nairobi, infrastructure, storage

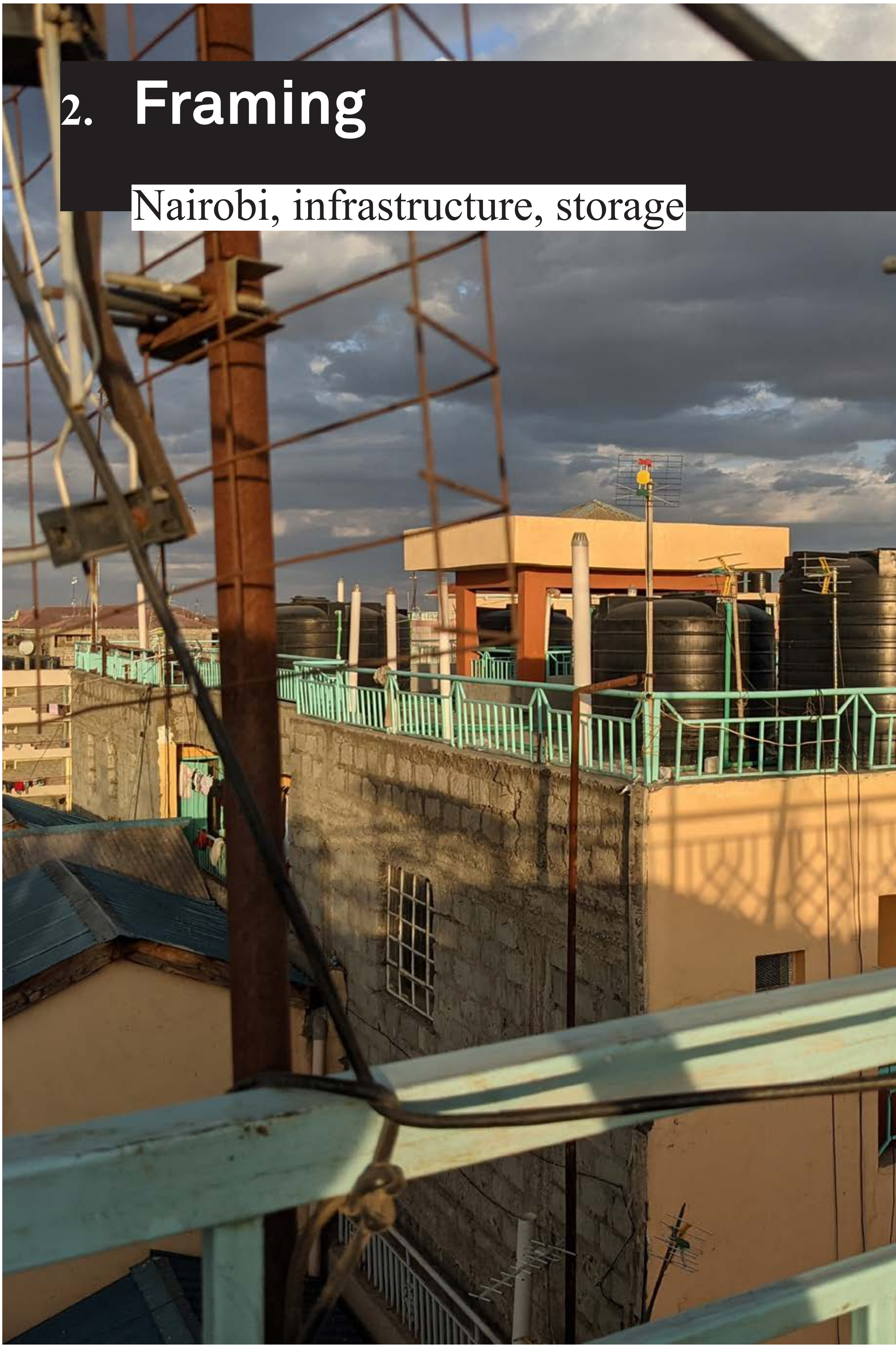

Figure 2: Rooftops with antenna and water tanks in Pipeline, Nairobi; photo by author (2022).

At the heart of this dissertation lies an unapologetically joyful fascination with supposedly mundane things and practices that are constitutive but 'invisibly visible' parts of our cities and infrastructures (‣ Chapter 5). Specifically, I focus on the myriad containers and receptacles that are constantly filled, emptied, and refilled with 'stuff' such as water and electricity by urban residents, and that can be found in all kinds of households in all kinds of neighborhoods, as well as in the public and common spaces of Nairobi: water tanks, jerry cans, power banks, rechargeable lights, and more. Ultimately, I explore and discuss the importance and role of these mundane, largely domestic storage arrangements for the broader urban-infrastructural functioning and condition of a 'southern city' in the early twentifirst century. Details and analysis are mainly provided in the four academic papers of this cumulative thesis:

- Storage city: Water tanks, jerry cans, and batteries as infrastructure in Nairobi; co-authored with Sophie Schramm (‣ Chapter 4)
- Mitungi as ... Thinking about urban space and infrastructure with the jerry can (‣ Chapter 5)
- Nairobi's *batteryscape*: Everyday electricity storage, energy justice, and infrastructural heterogeneity in urban Africa (‣ Chapter 6)
- From dams to tanks to jerry cans: Storage as a multi-scalar analytic (‣ Chapter 7)

The individual papers contain most of the theoretical, empirical, and analytical content, but – at the risk of later repetition and redundancy – this framing chapter provides context and rationale for the geographical, infrastructural, and discursive-theoretical position of my study as a qualitative, exploratory investigation of urban households' domestic water and electricity storage as part of HICs in Nairobi, Kenya.

2.1. **Nairobi and its infrastructure space**

The history of Nairobi is well told and usually goes something like this: a relatively flat, swampy land with cool waters; a settler-colonial railroad that needed a camp in 1898; a series of annexations, expulsions, and expansions; post-independence euphoria later torpedoed by 1980s neoliberalism; and finally, fueled by an ever-growing population and international capital, a city desperately seeking 'world-class city' status (Ogot and Ogot 2020). In this incredibly oversimplified account of some 125 years of urban history, beginning with the demarcation of 'enkare nyrobi' as a railway depot in 1899, Nairobi's population grew to now about 5 million people spread over the roughly 700 km^2 of today's Nairobi City County (NCC), which is one of the country's 47 counties, located in central Kenya at an elevation of approximately 1,800 meters above sea level and, as the capital, home to most of the political power and governmental bodies of Kenya's multi-ethnic nation-state (Sverdlik 2021). While unique and ordinary like any other (cf. Robinson 2006), Nairobi is also a paradigmatic city of the early twentifirst century, where many situated articulations of contemporary urbanity and urbanization can be witnessed; from rapid urban sprawl and informalized settlements to the mushrooming of upscale malls and the rise of platform urbanisms.[3]

As much as Nairobi's multiple articulations of the contemporary *urban* already make it a fascinating case for urban studies, planning research, and related endeavors, there has also been considerable engagement with what can be called the city's 'infrastructure space' (Easterling 2016), that is, the interrelated physical, digital, and organizational, sociotechnical as well as socioecological systems that shape and enable our urban worlds. Similar to many other cities of the 'Infrastructural South' (Silver J 2023), Nairobi's contemporary infrastructures are built on colonial, in many cases deliberately discriminatory and blatantly racist planning legacies that have mutated into place-specific articulations and geographies of infrastructural fragmentation, heterogeneity, and incompleteness (Guma 2020; Pollio et al. 2023; Schramm 2017). While these contemporary qualities are not problematic *per se*, the city of Nairobi has also long been a space

[3] Specific examples include: Continued rapid population growth that overwhelms many attempts at coordinated urban development, resulting in and met by variegated forms of urban planning and governance; from states of exceptions to *plugged-in* interventions to draconian responses (Guma et al. 2023a; Kimari 2024; Schramm and Bize 2023); urban sprawl into the hinterlands of the wider Nairobi region, reconfiguring urban-rural relations and continuing to generate value and to-be-extracted capital for a selected few (Gillespie and Mwau 2024; van Noorloos et al. 2019); the persistence of informalized settlements, with their important socialities but undoubtable problems, despite state-led 'upgrading' projects and outright evictions, as well as community-led projects and NGO interventions (Mwau and Sverdlik 2020; Ouma 2023a; Schramm 2017); the influx of foreign capital and domestic investments in real estate developments, resulting in the mushrooming of shopping malls, upscale apartment buildings, and gleaming office towers in selected parts and along major routes of the city (Gillespie and Mwau 2024; Pitcher 2017); the emergence of a 'tenement city' (Huchzermeyer 2011) full of poorly serviced and badly maintained, sometimes even collapsing, *ghorofa* buildings for lower to middle income groups, especially in the eastern parts of the city (Schmidt 2024; Smith C 2020); the implementation of 'smart' technologies and the rise of platform urbanisms, largely driven by international investors and the 'Californian ideology' of neoliberal tech disruption (Guma 2021; Pollio 2024; Pollio and Cirolia 2024); and most recently, the (re)emergence of the city as a stage of political expression and protest, mostly led by a young generation of well-educated but economically marginalized Kenyans who are trying to have their voices heard in a political system that has long served the elite (Warah 2024). While not an exhaustive list, these are some of the key descriptors to keep in mind when investigating the city of Nairobi in the 2020's, and many will shine through or be directly touched upon in this thesis.

of rampant infrastructural inequalities and injustices, with marginalized and mostly low-income communities often receiving less services, less connectivity, and less frequent supply at often higher costs, while at the same time being disproportionately affected by the negative impacts of infrastructures and their development. Examples include the city's inequitable transportation and mobility infrastructure (Nyamai and Schramm 2023), or its overburdened, opaque, and highly fragmented waste collection and disposal sector (Ogutu et al. 2021; ‣ Chapter 6). And when it comes to water and electricity, which I discuss in more detail in Chapter 2.2, Nairobi can be highly differentiated and inequitable also, but often in ways that defy simple dichotomies of formal/ informal or connected/ disconnected.

In contrast to rather myopic, simplifying but still valid descriptions of Nairobi's urban-infrastructural realities, a number of authors have also shown the intricacies and importance of everyday infrastructuring – that is, the making of urban infrastructure through everyday practices and labor (cf. Graham and McFarlane 2014; Simone 2022). Akallah and Hård (2020) provide historical accounts of the long-standing use of non-networked, non-utility solutions by urban residents, i.e.

Figure 3: Nairobi Expressway at night in Westlands; photo by author (2023).

for water supply. Kimari (2019) shows how defiance and the use of simple technologies such as a pump, although potentially met with state violence, can challenge the persistent injustices faced by an urban majority. Cirolia and others (2023) unravel how tech platforms not only rely on the labor of countless *boda boda* (motorbike) riders, but also reshape urban-infrastructural configurations through and with them. These are just some of the examples of how Nairobians have 'continued to be their own infrastructure for close to a century, finding innovative ways to provide services for their neighborhoods in light of the inability, or unwillingness, of the county administration to do so' (Kimari 2019: 149); and – as Constance Smith (2019) has shown for the infrastructurally neglected Kaloleni estate – they keep doing so by also claiming and 'making' their (digital) futures. In addition, through efforts of NGOs, non-profits, and community initiatives – such as the *Mathare Social Justice Center*, *Kounkuey Design Initiative*, *Muungano wa Wanivijiji*, and many more – Nairobians are demanding their participation in the 'formal' planning and design of urban spaces and infrastructures (Mulligan et al. 2020; Ouma 2023a). Coordinated or quotidian, the many practices of everyday infrastructuring in Nairobi – from riding a motorbike, to using a pump, to taking part in a participatory design workshop, and more – can then be conceptualized as a 'urban way of survival' (Guma et al. 2023b), often part of the 'hustle' that has become such a common descriptor of urban life in Nairobi (e.g. Thieme 2018, van Stapele 2021). However, there is always a risk of romanticizing the everyday struggles of Nairobians to make their city work, of over-celebrating their hustle and modes of survival, of over-estimating their agency and impact (cf. Cirolia 2019), while Nairobi and its infrastructural configurations have also seen major interventions by state and non-state actors in recent decades.

With African cities like Nairobi being 'capitalism's urban frontier' (Gillespie 2020), the 'infrastructural gap' that has allegedly plagued these cities for decades is currently being filled by so-called infrastructure-led developments, largely fueled by foreign capital and aimed at the cross-border integration of 'resource frontiers and industrial hubs with the global economy via large-scale networked infrastructure' (Schindler and Kanai 2021: 49; cf. Goodfellow 2020). For Nairobi, prominent examples are massive transport projects such as the Standard Gauge Railway linking Nairobi to coastal Mombasa, and the controversial Nairobi Expressway (Guma et al. 2023a; ‣ Figure 3). Leaving aside consequences such as rampant evictions (Kimari and Cap 2022), these interventions have a broader (geopolitical) role in *fixing* foreign capital and for the infrastructural territorialization of the Kenyan state (Huang and Lesutis 2023; Lesutis 2021). At the same time, adjacent developments, such as major bypass roads and a much-delayed Bus Rapid Transit system, form ambiguous relations with urban politics and affected residents, which in turn co-shape the temporalities and spatialities that emerge around and along major infrastructure projects (Maina and Cirolia 2023; Mwaura and Lawhon 2024). Also, the proliferation of 'smart' and digital solutions for infrastructural applications in Nairobi – such as water and electricity metering, delivery and mobility services, *fintech*, and more – has been driven by foreign capital and companies, as well as a political economy of international organizations, NGOs, and local start-ups. Here, the Kenyan state plays an active role in facilitating possibilities through subsidies, incentives, and regulations, or simply by the lack thereof (Cirolia et al. 2024; Ndemo 2019). Digital possibilities have been widely embraced – by the private and public sectors alike, and by urban residents – resulting in the emergence of new urban infrastructural and economic arrangements that defy traditional dichotomies of formal/ informal, digital/ analog, state/ citizen (Pollio et al. 2023; Guma 2021; Guma and Wiig 2022).

The virtual and analog realms of Nairobi's infrastructure space are currently undergoing a reconfiguration, with an increasing number of private and foreign actors providing targeted, but piecemeal, solutions to not-yet-capitalized 'infrastructural gaps.' At the same time, urban residents ensure the actual infrastructural functioning, while the Kenyan state and the municipal NCC government – with exceptions – tend to facilitate infrastructure-led developments rather than invest in public projects. However, due to Kenya's institutionally inscribed devolution of power – from the nation state to individual counties – much of the urban governance in the capital is officially the responsibility of the elected NCC government and its various departments, such as 'Built Environment and Urban Planning.' Yet, not only has the power of the NCC recently been overridden, albeit temporarily, by the presidentially appointed Nairobi Metropolitan Services, or NMS (Ouma 2023b; Schramm et al. 2023), but the national government and various institutions always play a strong role in shaping Nairobi's infrastructure space. On the one hand, Kenyan presidents tend to leave infrastructural legacies in Nairobi, such as the aforementioned Nairobi Expressway under Uhuru Kenyatta or the equally massive Thika Road under Mwai Kibaki; and the broad development goals of Kenya's nationwide *Vision 2030* are reflected in Nairobi's current master plan (Kimari and Cap 2022; Smith C 2017). On the other hand, numerous agencies, regulators, and utilities – whose mandates may lie at the national level, the county level, or somewhere in between – significantly shape the development and governance of infrastructures in Nairobi, such as the state-owned Kenya Power & Lighting Company (KPLC). When engaging with any part of Nairobi's infrastructure space, one is typically confronted with a complex and dynamic web of diverse and sometimes conflicting actors, responsibilities, plans, and rationalities (Guma 2021; Myers 2011; Schramm et al. 2023) that can range from the micro-political in individual neighborhoods to the geo-political, and which can easily shift according to political currents.

Overall, Nairobi and its infrastructure space in the early twentifirst century are constituted by dynamic and sector-specific arrangements of urban statecraft, municipal/ county governance, increasing involvement of private and foreign actors, and – most importantly – some 5 million residents who contribute to the continuous infrastructuring of the city, albeit in varying degrees of participation and agency. This makes the city of Nairobi a highly compelling, potentially paradigmatic case for empirical research into broader patterns and questions of urbanity and urbanization across the 'Infrastructural South' and beyond. But understanding these conditions through the spectrum and interplay between 'major' (state and/ or capital-led) and 'minor' (individualized and/ or community-driven) articulations of infrastructures (cf. Kumar 2024; Silver J 2023) allows for nuanced investigations of selected geographies, politics, and processes – such as an ongoing 'individualization of infrastructural responsibilities' (Kasper et al. *forthcoming*) – that may resonate beyond individual cases, beyond a single type of infrastructure, and beyond Nairobi.

2.2. Two basic resources flowing through the household

Backbone of our contemporary urban worlds are what Marvin has called 'distributive infrastructures' that consist largely of 'pipes, cables, wires and tracks, which transmit resources to markets of commercial, industrial and domestic consumers' (Marvin 1992: 228). Think of the roads and rails that allow for mobility and ensure that food arrives in our stores and markets; think of the fiber optic cables that carry data between continents and within cities; and think of the many pipes and wires through which two of the most important resources *flow* into and through cities: water and electricity. Both are incredibly important to virtually every facet of contemporary (urban) life, and thus are highly political, sociotechnical vectors of urban inequalities and place-specific differentiation. What makes them even more intriguing 'objects' of investigation for a study of 'artefacts and practices of storage' is that we tend to understand them as constantly flowing, fluid, hard-to-contain resources (e.g. Fischer-Kowalski and Hüttler 1998; Kaika 2005; Silver J 2015). Arguably, both water and electricity (or energy more broadly) tend to resist storage, and we often go to great lengths to contain them; just think of massive dams that store water for later use, or for energy production. Moreover, with an idealized but largely Euro-American notion of the 'unitary, orderly city integrated by universal networks' (Monstadt and Schramm 2017) that distributes to everyone at all times, much of the dominating Western understanding of how water and electricity are supposed to reach and be experienced at the household level is simply about flipping a switch or turning on a tap, resulting in a continuous flow of safe energy or potable water. But in many cases, it's a little more complex than that.

'Water is life'

Access to water is a basic need and human right, and in the course of my fieldwork I have heard no phrase more often than 'water is life.' Sometimes as a throwaway statement, sometimes meant with sincerity. Regardless of the intention, the incredible importance of water 'for life' and for urban agglomerations cannot really be overstated. Not only are all cities predicated on the availability of water – and Nairobi's name is directly derived from a Maasai phrase meaning 'place of cool water'[4] – but the importance and volatility of urban water supply have sparked much public and academic debate, particularly in reference to anthropogenic climate change and governance failures that cause so-called 'water crises.'[5] These 'crises' often affect marginalized populations the most, leaving them vulnerable and alone in their attempts to secure safe access to water. But even before and beyond acute shortages, water supply and access can be highly conflictual, unequal, and volatile. Some cities might have a fairly universal and reliable supply, usually based on large technical systems of pipes, pumps, valves, reservoirs, and more. But many others – especially cities with colonial, technocratic planning legacies (cf. Kooy and Bakker 2008; Niranjana 2021) – hardly fulfill the 'promise of infrastructure' (Anand et al. 2018), i.e. providing water to all residents in an equal and direct manner. In turn, because 'water is life' and urban residents are nevertheless dependent on it, place-specific arrangements emerge that may involve different actors, technologies, and modalities (Alba et al. 2022; Monstadt and Schramm 2017).

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[4] According to Ogot and Ogot (2020), the name Nairobi is derived from the Maasai term 'engore nyarobe,' which means 'place of cold/ cool water.' Other sources may use slightly different spellings of the Maasai term and/ or slightly different translations.

[5] Specific examples include the 'water crises' of São Paulo, Cape Town, and Flint, Michigan, to name just a few from the last decade. While different and place-specific, any 'water crisis' is rarely a sudden event, but rather results from historically grown inadequacies of local infrastructures, financial pressures and/ or lack of investment, and incredibly 'banal' but damaging governance decisions (Anand 2017; Millington 2018, Millington and Scheba 2021).

These arrangements ensure that water does somehow flow to all urban households after all, albeit in heterogeneous, often unequal ways; and not always just through pipes.

In Nairobi, water access is indeed highly heterogeneous and unequal. Since colonial times, when supply was ‘de facto based on racial segregation’ (Nilsson and Kaijser 2009: 278), major infrastructure developments – even after Kenya‘s independence in 1963 – have mainly benefited high-income neighborhoods, while an urban majority has always had to supplement with or rely entirely on non-networked, non-utility modes (Akallah and Hård 2020; Blomkvist and Nilsson 2017). A heterogeneous landscape thus emerged in which, according to official figures from NCWSC, piped water reaches only about three-quarters of all households and the total supply covers only about 65 % of the daily demand (Schramm et al. 2023; ‣ Chapter 4). Accordingly, the hydraulic realities of households in Nairobi are highly diverse and include boreholes, water kiosks/ATMs, prepaid meters, water bowsers, a continuous water rationing program as well as frequent water outages, so-called ‘water cartels,’ significant differences in water prices by location and type of supply, etc. (Mutono et al. 2022; Sarkar 2022; Wamuchiru 2017). In addition, while

Figure 4: ‘Sorry no water’ sign on a toilet in an event space in Kilimani, Nairobi; photo by author (2022).

piped supply has long been intermittent and unreliable, all types of supply are facing volatility due to continued urban growth, over-exploitation of natural water bodies, and more frequent droughts (JICA 2013; Oiro et al. 2020; Shah G 2024). A ‘water crisis’ appears to be on the horizon for Nairobi, and the Covid-19 pandemic has exposed and exacerbated inequalities and fragmentation, so that even within a single neighborhood, the water situation can vary significantly between individual buildings and households (Kasper et al. *forthcoming*). The flow and circulation of water through Nairobi and to individual households is thus not only highly heterogeneous, but classic dichotomies such as connected/disconnected, formal/informal, or rich/poor are decreasingly helpful in adequately explaining the minute differences in the water-infrastructural realities in Nairobi (cf. Schramm and Ibrahim 2021). All the while, its residents continuously employ a variegated portfolio of strategies and practices to ensure safe water availability, for example by storing it in containers of different sizes, materialities, and for different purposes.

Figure 5: Electricity meters in an apartment building in Kibera (Canaan Estate); photo by author (2021).

'Electric city'

While not as necessary to 'life' as water, electricity has become quintessential to the *modern urban*. Moreover, as the 'common denominator of a new technological revolution' in ICT and energy systems (Burdett and Rode 2012: 2), electricity is poised to play an even more central role in our infrastructural lives, which are already hard to imagine without all the devices and infrastructures powered by it: lighting, computers, phones, countless displays, kitchen appliances, Wi-Fi routers, traffic lights, servers, pumps, and much more. However, differentiated and unequal access to electricity is highly prevalent within cities – including instances in the Global North and in 'world cities' such as Hong Kong (Castán Broto 2019; Protschky 2023; Yoon et al. 2024) – and these differences are often the result of and reproduce (colonial) planning legacies as well as persistent discrimination and injustices along class and racial lines. Further, differences in electricity access and use can be exacerbated by 'new' technologies such as prepaid meters, solar home systems (SHS) and other 'off-grid' modalities (Baptista 2015; Babourkova 2016; Munro and Samarakoon 2023). Research in urban Africa has further shown how long-standing issues with electricity supply, such as recurrent disruptions, reproduce a 'fragmented, splintered infrastructure that reinforces urban inequalities' (Silver J 2015: 986) and how heterogeneous electricity configurations require a great deal of adaptation on the part of users – for example, through the use of off-grid solutions or unauthorized tapping of electricity – which challenges the social contract between the state and citizens (Degani 2022). Overall, while electricity flows – formalized or informalized – to most households in large cities, everyday realities of access and use reveal that the benefits and burdens of 'heterogenous urban energy landscapes' (Castán Broto 2019) – from the perks of digitization to the health hazards of illegally tapped power lines – are more often than not unequally distributed in the 'electric city' (Burdett and Rode 2012) of today.

Turning to Nairobi and Kenya, the country's *Energy Act* of 2019 outlines the state's responsibility to 'facilitate the provision of affordable energy services to all persons in Kenya' (Republic of Kenya 2019: 24). And after significant increases in Kenya's electrification rates – from 15% of the country's total population with access in 2000 to 71% in 2020[6] – the act and related programs, investments, and incentives aim to fill the remaining gaps and cement electricity's role as the primary energy form for regular consumers, e.g. households that currently consume 31% of the electricity in Kenya (EPRA 2024; Petrik et al. 2020). Moreover, the national sector and

[6] For urban Kenya, including Nairobi, this number rose from 50% to 95% over the same period (Tracking SDG7 n.a.).

Nairobi's electricity landscape show several positive characteristics, such as a fairly sustainable energy mix, with renewables like hydropower and geothermal providing 83% of all electricity in 2023/24 (EPRA 2024), or the near-universality of household electrification in Nairobi, with electricity as the primary source of lighting ranging between 94% and 97% across Nairobi's eleven sub-counties (KNBS 2019). However, there 'reason to doubt the veracity of connection numbers reported by the utility [KPLC]' (Taneja 2018: 5), and these numbers were not achieved solely through official programs or metered connections, but – across Kenya – informalized modes of access still persist, especially in low-income areas. Also, the current proliferation of prepaid meters has not only supported electrification but resulted in variegated consumption patterns, depending on fluctuating costs and household finances (Guma 2021; Ulsrud and Saini 2022; Smith S 2019). Moreover, Nairobi is also characterized by the prevalence and uneven distribution of aging infrastructures, low voltage and consequent brownouts, and – most importantly – planned and unplanned outages or blackouts, which total about 90,000 per year (Taneja 2018). Disruptions are less frequent and less prolonged in higher-income areas (Ferrall et al. 2022), and 'while the richer [residents] can use high-cost generators and inverters to cope with outages, the poorer must wait until power is restored' (Taneja 2018: 16). Due to the constant possibility of an outage, rising electricity costs, and other factors, households usually use multiple energy sources, such as charcoal and liquefied petroleum gas (LPG) (Karekezi et al. 2008; Njoroge et al. 2020), and they employ variegated measures for their electricity security: from simply having a few backup lamps to investing in SHS or backup systems that can power a full house. Increasingly, these measures involve electrochemical energy storage, i.e. batteries of various sizes, types and applications.

Household, dispositif, two infrastructures

Water and electricity infrastructures are crucial to the planning and governance of cities, and they often occur in very place-specific, historically evolved, highly political, and heterogeneous articulations that strongly affect individual households. Moreover, both are highly interconnected – e.g. hydropower accounts for a quarter of Kenya's installed electricity generation (EPRA 2024) – and intertwined with other flows and infrastructures at different scales; from global financial circuits to nationwide or citywide systems to individual households (Bruns et al. 2022; Monstadt and Coutard 2019). While a multi-scalar perspective helps to frame and study place-specific infrastructure articulations and urban developments (Robinson et al. 2024), urban residents experience and relate to many distributive infrastructures at the household level (where also a lot of storage is taking place; ‣Chapter 2.4.). Here, in the quotidian times and spaces of the *home*, infrastructures and flows ‘become integrated in the practices of everyday life’ and ‘different actor perspectives and expectations come together around such junctions of infrastructures’ (Rohracher and Köhler 2019: 2375). Thus, and in order to avoid generalizations at the neighborhood scale, which, as noted above, is becoming less and less useful in describing infrastructure experiences in Nairobi, *the household* provides a compelling entry point for researching the city‘s infrastructure space.

However, the notion of *the household* has long been rightly criticized for its ethnocentric, Euro-American, and limited definition as ‘a social and functional unit combining co-residence, solidarity, and economic autonomy’ (Hetrich et al. 2020: 123; cf. Yanagisako 1979). Neverthelss, based on my experience and its use in many studies or surveys, *the household* is a highly applicable point of reference in the ‘tenement city’ of Nairobi. On the one hand, it is a widely understood and used framing. On the other hand, it allows for a relational understanding of a domestic space as a node that entangles different actors, relations and flows, rather than just a spatially delimited container space (cf. Hamberger 2018; Rohracher and Köhler 2019). A relational understanding of households also aligns well with the way in which Rateau and Jaglin – for their work on West African cities – have framed the (electro-)infrastructural setting of individual households as so-called *dispositifs* (cf. Akrich and Latour 1992; Jaglin 2014), meaning that each household and its mix of energy sources is understood as

> ‘a specific set of actors, resources, material artefacts, technical knowledge, and formal and informal institutions. [...] At the household and neighbourhood levels, socio-technical *dispositifs* are selected and assembled through practices in various combinations that vary across the urban space. At city scale, this results in an urban electricity configuration’ (Rateau and Jaglin 2022: 185)

Understanding infrastructural articulations as relational settings that emerge at the household level – in my case for both electricity and water – allows to investigate the intricate and minor, everyday infrastructures, while being able to relate and contextualize them across scales. With a reading of infrastructures rooted in the everyday urban, academic engagements focusing on dispositifs, technical artefacts, and social practices of water and electricity have become important and highly productive arenas for urban/ infrastructure research (Cirolia and Pollio 2024; Furlong et al. 2019; Jambadu et al. 2024; Munro et al. 2023; Pilo‘ 2023). By focusing on domestic storage as part of heterogenous infrastructure configurations (‣Chapter 2.3), the thesis adds nuance and new perspectives to these arenas. Here, deliberately working with two key distributive infrastructures and their usually flowing but often domestically stored resources – water and electricity – has added value in that it allows empirics and analysis to speak about, across, and beyond their specificities. By thinking through and with both infrastructures, and with storage more broadly (‣ Chapter 2.4.), this can provide insights that go beyond their initial framing and tell stories, contribute to theory, and allow for practical applications that may relate not only to water and/ or electricity infrastructures, but to our understanding of contemporary cities, urban infrastructures, and *infrastructure as an analytic*.

2.3. **Infrastructure as an analytic (for southern cities)**

This thesis rides the wakes of two academic 'turns,' namely the 'infrastructure turn' and the 'southern turn,' which have influenced urban studies and planning research over the last two decades. The 'southern turn,' coined by Rao (2006) and popularized by McFarlane (2008), emphasizes the importance of understanding urbanization and planning practices from the perspective of the global south and advocates for concepts and practices rooted in southern contexts rather than relying on Euro-American theories. Often inspired by postcolonial critique of authors such as Edward Said, Frantz Fanon, Dipesh Chakrabarty, or Achille Mbembe, some urban scholars have sought to challenge 'established theories, modes of theorization and the universality of northern ideas' by applying a *southern urban critique* (Lawhon and Le Roux 2019: 1251). Instead of relying on teleological concepts of development or the *modern urban*, so-called 'southern cities' in all their multiple expressions are approached and studied in their actual constitution and not – as far as possible – with normative ideas of urbanity and urbanization in mind.[7] This has helped – at least to some extent – to decenter urban studies and planning research from the hegemonic centers of theory production to the supposed margins of the global south, where the global urban majority yet resides. A conscious and pragmatic recognition of the urban-infrastructural realities in cities like

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[7] Important contributions here include Robinson's (2006, 2022) calls to resist the hierarchization of 'global/ world city' concepts, but rather to engage with 'ordinary cities' across geographies and with comparative tactics; Roy's (2005, 2011) nuancing work on informality as a pervasive quality of contemporary urbanization; and – most recently – Jon Silver's (2023) proposition of the 'Infrastructural South,' which synthesizes much work on African cities and their infrastructures to provide 'counterhegemonic notions of modernity' not tied to a geographical South, but rather as an epistemological position for the study of cities in the twentifirst century (cf. FOS Research Collective et al. 2024a). These works and those of many others (e.g. Bhan 2019; Mbembe and Nuttall 2004; Pieterse 2012; Simone 2001) have productively contributed to the 'southern turn.'

Nairobi – rather than a preconceived notion of how cities and their infrastructures *should be* – is thus a guiding principle of this thesis, which has already been evident in Chapter 1 but shall further help to avoid the pitfalls of premature categorizations and judgments.

Despite the importance of a postcolonial reading of cities, particularly African ones, the empirics and epistemics of this thesis are even more informed by the 'infrastructure/ infrastructural turn' (Dodson 2009; Graham 2010), which has not only contributed to an increase in research on (urban) infrastructures worldwide, but also – somewhat in parallel and in conjunction with the ‚southern turn' – has itself undergone a decentering from a largely technocratic reading of infrastructures towards more hybrid, sociotechnical and socioecological understandings (Alda-Vidal et al. 2018; Foli 2024; Odendaal 2021). This reframing moves away from 'rationalistic or "mechanistic" ideas about artifacts and infrastructure' (Star and Ruhleder 1994: 253) and instead focuses on more-than-technical *relations* (cf. Bowker 1994; Jaglin 2014). This means that any infrastructural system and artefact, whatever its scale, is understood as an arrangement of material and immaterial parts that are not only technical but (potentially) also social, cultural, political, organizational, legal/ regulatory, informational/ knowledge-based, financial, bodily/ corporeal, and ecological/ more-than-human. Such broad and relational ontology, now prominent in urban studies, geography, anthropology, and related disciplines (cf. Andueza et al. 20021; Barua 2021; Buier 2023), is used to unpack the 'black box' of various infrastructures and their operational intricacies, for example at moments of breakdown and disruption (Bennett 2005; Graham 2010). Accordingly, and often influenced by seminal work of authors such as Star (1999), Graham and Marvin (2001), Simone (2004), and Larkin (2013), much research has moved beyond infrastructure as a mere object of study to *infrastructure as an analytic*, that is, a structured approach or lens through which complex phenomena, relations, and broader issues are examined and understood, such as urban inequalities and fragmentation, state-citizen relations, global value chains and metabolic flows, the (re)production and expansion of capital, and colonial and ecological exploitation (e.g. Furlong and Kooy 2017; Ranganathan 2020; Silver J 2023).

Infrastructure as a relational analytic

By following the 'infrastructure/ infrastructural turn,' I apply an understanding of *infrastructure as a relational analytic* to my research on the 'infrastructure space' (Easterling 2016) of Nairobi, more specifically the everyday storage of water and electricity, because it shares much with relational understandings of households and their dispositifs (‣ Chapter 2.2) and of cities, and space in general, as multiple and relationally produced (‣ Chapters 1 & 5). Also, the wider and relational ontology offered by the 'turn' helps and demands to move beyond initial scales and concerns of investigation, and it provides established notions that inform my understanding of what infrastructures do, are, and can be described as. Yet, to productively deploy *infrastructure as an analytic*, especially for a southern city like Nairobi, one shall not get lost in the multiplicity of contemporary infrastructure concepts (Kroth 2022) but consciously apply selected notions that can guide one‘s research. Thus, for the purposes of this dissertation, I understand (urban) infrastructures as ...

- ... sociotechnical hybrids of human practices and (mundane) technical artefacts: Rooted in scholarship on large technical systems and the history of technology (Edwards 2003; Mayntz and Hughes 1988) – and further inspired by Science and Technology Studies (STS) and adjacent fields such as new materialism, actor network theory, and object oriented ontology – infrastructure articulations are now widely recognized as place-specific, sociotechnical hybrids (cf. Bennett 2005; Graham and Marvin 2001; Kroth 2022; Meehan 2014; Ramakrishnan et al. 2021). While the material and immaterial, technical parts of infrastructures – from pipes and roads to antennas and protocols – are critical for the delivery of basic services, human actors – such as ordinary urban residents or technicians – are equally important in shaping and stabilizing infrastructures with their quotidian labor, everyday practices, and vernacular knowledge (Andueza et al. 2021; Furlong 2016). The many efforts by Nairobians to secure their water and electricity supply are a case in point. Moreover, because infrastructures only function through everyday engagement of many humans, mundane technical artefacts and devices becomes relevant to these sociotechnical arrangements too, or as Shove (2016: 246) puts it, these artefacts are the 'sensitive tips of infrastructures … defining both the extent and the pattering of demand, and the institutional and material configuration of supply.' Examples include buckets (Meehan 2014), washing machines (Watson S 2015), Wi-Fi routers (Mackenzie 2005), and other minor things that exude their own '*tool power*' (Meehan 2014) – or 'agency' (Latour 2005) – and become enmeshed with human practices and major artefacts and systems, ultimately forming the sociotechnical hybrids we call infrastructures.

- ... socioecological hybrids of multi-scalar relations and flows: Emerging from Urban Political Ecology (UPE) – with its roots in critical, Marxist thought (e.g. Harvey 1973; Lefebvre 1991) and influences that challenge a human-centered perspective (e.g. Haraway 1985; Latour 2005) – cities and their infrastructures are also understood as dynamically produced through metabolic processes and power relations that are intertwined with socioeconomic inequalities and environmental change. Rather than being neutral or merely sociotechnical, infrastructures are tools that shape – and are shaped by – economic, political, social and environmental dynamics in cities and beyond (Swyngedouw and Heynen 2003; Tzaninis et al. 2021). For example, water infrastructures involve sociotechnical elements, but also rivers, groundwater, and the wider hydrological cycle (Swyngedouw 1996); energy infrastructures are co-produced by and re-produce environmental injustices and socio-spatial differentiation (Castán Broto 2019); and overall, infrastructures are seen as means for the 'urbanization of nature' (Swyngedouw 1996), thus shaping how and why resources such as water, energy and waste flow into, through and out of cities. Relatedly, the unequal flows of water and electricity through Nairobi can be understood as resulting from the 'interplay of a historical socio-political and economic disenfranchisement that operates in tandem with severe environmental crises' (Kimari 2019: 142). Recently, metabolic readings of infrastructures have been further nuanced, situated, and 'provincialized' to reflect and utilize adjacent discourses, e.g. on the 'southern turn,' more-than-human perspectives, and anthropogenic climate change (Kaika et al. 2023; Lawhon et al. 2014). A socioecological understanding of urban infrastructures thus involves large-scale but situated relations, flows and politics but also multi-scalar (power) relations and (material) flows – from the body to the planet – involving humans and non-humans as well as all kinds and scales of natures, politics, capital, and governance arrangements.

- …dynamic and heterogeneous configurations: Rooted in sociotechnical and socioecological readings of infrastructures, and in line with the 'southern turn,' situated infrastructure arrangements – particularly in (southern) cities – are now understood as heterogeneous and dynamic. In response to important, but ethnocentric, Euro-American critique of the neoliberal 'splintering' of cities and their infrastructures (Graham and Marvin 2001), many authors have flagged that infrastructures in cities with colonial planning legacies have always been 'splintered' and differentiated, with various overlapping actors and modes of infrastructural provision and service delivery (Graham and Marvin 2022; Kooy and Bakker 2008).[8] These systems – or

[8] For example, instead of a single centralized water network, urban residents potentially tap into and are also part of a place-specific and adapted variety of sometimes competing, sometimes complementary water sources, from the network to water delivery services to rainwater harvesting and more (Björkman 2014; Monstadt and Schramm 2017); as is the case in Nairobi.

rather *configurations* (Jaglin 2016) – should not be understood as failures of modernization, but rather as expressions of a 'mutating modernity' (Silver J 2023). Instead of adhering to a unitary ideal of infrastructural provision with one largely dominating mode of supply, heterogeneous configurations are inherently diverse and multi-modal as well as 'incomplete' or 'in formation,' but not failed (Guma 2020; Mwaura and Lawhon 2024). Everyday infrastructuring practices by urban residents and various other actors are crucial contributors to such dynamic heterogeneity, with different ways of infrastructural supply, access, and use sometimes competing, sometimes forming synergetic relations, sometimes just running in parallel. Yet, all these various modes of service delivery and their technologies are also situated in more or less rigid institutional and organizational environments as well as in historical and techno-political landscapes (Jaglin 2014; von Schnitzler 2016). Accordingly, single modes of service delivery, but also whole infrastructure configurations, are '*open processes* of service production, embedded in their urban context, moulded on the one hand by competing forces, and on the other hand by inertia effects and path dependency' (Jaglin 2014: 436). While there is now an almost overwhelming terminology for such sociotechnically and socioecologically diverse infrastructure configurations (Cirolia and Pollio 2024), at their core, they are dynamic, situated but spatially and technologically diverse arrangements of 'actors, technical objects, institutions, economic interests, social practices and representations' (Jaglin 2016: 187). Place-specific expressions may vary from city to city, neighborhood to neighborhood, block to block, and household to household, but ultimately, they materialize through institutional, political, and ecological landscapes as well as specific technologies and practices to enable – according to the capacity of each society or geography – the delivery and use of basic services and resources.

- ... propositional spaces: On the heels of a heterogenous and 'pragmatic' understanding of infrastructures (Jaglin 2016), we now witness a turn towards more propositional engagements. Critical interventions to reframe 'southern' infrastructures from failed to incomplete, from chaotic to heterogeneous have been productive, but scholars and practitioners are now tasked with moving from analysis and critique to potential interventions in the planning, design and governance of (urban) infrastructures. This has led to proposals for new infrastructure concepts, e.g. *modest* (Lawhon et al. 2023) or *popular* (Silver J 2023) and is already influencing physical interventions in urban spaces (Mulligan et al. 2020) as well as design approaches for 'modular, adaptive, decentralized' systems (Thomson et al. 2024). More so, Baptista and Cirolia (2022) call for 'propositionality as a research sensibility,' recognizing and utilizing urban infrastructures – as well as any research on them – as highly propositional spaces that hold the potential to improve the infrastructural lifeworlds of urban residents. In line with the propositional nature of urban/spatial planning, this thesis thus approaches 'artefacts and practices of storage' in Nairobi as full of propositional potential for all kinds of spatial disciplines capable of shaping urban-infrastructural lifeworlds. Ultimately, my empirics and analysis are intended not only to provide critique and theoretical merit, but also to offer inspiration or even precise propositions for how to use its findings for more just and sustainable urban futures.

In summary, I draw on STS, UPE, and southern urban critique for my understanding of urban infrastructures, as many others have done with their own nuances and strategically placed foci (e.g. Alda-Vidal et al. 2018; Furlong 2014; Odendaal 2021). Accordingly, and for the purposes of this thesis, I understand urban infrastructures as dynamic, heterogeneous sociotechnical and socioecological configurations that integrate human practices, mundane technical artefacts, and larger ecological and political processes. Shaped by multi-scalar relations and place-specific political landscapes, these infrastructures enable the delivery of basic services and resources in multiple ways and modalities, while serving as propositional spaces for rethinking and improving urban lifeworlds. In such a reading, infrastructures are both the enabler (or medium) of myriad relations and flows and, *vice versa*, the 'product' of them. However, and despite the multiplicity that such readings offer, infrastructures depend not only on their respective flows, circulations, and materialized connectivities, but also on storage and/or decelerated circulation, to which we turn in the following.

2.4. **Turning to storage**

Many thousands of years ago, some hunter-gatherer societies began to store essentials such as food and water, which led to a 'sedentary way of life' and increased population sizes and densities (Testart 1982: 524; cf. Balbo 2015). The first spark of urbanization was lit, leading to the increasingly urban and infrastructured planet of today, now fully dependent on the constant availability of basic services and resources such as water, transport, information, electricity and other forms of energy, to name but a few. Their distributive infrastructures have thus become the flow-enabling backbones of the *modern urban*, while the good, the bad and the ugly of our contemporary planetary condition – and of circulation more generally – depends not only on material and immaterial networks, flows, corridors, and architectures of various movements. Rather, infrastructures and appliances of storage – that is, of temporarily suspended circulation (Shryock and Smail 2018) – are equally important, as they can capture value and capital, or balance mismatches between supply and demand (Banoub and Martin 2020; Shove and Chappells 2001). Think of cold storage, silos, and home refrigerators for our food. Think of massive dams, water towers, and jerry cans for more or less potable water. Think of pumped hydro, LNG terminals, LPG cylinders, and all kinds of batteries for energy. Think of servers, cloud storage, and flash drives for data. From its prehistoric beginnings, the urban world of today has only been possible because of myriad storage arrangements that hold and provide basic resources.

With ongoing transformations such as digitization and energy transitions, and the compounding policrisis of anthropogenic climate change, geopolitical upheaval, and global health threats, the importance of infrastructures of storage is likely to grow (Marsden et al. 2024; Randle 2024a). On the one hand, major storage arrangements by government actors or the private sector are likely to become even more important as our cities and our hunger for resources continue to grow: Grid-scale batteries and green hydrogen storage to power our energy transitions (Schrotenboer et al. 2022; White-Nockleby 2022); large-scale data centers in the global periphery or within metropolises (Johnson 2019; Monstadt and Saltzman *forthcoming*); massive dams and natural water storage to quench our thirst (Randle 2022; ‣ Figure 6). On the other hand, at the everyday scale of urban-infrastructural realities, we can experience an 'individualization of infrastructural responsibilities' (Kasper et al. *forthcoming*), a 'splintering from below' (Kooy and Bakker 2008), and thus the rise of minor storage urbanisms composed of countless containers and storage practices. After all, as Bize (2017: 1) has pointed out for Nairobi, the splintering of urban infrastructures means that 'storage is *partially* decentralized; storage facilities crop up at the household level to manage the uneven supply of, say, electricity or water.' As urban residents or property owners are forced or incentivized, for whatever reason, to actively participate in the infrastructuring of basic services, their efforts often involve the storage of resources that are typically flowing or otherwise easily mobile. Rather historical examples include night storage heaters, which were particularly popular in mid-twentieth-century Europe and convert nightly, cheaper electricity into stored thermal energy (Shove and Chappells 2001), or the iconic wooden water towers that have long been an important enabler of New York City's verticality, providing water above the sixth floor (Berg 1916). Other contemporary examples of minor arrangements include LPG cylinders for cooking (Kojima 2011;

Figure 6 (above): Ndakaini Dam (a.k.a. Thika Dam) in Murang'a County, Kenya; photo obtained from NCWSC.

Figure 7 (below): LPG cylinder and gas stove top in Kibera (Canaan Estate); photo by author (2021).

‣ Figure 6), battery systems as part of SHS (Ding et al. 2015), and the ubiquitous presence of all kinds of household water containers, especially but not only in southern cities (Slavik et al. 2020).[9]

The storage of water and electricity

When it comes to water infrastructures, major storage arrangements have received their fair share of academic scrutiny. Large dams and reservoirs, levees, and other water retention infrastructures are critical enablers of the *modern urban*, allowing for the control of water flows, the smoothing of seasonal fluctuations, and simply being prime examples of the 'urbanization of nature' (Bijker 2007; Kaika 2005; Randle 2022). Given their scale and centrality to many water systems, major water storage arrangements are often enmeshed in highly political and environmental debates, while providing resilience and flexibility for networked supply (Kaika 2005; Mehta 2001; Randle and Linville 2024). Arguably, less is known about the minor water storage arrangements of everyday urban life. Small tanks, buckets, cisterns, and the like are repeatedly mentioned, but rather as side notes in publications on water infrastructures in southern cities (e.g. Alba et al. 2022; Bakker 2003; Björkman 2014), and there are plenty studies from health, biological, or engineering disciplines that have investigated water quality in various containers and locations (Slavik et al. 2020). Yet, there is only a small catalog that specifically examines minor water storage in an urban and/or infrastructural framing: Burt and Ray's (2014) study in Hubli-Dharwad, India was one of the first to highlight how domestic water storage creates 'reliability and convenience' and thus persists even as the larger water system becomes more formalized and reliable; Meehan's (2014) observations on water barrels in Tijuana, Mexico highlighted the '*tool power*' of these 'ordinary infrastructures' in terms of permanently shaping situated configurations; and the accounts of Millington (2018) from São Paulo, Brazil, and Acevedo-Guerrero (2022) from Barranquilla, Colombia, nuance the mediating role of domestic water storage between urban households, larger systems, and broader ecologies, resulting in variegated geographies of power. Despite these important contributions, water storage – especially in its minor and domestic forms – remains a side issue in the study of

[9] In Nairobi, for example, water tanks of 500 to 20,000 liters, 20-liter jerry cans, so-called *super drums* of 120-250 liters, simple buckets, and many other water receptacles can be found on streets, in yards, on rooftops, and inside homes, given the city's intermittent, unreliable, and unequal piped water supply. Similarly, domestic electricity storage in the form of power banks, rechargeable and battery-powered lighting, and traditional alkaline batteries are staples of all types of households; and new, extensive backup battery systems, often attached to individual SHS, are also increasingly common, as they are in other African cities (Munro 2020; Rateau and Jaglin 2020).

urban infrastructures, and its larger role in citywide configurations remains vaguely described and theorized.

While water storage is considered an 'ancient' human activity (Randle 2022), the storage of electricity – i.e. electrochemical energy storage with batteries – is comparatively new but has nonetheless become ubiquitous in, and detrimental to, contemporary cities. On the one hand, lead-acid batteries have played an important role since the early twentieth century, and continue to do so, in providing a basic level of power when a direct grid connection is (temporarily) unavailable or infeasible: to start your fossil-fueled car, to power loudspeakers at an outdoor event, to serve as an *uninterruptible power supply* (UPS) for ATMs or desktop computers, etc. (Turner 2022). On the other hand, since 'the advent of cell phones and portable electronics' in the 1990s (Kubrak 2022: 018), electricity storage – especially but not only with lithium-ion batteries (LIBs) – is constantly performed by urban residents with multiple artefacts: phones, laptops, power banks, and so on. Even more so, as SHS and larger backup systems become a viable option for households to mitigate rising electricity costs and/or unreliable grid supply, electricity storage is becoming more and more a part of individual energy dispositifs, especially also in southern cities (Fett et al. 2021; Ransan-Cooper et al. 2020; Rateau and Jaglin 2020). In addition to all decentralized applications of batteries, electricity storage is also being envisioned and tested at 'grid scale' (White-Nockleby 2022). Especially but not only for mini-grids in rural areas or on islands, advances in technology and manufacturing have made batteries a viable option as core parts of electricity systems (Eras-Almeida and Egido-Aguilera 2019; Pedersen and Nygaard 2018). However, 'grid-scale' batteries have not been discussed specifically, let alone implemented, for urban settings – with the notable but particular exception of so-called *virtual power plants*.[10] And the many minor electricity storage arrangements of the urban everyday are also rarely discussed in their broader urban and/or infrastructural relations. There are, for example, some valuable studies from urban Africa that mention batteries in passing but do not focus on them (e.g. Degani 2022; Koepke et al. 2014; Munro 2020), but, ultimately, we are left wondering what all the batteries that have become part of our lives and cities are actually doing to the urban and infrastructural assemblages in which they are enmeshed, beyond 'just' storing electricity.

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[10] Virtual power plants are groups of decentralized, digitally connected power sources, such as SHS, that collectively operate as a single power plant (Abdelkader et al. 2024).

The notion of storage

Despite its ancient history and ubiquity, the notion of storage, including many of its resource-specific expressions, has been comparatively neglected by infrastructure studies, urban studies, geography, and related disciplines, leaving its conceptual and empirical potential untapped and thus 'largely untheorized' (Randle 2024a: 2). There is, of course, a vast catalog of literature from various engineering disciplines on the technologies and operation of all kinds of storage arrangements – e.g. on battery technologies, water tank design, dam construction, data storage hardware and software, food storage technologies, etc. –, but such literature rarely touches on the broader urban and infrastructural implications of storage. Even from a more critical and social science perspective, this untapped potential is not surprising either, as storage may evoke a more static and container-based perspective that runs intuitively contrary to dominant flow-based and relational readings of infrastructures and space (cf. Furlong 2022; Randle 2024a). Yet, there have always been engagements with various forms and regimes of storage by disciplines such as archaeology, cultural anthropology, interior design, and STS. With notable exceptions such as storage-as-disposal – e.g. the longstanding issue of nuclear waste storage (Murdock et al. 2018 [1983]) – this multidisciplinary catalog of literature largely understands storage as the deliberate, anticipatory, and technology-enabled practice of accumulating and preserving all kinds of 'stuff' for later use and/or capital expansion, with ecological, economic, political, and spatial implications.[11] In this vein, Randle suggests to acknowledge storage as a 'volumetric and temporal arrangement' (2022: 2284) that includes both the (physical) capacity to store and the action to store (2024a). Similar to a sociotechnical reading of infrastructures (‣ Chapter 2.3), any storage arrangement can

[11] For example, cryopreservation for the storage of biomaterials such as stem cells or vaccines is not only important for buffering against bottlenecks, but is also imbued with (bio)political implications arising from related paradigms such as *preparedness* (Keck 2017; Liburkina 2024). Similarly, the largely Euro-American phenomenon of *prepping* – understood as the individualized 'storing of food, water and weapons … for the purpose of independently surviving disasters' (Campbell et al. 2019: 798) – also rests on a paradigm of constant preparedness, resulting in anticipatory and politicized practices by individuals and households (du Plessis and Husted 2024). But domestic spaces are not only used to store essentials for emergencies; rather, the domestic storage of all kinds of 'stuff' – necessary or not – is 'a routine practice in the organisation of everyday life' (Collins and Stanes 2023: 741). Accordingly, storage is an important but often forgotten architectural element, with considerable implications for the quality of living and the minor spatialities of the home (Marco 2022). And from an archaeological perspective, the storage of food and other resources not only played an important role in human domestication, but also gave rise to social stratification and inequalities, making research on storage 'fundamental to understand the establishment of socio-ecological and socio-economical structures' (Balbo 2015: 305). Moreover, storage undoubtedly has always had and continues to have a strong economic function, since – in some cases – the accumulation and 'fix' of capital is closely linked to the storage of commodities and/or specific forms of value generation that thrive on or require a temporary suspension of circulation (Banoub and Martin 2020; Simpson 2019).

thus be seen as a hybrid of human action or practice (*storing*) and a technological artefact that has the 'tool power' to store something (*container*).

A sociotechnical and situated reading of storage is undoubtably productive (‣ Chapter 4) but it cannot fully capture the potential complexity of storage arrangements because – among other reasons – the actual 'stuff' that is stored, with its relations beyond the actual storage site, is rather neglected. Here, an UPE-inspired lens helps us think of storage arrangements – from the food in your pantry to the millions of gallons of water in dams – also as 'socioecological assemblages' (Acevedo-Guerrero 2022), as 'infrastructural ecologies' (Banoub and Martin 2020), and as 'living, porous sites' (Randle 2022). Rather than 'just' being a situated hybrid of human action plus container-artefact, storage may involve a world of multi-scalar relations, politics, materialities, and natures that entangle each arrangement with places, circulations, and actors beyond its immediate location. Accordingly, I propose and follow, a relational and hybrid notion of storage, as a sociotechnical and socioecological assemblage of *storing* practices, *storage* containers, and *stored* 'stuff' that temporarily suspends the circulation of said 'stuff' for the purpose of its later use at some undefined point in the future. This definition shall help to ground the study of any, single or multiple, situated storage arrangement – all the water tanks of a city, a single battery, etc. – with its specific sociotechnical and socioecological intricacies, or rather its own dispositif. At the same time, this invites or even demands a more-than-situated and multi-scalar perspective on storage, in which each storage arrangement must be understood also in its material and immaterial relations in wider networks and circulations from which many of its ecological, economic, political and spatial implications arise.

Given the 'potential for a storage lens to reveal entanglements and relations typically obscured in analyses more focused on flows, circulations, and movement' (Randle 2024a: 8), there is still much to explore, understand, and analyze about the many storage arrangements of urban-infrastructural articulations everywhere, but especially for splintering, heterogeneous infrastructure configurations that – as in the case of Nairobi – have a need for storage at the household scale (Bize 2017). So far, however, storage of water and electricity has been largely addressed by natural, health, and engineering disciplines, and less by critical urban studies, planning research, or geography, with the exception of a few crucial engagements, such as Randle's (2022, 2024b) work on reservoirs in the US. But usually, research on the storage of water or electricity or any other storable 'stuff' tends to a) stay close to its original framing and scale, and b) not discuss storage across different resources and types of storage. I thus argue that – with a hybrid and relational reading of storage in mind – investigating and juxtaposing storage arrangements of different resources promises a productive lens for urban infrastructure research that may lead to new findings and theory on urban, sociotechnical, and socioecological relations and about storage more broadly. Grounding such research in the everyday realities of urban households and connecting it to other, larger scales and spatialities can then provide new insights into questions of the networked or post-networked city (‣ Chapter 4), approaches to urban research (‣ Chapter 5), distributive and cosmopolitan justice (‣ Chapter 6), and the interconnectedness of different scales of storage (‣ Chapter 7), to name just a few.

3. Operationalizing

From question to outputs

Figure 8: KPLC workers remove overgrowth from power lines; photo by author (2022).

This chapter outlines my epistemological and methodological framework for exploring the everyday storage of water and electricity in Nairobi, grounded at the household level as a critical site and starting point for the study of urban infrastructure configurations (‣ Chapter 2.2). At its core, this study examines why and how diverse households employ variegated practices and artefacts to temporarily suspend the circulation of both resources for later use at some unspecified point in the future. However, because storage arrangements at different scales – from large to small – and by different actors – from the state to the household – stand in strong relation to each other, a multi-scalar sensibility needs to be applied to the conceptualization and operationalization of the respective research; that is, specific questions, target areas, tool design, interlocutor recruitment, analysis, and writing need to be able to reflect back on broader urban, infrastructural, material, ecological, and political relations. Moreover, with a rather limited, patchy catalog of literature on the urban-infrastructural role and significance of domestic storage, this study is largely an exploratory and qualitative exercise that seeks to uncover and inductively theorize about household storage dispositifs as part of heterogeneous infrastructural configurations; taking Nairobi as a paradigmatic case of southern urbanism in the early twentifirst century.

3.1. Research question, objectives, and approach

Together with an understanding of storage as a sociotechnical and socioecological assemblage, the 'case' of Nairobi, with its 1.5 million households (KNBS 2019), provides an opportunity for a non-hegemonic, non-normative understanding of the everyday production and stabilization of place-specific infrastructure configurations that are otherwise often represented as development failures (cf. McFarlane 2010; Guma 2020). Actively resisting such a teleological notion of urban development, but rooted in 'a joyful and unapologetic fascination with the supposedly mundane' of our urban-infrastructural lifeworlds (‣ Chapter 5), the study of everyday storage can serve not only as an academic exercise but also as a propositional inspiration, ultimately asking how we – as researchers, planners, designers, policy makers, utility workers, technicians, and all other urban residents – can contribute to a more equitable urban-infrastructural future by using storage as a lens for understanding, planning, constructing, and governing our cities and their infrastructures?

However, in order to reflect on the potentiality of storage, there is a lot of empirical groundwork to be done, given the lack of detailed information and studies that have directly addressed either domestic water storage or electricity storage in Nairobi, let alone both. Accordingly, the main research question of this dissertation is simple:

> ‘What roles and significance do practices and artefacts of water and electricity storage play within heterogeneous infrastructural configurations and in everyday life in Nairobi?’

To answer this question, I begin with the informed assumption that the domestic storage of water and electricity, its practices and artefacts, are elemental parts of everyday life and place-specific infrastructural configurations in Nairobi. To further nuance this assumption and ultimately answer the research question, I further pursue two interdependent yet non-hierarchical assumptions, namely:

- Diverse dispositifs, heterogeneous configurations (A1): As highlighted in Chapters 2.2 and 2.4, individual storage capacities, artefacts and practices – and thus individual storage dispositifs – are likely to be diverse and thus shape and are shaped by their respective infrastructure configurations in all their sociotechnical and socioecological diversity. Thus, my first guiding assumption is: ‘*Domestic storage of water and electricity, its practices and artefacts constitute household-specific dispositifs and thus (re)produce and are (re)produced by place-specific, heterogeneous infrastructure configurations.*’

- Situated arrangements, multi-scalar relations (A2): When considering situated storage dispositifs as elemental for place-specific infrastructure configurations but also interdependent with a) other aspects of Nairobi’s urbanity (e.g. socio-spatial differentiation) and b) wider sociotechnical and socioecological relations (e.g. resource flows), domestic storage is also likely to shape and be shaped by more-than-infrastructural relations and conditions. Due to storage’s inherent demand for space, time, and capital, as well as its ability to ‘shape material circulations and landscapes alike’ (Randle 2024a: 8), we can expect to encounter alterations to (pre-existing) architectures, the emergence of related economies, techno-political questions of justice, and more. Accordingly, my second guiding assumption is: ‘*Domestic storage of water and electricity, its practices and artefacts shapes and is shaped by larger sociotechnical and socioecological relations, which results in distinct urban-infrastructural articulations and effects.*’

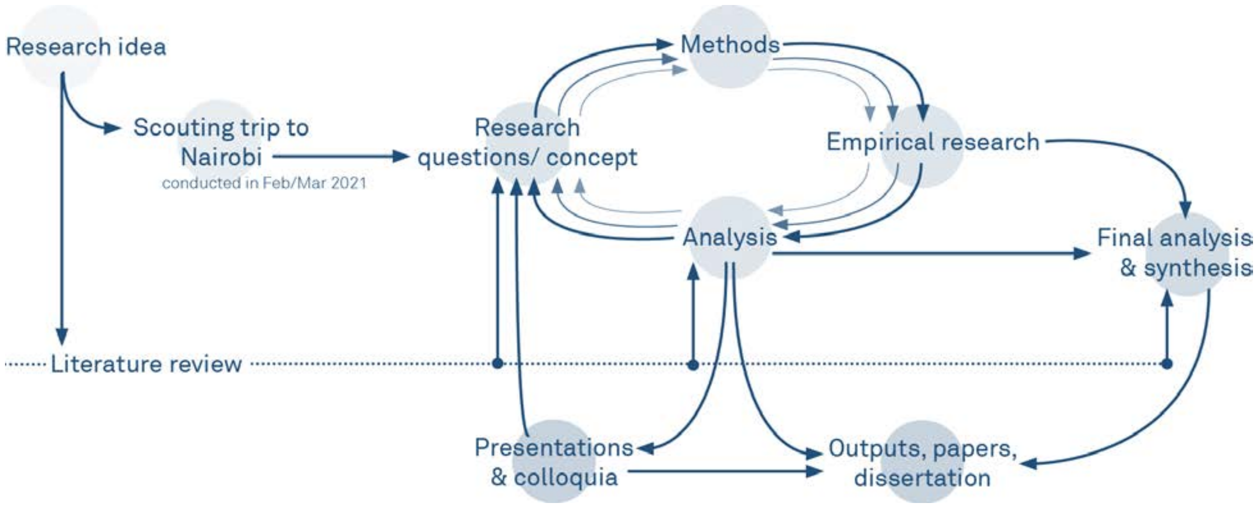


Figure 9: Iterative research design; graphic by author.

While the main research question and the two guiding assumptions are the cornerstones of my empirical and analytical efforts, they and their particular formulation were subject to minor changes and adjustments over the course of the project. Due to the inductive and qualitative nature of the study, my empirical and iterative analysis, as well as conversations with colleagues, led to some necessary and productive changes. For example, after initially referring to 'private storage,' the term 'domestic storage' now focuses the research more strongly and sharply on the realm of *the household* (▸ Chapter 2.2), rather than potentially including non-domestic arrangements. Similarly, after initially being concerned only with the 'urban form' that might result from the prevalence of domestic storage, the second assumption (A2) now accommodates a necessary multi-scalar and socioecological reading that is not bound to the urban alone. Yet, irrespective of the iterative changes in terminology and perspective, this dissertation project is based on four distinct objectives, or work packages, that help to operationalize and streamline the study, namely:

- O1: Understanding the larger urban-infrastructural conditions in Nairobi that result in or relate to domestic storage: (planning) histories, geographies, current supply systems, policies, politics, and actor landscapes.
- O2: Exploring domestic storage dispositifs in Nairobi and their entanglement with infrastructural configurations: humans and non-humans involved, artefacts used, specific storage practices and frequencies, specific uses of stored water and electricity, etc.

- O3: Theorizing on (domestic) storage and situated storage dispositifs as part of broader sociotechnical and socioecological relations and place-specific urban-infrastructural articulations: in relation to individual experiences, socio-spatial differentiation, infrastructural imaginaries, situated techno-politics, broader material and immaterial relations and networks, and epistemologies.
- O4: Discussing potential propositions for the planning, governance and design of cities and urban infrastructures (in the global south): policies, planning approaches, modes of provision, design of storage artefacts.

Research design and approach

The research design of this study follows a largely qualitative and exploratory as well as iterative approach. In doing so, I emphasize the 'search' in 're-search' (Wildner 2014), which is consistent with the inductive, theory-producing nature of my empirical and analytical efforts, where 'the variables and theory base are [largely] unknown' (Creswell and Creswell 2018: 162). Given the relatively limited information and theory on domestic storage (in Nairobi), a largely qualitative approach further supports the exploratory nature of the study, which involves 'emerging questions and procedures, […] data analysis inductively building from particulars to general themes' and ultimately 'making interpretations of the meaning of the data' (ibid.: 41). With its qualitative, ethnographically inspired and iterative nature, this study shares methodological sensibilities and tactics with 'grounded theory' (Glaser and Strauss 2017 [1967]) and its ambition that themes or even new theories emerge naturally from the data itself, instead of working with pre-conceived concepts. However, with clear guiding assumptions and the strong inclusion of existing literature and theory throughout the study process (▸ Figure 9), my study approach stands in contrast to orthodox grounded theory and its deliberate rejection of existing literature and theory, especially in later stages of a research process (Hallberg 2010). Yet, rather than building theory fully from the ground up, I draw heavily on existing concepts and terminologies about infrastructures and southern urbanisms, such as heterogeneity, dispositif, energy justice, and more. Building on existing ideas and theories helps to a) strengthen and streamline the analytical value and process, and b) already position the study in relevant discourses. Ultimately, this thesis follows a simple qualitative case study approach because, 'the closeness of the case study to real-life situations and its multiple wealth of details' for two main reasons:

> 'First, it is important for the development of a nuanced view of reality, including the view that human behavior cannot be meaningfully understood as simply the rule-governed acts found at the lowest levels of the learning process and in much theory. Second, cases are important for researchers' own learning processes in developing the skills needed to do good research.' (Flyvbjerg 2006: 223)

Both a nuanced view of the minute realities of domestic storage and, as a doctoral student, my own learning process are central to this dissertation. Also, since Nairobi and its infrastructural space has many features that resonate with the situation in many other agglomerations – for example, rather heterogeneous landscapes of water and electricity supply (‣ Chapter 2.2) – my study serves as a 'paradigmatic case' for a rather unexplored topic with the aim 'to develop a metaphor or establish a school for the domain that the case concerns' (ibid: 230); i.e. domestic storage and its larger urban-infrastructural significance. While the exact definition of a 'case study' and a 'case' depends largely on the context and points of reference, my main case and unit of analysis is the urban agglomeration of Nairobi, while a) drawing and inferring from diverse yet distinct sub-cases – i.e. individual households – without being representative (cf. Gerring 2004; Levy 2008), and b) focusing the empirics on purposefully selected target areas (‣ Chapter 3.2). Finally, and in line with the overall exploratory, qualitative, and inductive case study approach, the research design and process – as implemented between 2021 and 2024 – constituted of iterative, intertwined cycles of research objectives and premises, fieldwork and other data collection, analysis, writing, presentation at conferences and colloquia, and synthesis (‣ Figure 9). As fieldwork was conducted and/or perspectives emerged, research questions, objectives, and terminology were adjusted, ultimately leading to four publications (‣ Chapters 4, 5, 6, & 7) that form the basis of this cumulative thesis.

3.2. Target areas and methods

For the purposes of this study, I define Nairobi not only as the administrative NCC, i.e. the municipal county of Nairobi with its official population of 4.4 million in 2019 (KNBS 2019), but now probably closer to 5 million due to continuous population growth and the tendency of the Kenyan census to undercount. Rather than pre-emptively restricting research to the NCC alone, there are reasons for expanding the geographic scope slightly: many infrastructural networks and relationships, including ecological ones such as aquifers, but also the national KPLC grid, are barely affected by these administrative boundaries (cf. Blomkvist and Nilsson 2017; Oiro et al. 2020; Petrik et al. 2020); recent developments in urbanization and infrastructure construction are not confined to the NCC, but extend along 'corridors' or simply cross city boundaries to outlying towns such as Ongata Rongai (Mundia 2017); and the growth of Nairobi and surrounding towns has led to the emergence of a contiguous metropolitan area of around 5.8 million people (OECD and SWAC 2020). Thus, my empirical research, conducted over several visits to Nairobi between 2021 and 2024, largely targeted households and other interlocutors located in the NCC, but also some located just outside its administrative boundaries (‣ Figure 17). Moreover, as I expected individual storage arrangements to be highly heterogeneous across Nairobi and even within individual areas and neighborhoods due to a notable, fine-grained differentiation of infrastructural experiences in Nairobi (cf. Kasper et al. *forthcoming*; Schramm and Ibrahim 2021), a first phase of fieldwork in 2021 deliberately targeted all kinds of geographies within Nairobi to gain exploratory insights into storage dispositifs and potentially important factors for their variation. After conducting and analyzing a first set of interviews with both households and thematic experts, as well as some other data collection activities, I focused my remaining empirical work – while still collecting additional data through interviews with thematic experts and other means – on four purposefully selected target areas because of their exemplary character for paradigmatic urban, infrastructural, and architectural articulations in Nairobi, namely:

- Eastleigh (‣ Figure 10): Sometimes referred to as 'Little Mogadishu,' Eastleigh is a dense, central neighborhood east of Nairobi‘s central business district (CBD) with a long history dating back to colonial times, when it served largely as a place of residence for Asians and a small African elite (Carrier 2016). Now dominated by ever-growing multistorey and mixed-use buildings, Eastleigh has become not only a prime example of Nairobi‘s 'tenement city' (Huchzermeyer 2011), but also a major commercial hub and economic powerhouse within the city, while being home to a large Somali diaspora that connects it to global trade and financial networks (Tayob 2021; Varming 2021). Despite its long history and economic importance, however, Eastleigh has experienced political marginalization and police violence due to its alleged function as a hub for terrorists (Rinelli and Opondo 2013), while at the same time experiencing rampant infrastructural neglect, resulting, for example, in dilapidated roads and an overburdened water network that has not kept pace with the area‘s growth (Asoka et al. 2013; Kasper et al. *forthcoming*). Note: The selection of Eastleigh was also a pragmatic and synergetic one, as it was simultaneously a target area of a research project of TU Dortmund (TUD) and the University of Nairobi (UoN), on which I also worked (see below).

- Kibera (‣ Figure 11): Originally demarcated in 1917/18 as a military reserve for Nubian soldiers, the informalized settlement of Kibera is now home to hundreds of thousands of people in twelve *vijiji* (villages) of diverse socio-cultural backgrounds spread over 2.4 km² in a rather central location of the usually more affluent western parts of Nairobi (Desgroppes and Taupin 2011; Ogot and Ogot 2020). For decades, Kibera has been a hotbed of NGO interventions and research projects, while slum upgrading efforts have led to evictions and clearances, but also to infrastructure improvements (DeGrauw 2020; Schramm 2017). Yet, non-utility water supply – mainly in the form of water points – continues to be the norm in Kibera, and illegal wiretapping for electricity remains common, although official connections with prepaid meters have also been rolled out (Kasper et al. *forthcoming*; de Bercegol and Monstadt 2018). For the most part, Kibera‘s architecture is dominated by small shacks – often made of *mabati* (corrugated iron) – while many of Kibera‘s residents work in informalized occupations and/or as service workers in surrounding neighborhoods (Desgroppes and Taupin 2011; Schmidt et al. 2020). Note: Like Eastleigh, Kibera was a target area for another research project (see below), which contributed to its selection.

- Ongata Rongai (‣ Figure 12): The town of Ongata Rongai is located just outside the NCC in Kajiado County, south of Nairobi. Similar to many other surrounding towns, such as Kitengela and Ruaka, the formerly sparsely populated area has grown into a sprawling agglomeration in recent decades, now home to nearly 200,000 residents (County Government of Kajiado 2023). A heterogeneous, multiethnic urban space in its own right, with various small neighborhoods and diverse types of residential architecture (Landau 2015), Ongata Rongai has attracted – in addition to rural migrants – a large number of middle-income families, who have built their single-family homes along many of the often-unpaved side roads. Located outside the NCC, the town is not served by NCWSC, but has its own water supplier called Oloolaiser Water. However, recent growth has led to extensive strain on infrastructures, local ecologies, and wetlands (Howland 2023), leaving many households with no choice but to seek additional water and energy supply options, such as water delivery services and SHS, if possible.

Figure 10 (above): High-rise apartment buildings in central Eastleigh; photo by author (2021).

Figure 11 (below): Water point in Silanga village, Kibera; photo by author (2021).

Figure 12 (above): Water tanks of single-family houses in Ongata Rongai; photo by author (2022).

Figure 13 (below): Central Westlands by night; photo by author (2021).

- Westlands (▸ Figure 13): Known for its longstanding role as a neighborhood for international residents, which evolved from its status as an exclusive white settler area in colonial times (Ogot and Ogot 2020), Westlands has since the 1990s undergone a transformation from a largely residential, low-rise area to a mixed-use area with a growing number of high-rise buildings for office use and 'luxury' apartments. In an administrative sense, Westlands refers to a larger constituency that includes areas such as Muthaiga, Kangemi, and Kitisuru, but for this study – and in line with its colloquial toponym – the name Westlands refers to a loosely defined area centered around the Westlands Roundabout. While Westlands is arguably one of the infrastructurally best served areas in Nairobi, its residents are not always shielded from the disruptions and necessary infrastructuring that characterize Nairobi's water and electricity configurations; however, targeted studies or any granular data on Westlands are currently lacking.

As part of the empirical research in all four target areas and beyond, I used a range of data collection methods that provided different data points and perspectives, namely 36 so-called expert interviews, 39 enriched household interviews, and several go-alongs or urban explorations. In addition, countless informal conversations with Nairobians and unstructured observations contributed to my insights, while I also conducted document reviews, made a few unsuccessful attempts at data collection (e.g. a diary technique), and drew on data from a parallel research project. By combining these methods with a rigorous but non-systematic literature review, and by staying close to the everyday storage realities of households as my primary concern, I was able to develop a deep and broad understanding of the issues and themes at stake, from the minute intricacies of domestic storage arrangements, to the basics of battery technologies, to broader questions of regional water flows.

Semi-structured interviews with thematic experts

So-called 'expert interviews' (Döringer 2021) were conducted city-wide and included conversations with a wide range of actors, from government officials to manual workers such as plumbers, that captured both 'facts' and nuanced perspectives on respective infrastructure systems, storage artefacts and practices, and broader urban infrastructure or governance issues. The purpose of these interviews was to gain insight into otherwise closed settings or aspects of Nairobi's infrastructure space, and to better understand technical, organizational, and economic factors associated with domestic storage, e.g. water tank manufacturing, SHS installation, the water grid, etc. The interviews, which provided a flexible yet focused framework for exploring expert insights, typically lasted 30-45 minutes, with some lasting up to two hours. In most cases, the interviews were audio-recorded, but for a small number of interviews only handwritten notes were taken, either due to the interviewee‘s request not to be recorded or due to the soundscape of the interview location. In all cases, the language of the interview was English. The design of these interviews emphasized open-ended questions to explore the issues at hand, and the guidelines were continually adjusted to encourage conversations while incorporating thematic prompts to ensure alignment with the research objectives. For recruiting thematic experts, I assessed their relevance based on online research, pre-existing knowledge, and recommendations from other interviewees before contacting them through appropriate means, such as email or text message. Selection criteria were their potential expertise and insights on either broader urban and infrastructure development issues or, more commonly, sector-specific aspects of water or electricity. In several cases, the recruitment of expert interviewees either took a very long time over several visits to Nairobi or never materialized. Nevertheless, a total of 36 interviews were conducted with various thematic experts (‣ Figure 14), covering all relevant topics.

Enriched household interviews: Semi-structured interviews, visits, and more

In order to fully explore the sociotechnical intricacies of domestic storage arrangements and their respective dispositifs, the most central data collection activity of my empirical work came in the form of ‘enriched’ household interviews, meaning that classic semi-structured interviews are supplemented with ‘an expansion of forms of collecting information’ (Dowling et al. 2016: 686). In my case, each enriched household interview involved a physical visit to a household, a handwritten documentation of their water/electricity situation, a semi-structured but largely conversational interview with one person as the main data collection activity (usually lasting up to 60 minutes), and – in the majority of cases – additional but more informal conversations with other members of the household or persons related to it, such as partners, children (above the age of 16) or house helps. While all but two of the semi-structured interviews were audio-recorded, most of the additional conversations were recorded with handwritten notes or short audio snippets only. The selection of interviewees for enriched household interviews was purposeful, with the goal of including diverse socioeconomic, infrastructural, and architectural realities; specifically, depending on the exact location, occupation, housing status (e.g. tenant vs. owner), and type of building/housing. For the identification and recruitment of interviewees, I initially relied on pre-existing contacts,

Figure 14: List of interviewed thematic experts.

Topic	Role(s)/Position/Job	Institution/Company ▼	Type	Year
	Head of Africa Operations	Aceleron	Private/ Corporate	2023
	Deputy Director, Energy Efficiency	EPRA (Energy and Petroleum Regulatory Authority)	Government/ Utility	2023
	Senior Renewable Energy Officer	EPRA (Energy and Petroleum Regulatory Authority)	Government/ Utility	2022
	CEO	EWIK (E-Waste Initiative Kenya)	Private/ Corporate	2023
	Solar Technician #1	*independent*	Private/ Corporate	2022
	Solar Technician #2	*independent*	Private/ Corporate	2022
	Chairman	KEREA (Kenya Renewable Energy Association)	NGO/ CSO	2023
	General Manager, Distribution	KPLC (Kenya Power and Lighting Company)	Government/ Utility	2023
	Battery Engineer	ROAM	Private/ Corporate	2022
	Project Director	ROAM	Private/ Corporate	2021
	E-Mobility Lead	Siemens Foundation	NGO/ CSO	2022
	Chief, Urban Energy Unit, Urban Basic Services Branch	UN-Habitat	NGO/ CSO	2022
	CCO	WEEE Centre	Private/ Corporate	2022
	Engineer/Assistant Director	AWWDA (Athi Water Works Development Agency)	Government/ Utility	2022
	Brach Manager, Westlands	Davis & Shirtliff Group	Private/ Corporate	2022
	Plumber #1	*independent*	Private/ Corporate	2023
	Plumber #2	*independent*	Private/ Corporate	2022
	Senior Design Associate	Kounkuey Design Initiative	Private/ Corporate	2022
	General Manager	Kentainers	Private/ Corporate	2023
	Executive Director	KWAHO (Kenya Water for Health Organization)	NGO/ CSO	2021
	Operations & Maintenance Manager	NCWSC (Nairobi County Water and Sewerage Company)	Government/ Utility	2021/23
	Assistant Director, Water & Sanitation	NMS (Nairobi Metropolitan Services)	Government/ Utility	2022
	Operations & Maintenance Officer	Oloolaiser Water and Sewerage Company	Government/ Utility	2022
	General Manager	Runda Water Ltd.	Government/ Utility	2021
	Lead, Environment & Climate Change	SHOFCO (Shining Hope for Communities)	NGO/ CSO	2021/22
	Institutional Sales Lead	TopTank Ltd.	Private/ Corporate	2022
	undisclosed position	Vajra Drill Ltd.	Private/ Corporate	2022
	Water and Sanitation Team Leader, Urban Basic Services	UN-Habitat	NGO/ CSO	2021
	Principal Hydrogeologist	WRA (Water Resource Authority)	Government/ Utility	2021
Urban/ Misc.	Real Estate Research Coordinator	Cytonn Investments	Private/ Corporate	2023
	Property Owner (Westlands)	*independent*	Private/ Corporate	2023
	Property Owner (Ongata Rongai)	*independent*	Private/ Corporate	2023
	CEO	KARA (Kenya Alliance of Resident Associations)	NGO/ CSO	2022
	Project Manager	Kenya Green Building Association	NGO/ CSO	2023
	Chairman	Nairobi Waste Picker Association	NGO/ CSO	2023
	Founder	Zima Homes	Private/ Corporate	2022

Figure 15: Examples of social media images for interviewee recruitment; designed by author.

both personal and professional, and snowballed from there. However, after focusing on the four target areas only, I diversified my recruitment strategies to avoid selection bias by also using social media (‣ Figure 15) and, most importantly, the support of two research assistants, namely Cynthia Chepkemoi for Kibera and Eastleigh, and Kate Owino for Eastleigh and Ongata Rongai. Not only did they both provide invaluable support with parts of the recruitment and logistics, but Cynthia Chepkemoi also conducted a small number of interviews for me that were deliberately conducted in Swahili and later translated to ensure that any linguistic nuances could be captured (although in the end this did not make much difference). Ultimately, with the goal of having at least seven per main target location, a total of 39 enriched household interviews (‣ Figure 16) were conducted across Nairobi, involving 68 different respondents, including the additional, informal conversations, and all of varying length and depth; depending on the scale and specifics of each storage dispositif.[12]

Go-alongs and explorations

Inspired by the application of mobile/ walking methods to the study of urban/ infrastructure landscapes (Castán Broto 2019; Streule 2019), I conducted a series of seven mobile explorations (‣ Figure 17), with one urban walk in each of the four target areas (usually straight through),

[12] Notably, visits and interviews in lower-income and/ or informalized settings, such as Kibera, tended to be significantly shorter in duration, as the technical intricacies and scope of storage dispositifs were usually less extensive.

Figure 16: List of enriched household interviews

Location ▼	Name*	Gen.	Occupation	Status	Housing	Additional conversations	Year
Eastleigh	Ellen	F	Security Guard	Tenant	Apartment	Mother	2021
	Florence	F	Vendor	Tenant	Apartment	-	2022
	Mohamed	M	Store Clerk	Tenant	Apartment	Brother	2022
	Hope	F	Reseller	Tenant	Townhouse	Husband	2023
	Julius**	M	Casual Worker	Tenant	Apartment	-	2023
	Daniel	M	Store Clerk	Tenant	Apartment	***	2023
	Thomas	M	*unclear*	Tenant	Apartment	***	2023
	Sophia	F	*unclear*	Tenant	Apartment	***	2023
Kibera	Aaron	M	Casual Worker	Tenant	Shack	Neighbor, Wife	2021
	Sarah	F	*unclear*	Tenant	Apartment	Son, Neighbor	2022
	Norina	F	Vendor	Tenant	Shack	Daughter	2022
	Hazel	F	House Help	Tenant	Shack	Neighbor	2022
	Agnes	F	Casual Worker	Tenant	Shack	Neighbor	2023
	Hassan	M	retired	Tenant	Shack	***	2023
	Juno	F	*unclear*	Tenant	Shack	***	2023
	Caleb	M	Casual Worker	Tenant	Shack	***	2023
Ongata Rongai	Edith	F	University Lecturer	Owner	Single-Family House	Husband, Neighbor	2021
	Mabel	F	Secretary	Owner	Single-Family House	Husband	2022
	Grace	F	Secretary (School)	(On-Site)	Apartment	-	2022
	Melissa	F	*unclear*	Owner	Single-Family House	House Help	2022
	Lucy	F	Vegetable Vendor	Tenant	Shack	-	2023
	Joshua	M	Online Reseller	Tenant	Apartment	-	2023
	Lily	F	Marketing Manager	Tenant	Apartment	Niece	2023
Westlands	Margaret	F	Writer	Owner	Apartment	Husband, House Help	2021
	Mila	F	Teacher	Tenant	Townhouse	Neighbor, House Help	2022
	Alma	F	Architect	Tenant	Apartment	-	2022
	Betty	F	Governance Advisor	Tenant	Apartment	-	2022
	Harina	F	Author/ Consultant	Tenant	Apartment	-	2022
	Jacob	M	Pastry Chef	Tenant	Apartment	Sister	2022
	Max	M	Journalist	Tenant	Townhouse	Security Guard	2023
	Carol	F	Teacher	Tenant	Apartment	House Help	2023
Buru Buru	Oscar	M	Lawyer	Owner	Townhouse	Mother	2021
Kariobangi	Andrew	M	Cosmetologist	Tenant	Apartment	Wife, Property Owner	2021
Kawangware	Leona	F	House Help	Tenant	Apartment	-	2021
Kitengela	Michael	M	Artist/ Event Organizer	Owner	Single-Family House	Wife	2021
Lang'ata	Daniel	M	Travel Guide	Owner	Single-Family House	-	2021
Rosslyn	Jennifer	F	-	Tenant	Single-Family House	Husband, Security Guard	2021
Ruaka	Jonas	M	Research Coordinator	Tenant	Apartment	Sister	2022
Ruaka	Nora	F	Project Manager	Tenant	Apartment	-	2021

* All names of interviewees in this thesis have been replaced with pseudonyms.
** Was no longer living in Eastleigh at the time of the interview, but as the infrastructure situation in Eastleigh was one of the reasons for his family's move, we conducted the interview next to his old home in Eastleigh.
*** Interview conducted by Cynthia Chepkemoi in Swahili.

another walk from the CBD to Kariokor Market as well as one through and around the Dandora dumpsite, and – as a modal exception – an exploratory car drive through the peripheral eastern parts of the NCC, which are experiencing rapid growth and construction. For each of these explorations, I was accompanied by a person who either lived in the area or was very knowledgeable about the area, and whom I asked – during the walk/ drive – to reflect on their perspectives and information about water/ electricity supply and storage in the area. For Westlands, CBD/ Kariokor and the drive through eastern Nairobi, I was accompanied by curator and poet Bethuel Muthee; for Ongata Rongai, I explored the western parts of the growing town with Belinda Nyasio, a long-time resident of the area; for Kibera, Kevo Stero of the local artists‘ collective Maasai Mbili showed me around Kianda and the surrounding villages; for Eastleigh, Kate Owino, a research assistant with many contacts in the area, walked with me from Section III to Section I; and for the exploration of Dandora, I was guided by Solo, the chairman of a local waste picker association. During these walks, which lasted between two and four hours each, informal conversations with strangers added nuance and information, and the walks, with their intermittent conversations and varied impressions, were recorded with handwritten notes and short audio snippets. In addition to these walks, I also had two opportunities to walk/ drive with other researchers through their ‘fields’, specifically Mario Schmidt in Pipeline (Embakasi) in 2023 and Andrea Pollio and Zhengli Huang in Zimmerman in 2024; both visits contributed to my broader understanding of infrastructural realities in Nairobi, especially in dense and vertically rising residential areas.

Document and secondary data analysis

In order to nuance and contextualize the explorative empirics of interviews, conversations, and walks, I also reviewed a large number of publicly available documents and secondary data. Looking primarily for any storage-related policies or interventions by state actors or their potential recognition in planning documents, I reviewed legal texts, master plans, and regulatory guidelines at the county and national levels, such as the *Nairobi Integrated Urban Development Master Plan*, Kenya‘s 2019 *Energy Act*, the 2022 *National Building Code*, and many others. I identified and obtained most of the documents online, but a small number were sent to me directly by interviewees. I also obtained and worked with secondary data from the Kenya National Bureau of Statistics (KNBS), such as population statistics and import data. While my review and analysis of documents and secondary data did not follow a specific systematic and fully comprehensive approach, it added important data points, nuances, and a broader perspective.

Tested but discarded methods

While the analysis underlying this dissertation and its papers is largely based on data from the above methods, I have also tried other data collection activities that did not result in data that was used for further analysis. On the one hand, thanks to the efforts of my colleague at TUD, D. Nthoki Nyamai, a small set of questions about domestic water and electricity storage was included in a survey of pedestrians in Nairobi's CBD in late 2020. Given the rather indicative nature of the questions, and some concerns about the representational character of the data, I did not use the survey for further analysis, but it helped enormously in confirming some of my initial impressions, which productively shaped later data collection methods. On the other hand, I also attempted to conduct two other data collection methods myself that did not yield compelling insights and/or were abandoned. I had planned to spend at least two to three weeks in each of the four target areas in order to get a first-hand impression of local infrastructural realities, but after two stays, one in Westlands and one in Ongata Rongai, the empirical value of these stays was rather negligible because the time frame was too short to gain insights that could not be covered by interviews and household visits. I also tested a diary technique with some of my early household interviewees, first in analog form and then via text message. Each person was asked to reflect weekly on their water and electricity storage practices and related events. However, the response and retention rate of the interlocutors was very low, probably also due to my intermittent, usually short presence in Nairobi, so that it was not possible, for example, to gain insights into the temporal dimension of household storage from the information collected, which was one of the reasons for requesting such diaries. Ultimately, after several unsuccessful attempts with the diary technique, I abandoned the effort.

Data from the 'Urban Waterscapes and the Pandemic' project

In addition to data collection as a dedicated part of my dissertation project, another source of empirical information, particularly on water infrastructures and storage, was the mixed-methods empirics of 'Urban Waterscapes and the Pandemic' project, which officially ran from October 2021 to September 2022 as a collaborative project between the International Planning Studies (IPS) research group at TUD and the Department of Urban and Regional Planning at UoN. Led by Sophie Schramm and Elizabeth Wamuchiru, the project investigated how water practices, technologies and infrastructure in Eastleigh and Kibera were transformed by the 'infrastructural event' (Carse 2017) of the Covid-19 pandemic. As project researcher, and with the great help of a team of research

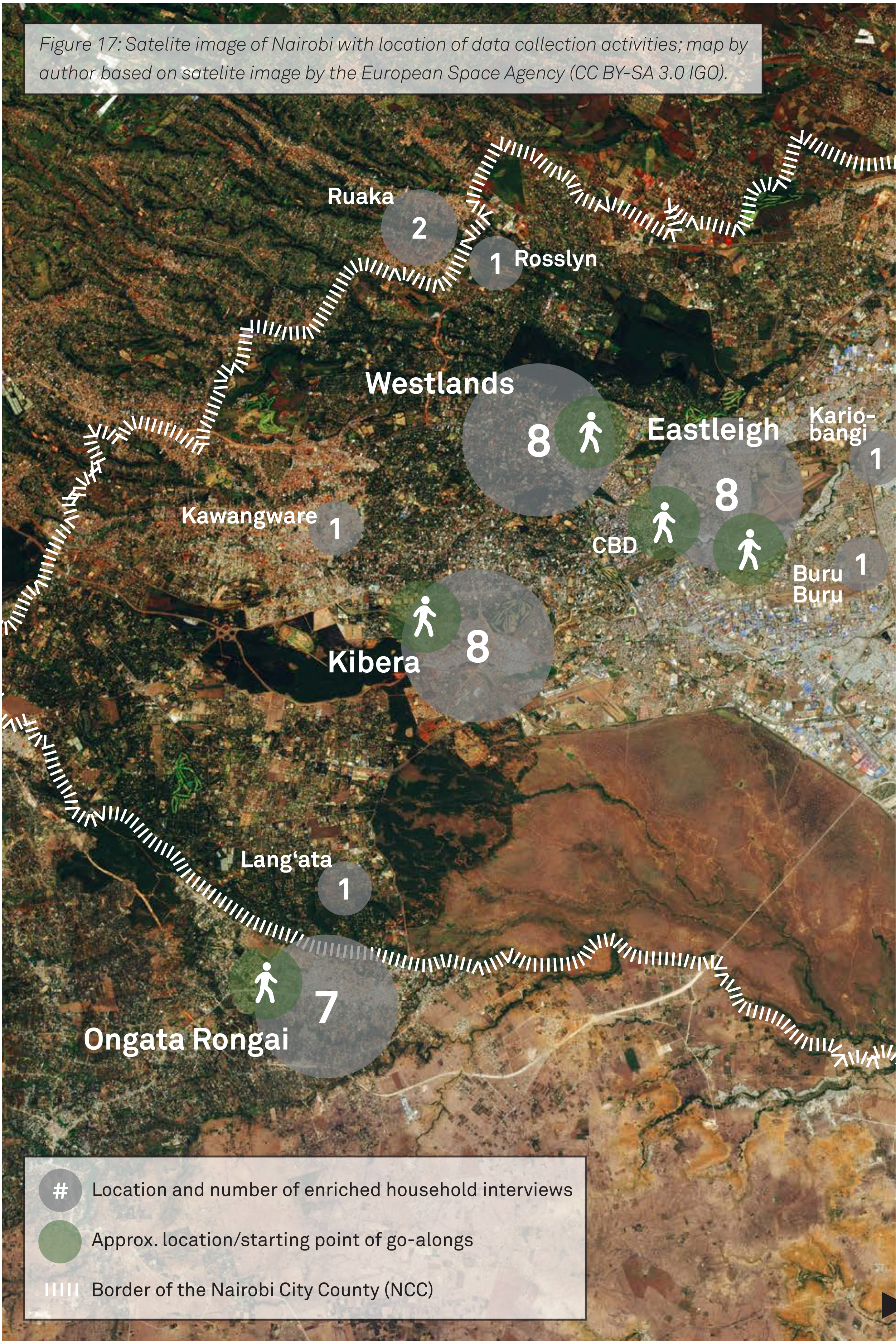
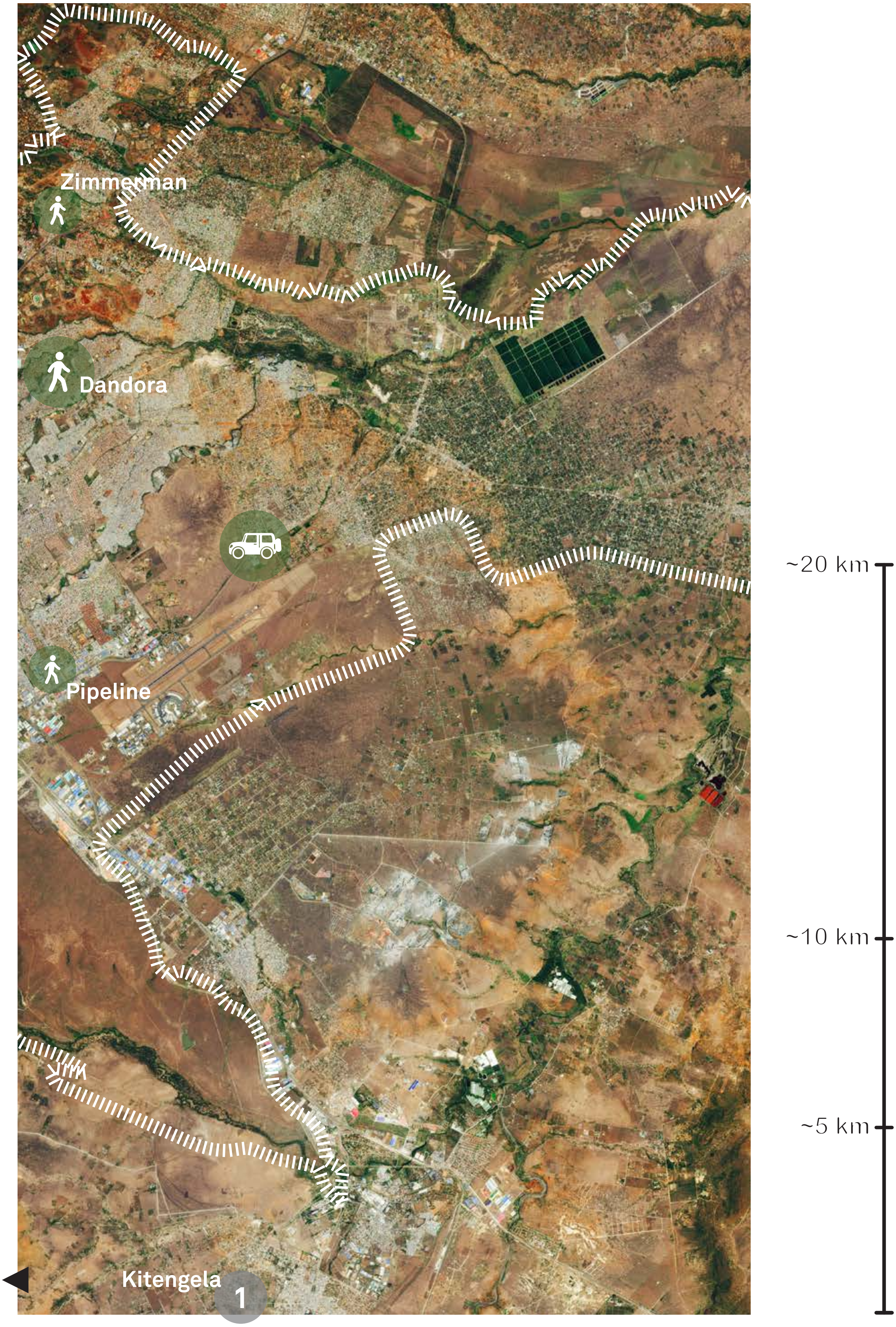


Figure 17: Satelite image of Nairobi with location of data collection activities; map by author based on satelite image by the European Space Agency (CC BY-SA 3.0 IGO).


Zimmerman
Dandora
Pipeline
Kitengela
1
~20 km
~10 km
~5 km

assistants, I led and managed most of the empirical data collection – site visits, semi-structured interviews with local experts, water vendors and residents, and a quantitative household survey with over 900 respondents in total – and subsequent analysis. At the time of writing, the project has resulted in two academic publications (Kasper et al. *forthcoming*; Schramm et al. 2023), an open access dataset (Kasper et al. 2022), a policy brief (Wamuchiru et al. 2022) and several presentations at international conferences. Not only are some of these publications referenced in this dissertation, but I have also sporadically made direct use of interview material and quantitative data for my own analysis and writing.

Data analysis

The analysis of the diverse but primarily qualitative material followed an iterative approach, integrating multiple ways to refine findings and develop insights. Key components included cycles of closed coding, *writing as analysis*, and discussions/presentations, each of which contributed uniquely to the research process. Closed coding – that is, organizing material according to a predetermined set of codes, in my case derived from existing literature/theory, field impressions, and previous findings – was applied iteratively, reflecting Saldaña's (2013) emphasis on the cyclical nature of qualitative analysis, in which data are revisited and reinterpreted to refine emerging themes. In my cases, this included a basic set of codes for a first batch of data, interviews and other sources alike, on water, electricity, and urban/other as broad categories with several subcodes, e.g. on practice, artefact, and conflict/tension. Each visit to Nairobi lead to a slight re-organizing and new codes were specifically designed for emerging themes and paper concepts; e.g. codes on *stabilizing*, *disrupting*, and *creating* (‣ Chapter 7). Accordingly, for three of the four papers in this cumulative thesis (‣ Chapters 4, 6 & 7), the interview materials were coded/organized separately but built on the findings and emerging questions from the previous analysis, usually adding new materials to code as well, due to the cyclical, iterative nature of fieldwork (‣ Figure 9). This systematic coding process was complemented by *writing as analysis*, an approach that treats writing as a mode of inquiry (Richardson and St. Pierre 2005) and 'encourages analysis and expression in and through the process of representation' (McCann and Ward 2012: 50). Through iterative drafting and redrafting, new understandings emerged, and thus 'writing did not simply repeat ideas already formed but was a way to ask questions and work through new associations' (Augustine 2014: 750). Collaborative discussions and presentations then formed another cornerstone of analysis, as engaging with colleagues, friends, and other peers helped me immensely to uncover blind spots, validate interpretations, and explore alternative perspectives. These interactions took place in a variety of settings, including conferences, colloquia, workshops, and informal discussions, which then informed my subsequent empirical and analytical steps. The iterative, sometimes messy nature of the analysis is consistent with the inductive logic of my research design, where I intended to build patterns and themes from the collected data rather than impose frameworks.

3.3. Limitations and outputs

In April 2023, as I was sitting with a group of peers in a small café in Westlands after a workshop day, someone working for a UN agency asked me, after chatting enthusiastically about my research, if I could somehow quantify or calculate all the water and electricity stored by households in Nairobi. It might be helpful for them and other agencies to have a method for doing this, in Nairobi and elsewhere. Given the qualitative nature of my research, and my general skepticism about supposedly accurate calculations of intricate and variegated elements of the everyday urban, such as domestic storage, I explained that this was beyond the scope of my research and would require a massive empirical effort. I also added that the results would not be able to serve as a blueprint for other geographies because of the place-specific nature of domestic storage, which already varies considerably between and within neighborhoods in Nairobi. Having made my case, our conversation slowly but awkwardly died down, and an atmosphere of mild disappointment hung in the air.

While there seem to be attempts to use AI image processing to estimate domestic water storage (Shahbaz et al. 2023), I remain firm in my belief that a necessarily place-specific quantification of domestic storage of water, electricity, and other resources would be a tedious effort with unclear benefits. Nonetheless, the conversation in the café, along with many other moments and reflections over the past few years, also speaks to the limitations of my dissertation project. While some may criticize or struggle with its qualitative nature in general, here is a non-exhaustive list of the limitations that I find important to acknowledge:

- Focus on water and electricity: The study focuses primarily on the domestic storage of water and electricity, largely overlooking the storage of other critical resources such as food, data, and other forms of energy. This limits its ability to discuss and theorize storage more broadly.
- Focus on households: By focusing the analysis on households, the study does not consider the storage practices and artefacts of unhoused or otherwise precariously housed populations. While the use of *the household* as the primary spatial framing was intentional and productive (‣ Chapter 2.2), it may further reproduce an ethnocentric, Western notion of home and dwelling that excludes other forms of living and their storage arrangements.
- Focus on everyday artefacts: By centering on the mundane aspects of storage, the study may inadvertently downplay the systemic and institutional factors that drive infrastructure challenges and resource insecurity. I attempted to address this by proposing 'storage as a multi-scalar analytic' (‣ Chapter 7), but the scale and lens of the everyday urban still dominates the thesis.
- Lacking exploration of temporal dimensions: Due to the unsuccessful attempt to collect storage diaries (‣ Chapter 3.2), the study does little to address temporal patterns or rhythms, such as seasonal variations or daily routines, that could be critical to understanding the dynamics, relationships, and ongoing production of storage arrangements.
- Limitations in recruitment: My initial reliance on pre-existing contacts and snowball sampling may have introduced a selection bias, particularly in reaching marginalized communities or those less connected to my contacts and networks. An example of this is the limited participation of interlocutors of Somali origin/ ethnicity in Eastleigh, despite their large presence in the area.
- Use of English as the primary language: Conducting most interviews in English may have excluded nuanced expressions and insights from participants more fluent in Swahili or other languages, potentially limiting the cultural and linguistic depth of my findings.
- Researcher positionality, bias, and power dynamics: My long association with Nairobi and hybrid insider-outsider perspective may introduce bias (‣ Chapter 1), as familiarity with the city and my own experiences with water and electricity storage may influence interpretation of data or overlook alternative viewpoints. In addition, despite my networks and cultural familiarity with Nairobi, interviews with participants of different socioeconomic and professional status may have been influenced by perceived hierarchies, affecting openness and honesty.

However, by acknowledging these limitations, there is also a tremendous untapped potential for future research to fill gaps and build on my findings, which I discuss further in Chapter 9.

Outputs beyond the papers

In addition to the clear limitations, it is also important to recognize that this work is more than the sum of its four papers. Beyond the empirical findings and publications that have emerged, there is a broader landscape of synergies, collaborations, further outcomes, and many intangible benefits that are associated with or directly derived from this study.

Most obviously, there are additional publications – peer-reviewed or not – that I have been involved in over the past few years and that have varying degrees of connection to my dissertation research, namely:

- The various outputs of the 'Urban Waterscapes and the Pandemic' project (▸ Chapter 3.2), which share empirical parts and analytical sentiments with this thesis (Kasper et al. 2022, *forthcoming*; Schramm et al. 2023; Wamuchiru et al. 2022):
- Two blog posts based on findings or impressions from my fieldwork (Kasper 2022, 2023);
- Published book reviews (FOS 2024a, 2024b) and a forthcoming special issue with and as the Flow/ Overflow/ Shortage Research Collective; and
- A forthcoming chapter on storage in a book on 'architectures of circulations.'

In addition, presentations at conferences, workshops, or other occasions not only critically shaped my analysis process (▸ Chapter 3.1), but also played an important role in bringing my research into discussion in front of international peers. Leaving aside several presentations that were not directly related to my dissertation research, the following list presents important vectors for disseminating findings:

- 'Urban future making through domestic water storage: Everyday infrastructuring in Nairobi in times of crisis', *Questioning Urban Future-Making in the Times of Disrupture*, December 2023. Berlin (Germany): Georg-Simmel Center for Metropolitan Studies (Humboldt University zu Berlin).

- ‘Holding together: Spatial, infrastructural, and mundane entanglements of and within mitungi in Nairobi’, *Reconfiguring African Studies through Spatialities*, October 2023. Bayreuth (Germany): Africa Multiple.
- ‘Battery city: Typologies, implications, and potential futures of everyday electricity storage in Nairobi’, *European Conference on African Studies* 9, May 2023. Cologne (Germany): Global South Studies Center.
- ‘Everyday storage of water and electricity in Nairobi: Reimagining infrastructures through storage artefacts and practices’, *4S/ESOCITE 2nd Joint Meeting*, December 2022. Cholula (Mexico): ESOCITE; Society for Social Studies of Science; Ibero Puebla.
- ‘Everyday infrastructuring through storage: Domestic storage of water and electricity as part of infrastructural presents and futures in Nairobi’, *African Infrastructure Futures*, November 2022. Cape Town (South Africa): African Centre for Cities.
- ‘Turning to storage: Domestic electricity storage as infrastructure in Nairobi’, *New Approaches to Mobility, Transport, and Infrastructure in Africa*, September 2022. Accra (Ghana): University of Ghana; HU Berlin, Goethe-Universität FFM; Point Sud.
- ‘Jerry cans, super drums, water tanks: Domestic water storage as critical infrastructure in Nairobi’, *Urban Circulations*, June 2022. Darmstadt (Germany): KRITIS.

Active participation in workshops was also part of this dissertation project and often led to important feedback and publication trajectories, especially from the following workshops:

- *Waterbodies: Space, flows and other stuff*, December 2023. Berlin (Germany): SFB 1265/ Technical University Berlin.
- *Governing Heterogeneous Urban Energy Landscapes*, July 2023. Limburg (Netherlands): Universiteit Utrecht.
- *Beyond Splintering Urbanism*, March 2022. Autun (France): Université Gustave Eiffel.

The combination of the four main papers that follow and the outputs outlined above provides a more complete picture of the results of my dissertation and their dissemination. However, there have been countless other conversations, collaborations, synergies, and side projects with colleagues around the world that relate in one way or another to this dissertation. Many of these peers and friends are mentioned in the *Acknowledgements*, but more generally I hope that this dissertation can also be read as part of 'a geography of relations among researchers of infrastructure in and from the South(s)' (FOS 2024b). With a relational understanding of the urban, its infrastructures, and its storage (‣ Chapter 2), this dissertation itself is ultimately a relational arrangement of many efforts, ideas, actors, and outputs that can hardly be fully 'stored' or adequately represented in the following pages.

Figure18: Electricity lines and apartment building with rooftop water tanks in Zimmerman; photo by author (2024).

ABSTRACT Against the 'normative concept of the networked city' (Graham and Marvin 2001), urban studies and infrastructure research have seen a shift towards investigations beyond the network that engage with the post-networked city, heterogeneous infrastructures, and other situations 'on, off, below and beyond' the grid (Munro 2020), especially in southern cities. Expanding on debates around southern urbanisms and their sociotechnical infrastructures, we explore a ubiquitous yet rarely discussed element of contemporary urban infrastructures: storage. In Nairobi, a city shaped by infrastructural heterogeneity and uncertainty, households of all backgrounds and sizes store water and electricity within various constellations of actors, practices and artefacts. We show how domestic storage, its artefacts and practices cumulate in a storage city that is not opposed to a networked or post-networked city but rather entangled with it. We present domestic storage as crucial infrastructure to the sociotechnical functioning of Nairobi, discuss diverse storage artefacts and practices, and highlight how a focus on storage can contribute to re-imaginings of infrastructural articulations beyond networks and flows.

co-authored with Sophie Schramm

4. Storage city

Water tanks, jerry cans, and batteries as infrastructure in Nairobi

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> 'It's so ingrained in us ... I am storing electricity and water because my country is like this ... You don't think about it, it's just instinct.' (resident interview in Ruaka)

Despite the importance of infrastructures and basic services for urban lives and economies, many cities across the globe struggle with the universal and centralized provision of water, electricity, and other essential resources. Especially in southern cities, basic supply is less defined by the ideal of the networked city but rather by heterogeneous infrastructure configurations (HICs) involving diverse sociotechnical sets of providers, sources, materialities, and practices (Lawhon et al. 2018; Jaglin 2014). Amidst such configurations, urban residents – for example in Nairobi, Kenya – have to navigate infrastructural uncertainty caused by rationings, blackouts, and other interruptions. One way of making urban life possible amidst unreliable or heterogeneous infrastructures is: Storage.

For long, academic engagements with urban infrastructures have focused on the spatialities, temporalities, materialities, and politics of flows, circulations, mobilities and other kinds of movements (e.g. Bender 2009; Graham and Marvin 2001; Kaika 2005). In line with recent provocations on infrastructural containment or confinement (e.g. Banoub and Martin 2020; Furlong 2022), we suggest expanding our understanding of infrastructures towards the artefacts and practices of domestic storage of water, energy and more. Focusing on the household and its storage artefacts, that is containers, as key sites and technologies of storage, this provides a new venue for investigations and imaginations beyond dualisms of connected/ unconnected, rich/ poor, formal/ informal, etc. Simultaneously, the everyday deployment of storage in Nairobi and elsewhere does not conflict with notions of networked or post-networked cities. Instead, in regards to uncountable sites, artefacts and practices of storage, we propose the notion of a *storage city* with multiple relations and connections to other systems and conceptualisations. Ultimately, we advocate for *storage as infrastructure*, given its enabling, imperative role for urban-infrastructural functioning in Nairobi. Such deliberate inclusion and shift in perspective may provide crucial insights for planning, design and governance of placespecific HICs across the networked/ post-networked spectrum.

As a first step to grasp *storage as infrastructure*, we use the examples of water and electricity in Nairobi, Kenya. Drawing from existing literature, our paper is grounded in qualitative fieldwork in the wider Nairobi area in 2021 and 2022: more than 20 structured key informant interviews (government, utilities, NGOs, etc.); close to 30 semistructured resident interviews; and multiple visits, strolls and informal conversations. We recruited resident respondents via existing contacts, social media and snowballing, and we based our final selection on diversity in terms of socioeconomic situations, geographic location, residential architectures and infrastructural connectivity. We conducted the majority of resident interviews – which always discussed both water and electricity in Eastleigh (dense central neighbourhood), Kibera (large informalized settlement), Westlands (up-market area) and Ongata Rongai (rapidly urbanising suburb). The paper is organised in three sections: a theoretical and conceptual framing based on existing literature; an exploration of the underlying reasons for, and expressions of, domestic water and electricity storage in Nairobi; and a final discussion opening up tasks and questions for further engagements.

4.1. **Networked, post-networked, storage city:** From flows to storage

Our understanding of *modern* cities and their infrastructural functioning has been shaped by the universalising promises of 'distributive infrastructures,' largely 'comprised of pipes, cables, wires and tracks' (Marvin 1992: 228). As crucial parts of the 'normative concept of the networked city' (Graham and Marvin 2001: 387), these infrastructures and the flows, circulations and mobilities they enable – promised the ideal of a 'unitary, orderly city' (Monstadt and Schramm 2017). However, the modernist vision of the 'networked city was rarely 'perfectly 'realised'' neither was it 'a universal and uniform 'thing'' (Graham and Marvin 2001: 88). For many southern cities, centralised networked infrastructures have rarely provided the promised services and supply in a universal manner (Furlong and Kooy 2017; Graham and Marvin 2022; Munro 2020). Yet, urban residents as well as governmental and private actors have found myriad ways to distribute water, electricity and other resources or services: tapping of wires and pipes; decentralised distribution systems; off-grid supply modes; etc. (Chakava et al. 2014; Cirolia et al. 2021; Schramm and Ibrahim 2021; Silver J 2015).

By highlighting the 'vitality and multiplicity of actual delivery systems' in southern cities, Jaglin (2014) questions the applicability of the networked city notion as a starting point for urban-infrastructure research and practice. Accordingly, calls for new vocabulary through more situated research in southern cities (e.g. Bhan 2019) have contributed to a rise of new notions, such as HICs or the post-networked city. The post-networked city stands for 'an urbanism of infrastructure that no longer assumes ... convergence of sociotechnical systems around a networked configuration' (Rutherford and Coutard 2016: 258), and often refers to off-grid infrastructures, for example boreholes and small-scale solar. Contrastingly, HICs include 'the diverse ways that people access services within and beyond conventional city networks,' which conceptually 'challenges the binary between networked and non-networked' (Cirolia et al. 2021: 1611). Referring to different yet overlapping conceptualisations, both notions are characteristic for many African cities (Hyman and Pieterse 2017; Jaglin 2016).

As part of the global ‘infrastructural turn’ (Graham 2010), we have also seen a general expansion of what infrastructures *are* (or might be), from Simone’s (2004) ‘people as infrastructure’ to recent provocations on human bodies, non-human beings, time and more ‘as infrastructure’ (e.g. Andueza et al. 2021; Barua 2021; Besedovsky et al. 2019). Other authors have pointed out that the increasingly ‘fuzzy boundaries’ of infrastructure may jeopardise sharpness and usefulness for academia and practice (Baptista and Cirolia 2022: 930; cf. Howe et al. 2016). Yet, a ‘wider infrastructural ontology’ (Barua 2021; cf. Addie 2021) holds opportunity and value to fully grasp how basic services and resources are provided, distributed and accessed within and through configurations or systems ‘without which contemporary societies cannot function’ (Edwards 2003: 188). From all the engagements and debates of the last decades, four key aspects define how we approach urban infrastructures for this paper. Firstly, we see the urban and its infrastructures as sociotechnical assemblies of ‘materials, technologies, social institutions, cultural values and geographical practices’ (Graham and Marvin 2001: 214), including diverse sets of human and non-human actors as well as processes of becoming (Alda-Vidal et al. 2018). Secondly, for the continuous becoming of infrastructure – for ‘infrastructuring’ (Simone 2022) – we stress the importance of everyday practices and labour of urban residents in making the city work (Graham and McFarlane 2014). Thirdly, we acknowledge infrastructural configurations in many southern cities as indeed heterogeneous. This involves ‘many different kinds of technologies, relations, capacities and operations’ (Lawhon et al. 2018: 726) and is mirrored in individual household *dispositifs*, a distinct sociotechnical situation with ‘a specific set of actors, resources, material artefacts, technical knowledge, and formal and informal institutions’ (Rateau and Jaglin 2022: 185). Finally, we do not see heterogeneity or any other deviation from a networked infrastructure ideal as developmental failures but – to the best of our abilities – we try to ‘provide a proper reading of infrastructural articulations’ (Guma 2022: 63), as they actually *are* and not as they *should be*.

Following the infrastructure propositions above, and in line with the expansion of notions and definitions, our investigation approaches *storage as infrastructure*. Given their often distributive character, infrastructures remain predominantly conceptualised through circulation, flows, networks, or the lack thereof (e.g. Barua 2021; Cirolia et al. 2021; Lemanski and Massey 2023). As others have already pointed out, urban studies, infrastructure studies and related disciplines have rarely specifically addressed the moments, spaces, practices and artefacts of infrastructural containment or confinement (Banoub and Martin 2020; Furlong 2022; Millington 2018; Shryock and Smail 2018). Research on domestic storage in Nairobi may thus contribute to a wider infrastructural ontology –

beyond the network, beyond the West, etc. – by building 'explanations from empirical observations of what [urban residents] actually do, the practices they perform' (Alda-Vidal et al. 2018: 105). For this, we start with analysing everyday entanglements of society and technology and merge those with the critical situatedness of postcolonial urban studies (Guma 2021). It is not our aim, however, to come up with a definite conceptualisation of infrastructure. Instead, for the sociotechnical, place-specific and constantly becoming infrastructural configurations of water and electricity in Nairobi, we simply aspire to show that domestic storage is more than 'appliances' or 'ordinary tools' but indeed infrastructure (cf. Meehan 2014; Shove 2016). Ultimately, this shall contribute to the ongoing endeavour of a critical urbanism beyond the network towards heterogeneous and/ or post-networked urban realities.

Domestic storage as diverse infrastructural practices and artefacts

Especially within highly erratic or heterogeneous infrastructural conditions – shaping much of urban Africa – storage of essentials becomes a highly visible, everyday phenomenon (Alba 2018; Dakyaga et al. 2018; Munro 2020; Rateau and Jaglin 2022). Nairobi's landscape is clustered with water tanks, jerry cans, so-called *super drums* and other water containers. Small power banks, larger battery systems, re-chargeable lights and comprehensive backup battery technologies are on the rise also. While electricity storage is currently receiving much attention in techno-managerial and engineering disciplines (e.g. Elshurafa 2020; Stadler and Sterner 2018), its role in producing distinct urban-infrastructural realities – especially in southern cities – has only been addressed peripherally (e.g. Munro 2020; Rateau and Jaglin 2022). For water storage, nondomestic forms and scales – such as reservoirs and dams – have been investigated (e.g. Bijker 2007; Kaika and Swyngedouw 2000), and domestic water storage has been discussed as a vector for disease transmission or as a distinct cultural phenomenon (e.g. Acevedo-Guerrero 2022; Lavie et al. 2020). However, the domestic storage of both water and electricity is rarely approached as key to urban-infrastructural functioning specifically. This leaves room for further investigations into situated, everyday infrastructuring through the use of and practices around 'boring' and understudied 'things' (Star 1999), such as jerry cans and batteries.

Banoub and Martin (2020: 1102) describe sites of commodity storage as 'more-than-human assemblages' that simultaneously 'constrain and enable accumulation.' This mirrors the reflections of Shryock and Smail (2018) on 'containers,' which 'both enable and inhibit transaction.' Accordingly, the notion of storage is not juxtaposed or in conflict with infrastructural notions of networks and flows but is rather entangled with those through specific sites and artefacts, i.e. containers. For our paper, we focus on domestic spaces, that is the household, as sites of storage where infrastructures and resource flows become 'integrated in the practices of everyday life' (Rohracher and Köhler 2019: 2375). Further, we start our investigations from the artefacts of domestic storage, the containers, that are crucial for the production of urban space and infrastructures in Africa. Consequently, we approach domestic storage as a sociotechnical hybrid of human storage practices in short, *storing* – and its artefacts – the storage *containers*. From this position, we unravel how those artefacts work, what domestic storage means for the notion and functioning of urban infrastructures, and how this relates to everyday practices of storage.

We focus on two key infrastructures and their usually *flowing* resources: water and electricity. From accounts on domestic water storage, we know that it is prevalent and diverse in southern cities and usually used to mimic continuous networked supply with tanks, jerry cans and such like (e.g. Burt and Ray 2014; Furlong and Kooy 2017; García-Betancourt et al. 2015; Kjellén 2006). As one of the few works that not only describes but also conceptualises domestic water storage infrastructurally, Millington's (2018) analysis of São Paulo's water crisis in 2014/15 shows how 'differentiated abilities of residents to store water' produce individually experienced scarcity of water. According to Millington, in an acute water crisis, storage becomes a 'visible' infrastructure (cf. Star 1999) and thus a 'point of contact – an intermediary infrastructure – between the household and the system' (Millington 2018: 31-32). However, focusing on a specific crisis and the allegedly sudden visibility of storage is not taking into account the potential regularity and constant visibility of domestic water storage, as infrastructures in general are often 'anything but invisible' but rather located along a 'range of visibilities' (Larkin 2013: 336). For example, Alba (2018) highlights the prevalence and diversity of water storage in Accra where buckets, jerry cans, large water tanks, and more, are constantly visible and used by households with and without piped connections. The artefacts and scope of storage vary by socioeconomic situation, and differences in storage styles and capacities can define 'how residents access water in terms of quantity, quality and means of access.'

Electricity storage has become a common feature of urban life also and helps to 'maintain modernity's illusive promise of continuous, uninterrupted supply' (Cross, in: de Seta et al. 2017). Simultaneously, transitions towards renewables, e-mobility and the promises of smart cities are prominent in societal and academic discourses, potentially cumulating in a future 'storage city' full of 'battery-powered gadgets and vehicles' (Xylia et al. 2019: 40). However, accounts from urban Africa show that electricity storage is not just a topic for smart, future, world-class cities but is practised in diverse ways within heterogeneous and often unequal infrastructure configurations. From Rateau and Jaglin (2022) we know that in Cotonou and Ibadan some households use battery systems as backups for outages. Together with myriad other batteries, those systems have become part of individual electricity dispositifs for some, albeit rather affluent residents. From Gulu Town in Uganda, Munro (2020) tells stories of urban residents that use batteries and battery-linked solar panels to navigate an erratic and uneven electricity configuration. For both water and electricity, the universality and diversity of storage show how it relates to a lack of regular supply, how all kinds of households are affected and react to it, and how storage inspires thinking beyond the on-/off-network dichotomy.

4.2. **Nairobi, a storage city:** Water and electricity

Nairobi has always been shaped by infrastructural heterogeneity and inequality, largely rooted in 'fast growth, colonial heritage, and lack of formal urban planning' (Ledant 2013: 338). While centralised, public infrastructures – such as piped water and electricity – were installed in settler-colonialist areas, the early decades of Nairobi saw little infrastructure provision to so-called 'native locations' (Ogot and Ogot 2020; Slaughter 2004). After independence, a 'period of growth and optimism' in the 1960s and 1970s, Nairobi struggled to expand basic services and infrastructures to its rapidly growing population. In the following decades, Nairobi experienced a surge of underserved informalized settlements, a dismantling of urban services, such as waste disposal and public transport, and a decreased reliability of networked services, such as water and electricity (Ogot and Ogot 2020; key informant interviews). From colonial times to the end of the twentieth century, marginalised Nairobians lived without networked infrastructures (Akallah and Hård 2020). Simultaneously, some urban elites unbundled themselves with generators, gated communities or the creation of an independent water network in the affluent suburb Runda (wa Mungai 2019; key informant interviews).

Since the 2000s, Nairobi has undergone massive urban-infrastructural transformations. While not without problems, slum-upgrading efforts have increased access to water, electricity and health facilities for some marginalised areas. At the same time, private and non-governmental actors provide services beyond centralised infrastructures (Chikozho et al. 2019; Corburn 2021;

Schramm 2017). Nairobi of the twentifirst century is a place where urban forms and infrastructure conditions are heterogeneous (Schramm and Ibrahim 2021; Wamuchiru 2017). Amidst this heterogeneity, all residents face – directly or indirectly – persistent shortcomings of networked infrastructures, in the form of low pressure or voltage, lack of connections, planned and unplanned outages, and more. Despite recent improvements, and in light of rapid urbanisation of Nairobi, many of our respondents are certain that universal services and centralised infrastructures will remain challenges for decades to come (key informant interviews). In the past, present and future, Nairobians across the city ensure the availability of electricity, water and other resources through artefacts and practices of storage. Against the prevalence and scope of domestic storage stands a lack of recognition by utilities, officials and urban planning documents of its importance to the everyday functioning of Nairobi (e.g. NCC 2014; key informant interviews); or as the water utility puts it, 'our responsibility ends at the meter point' (key informant interview). Apart from outdated guidelines on water storage in Kenya's *Building Code* as well as technical standards and solar-specific import tax benefits for batteries, storage of both water and electricity is hardly subject to any governmental regulations or policies (key informant interviews). With virtually no interventions from above, but triggered by rationing programmes and reoccurring interruptions, Nairobi has become a *storage city*.

Mitungi and water tanks: Domestic water storage in Nairobi

The historically rooted inequalities as well as the current unreliability and heterogeneity of Nairobi's water supply system have been well elaborated (e.g. Akallah and Hård 2020; Gulyani et al. 2005; Ledant 2013; Wamuchiru 2017). The city's networked water supply by the Nairobi County Water and Sewerage Company (NCWSC) is heavily affected by a massive daily water deficit of 300,000 cubic metres, against a demand of over 800,000 cubic metres. As a response, NCWSC has implemented a so-called *equitable distribution programme*, meaning water is distributed to neighbourhoods on specific days of the week only, with different days for different locations (key informant interviews). However, the programme has been shown to favour higher-income areas and the actual number of days as well as the amount and hours of water can be unreliable and unequal (resident interviews; Mutono et al. 2022; Schramm and Ibrahim 2021). While geographic locations and socioeconomic situations may define how much water connected households store, scarcity of piped water is universal and thus results in a heterogeneous universality of domestic water storage. More so, despite improvements in recent decades, official numbers show that only

76 % of households can access piped water, and even lower connectivity rates remain common in low-income areas and informalized settlements (key informant interviews; Ledant 2013; Mutono et al. 2022). Consequently, a heterogeneous landscape of water supply has emerged, in which households – connected or not – rely heavily on non-networked supply modes, such as water points. Water points usually feature large water tanks fed by the network or unknown sources, from which water users – mostly women and children – fetch water with jerry cans to then store at home or use to fill larger containers (resident interviews; key informant interviews; Sarkar 2022). With or without access to the network, Nairobians across the city rely heavily on water storage.

For fetching, storing and water delivery services, jerry cans play a central role across the city. Called *mitungi* in Swahili, they are *the* unit of water pricing in many areas, usually selling from 0.5 to 5 Kenyan shilling (KES) for fetched water and up to KES 100 for delivered jerry cans. Mitungi hold 20-23 L and are usually made of plastic, often in yellow. Some of them have a boxy jerry can design but many are reappropriated, round, 20-litre cooking oil canisters (▸ Figure 19). Private vendors also deliver mitungi but usually take them back after they are emptied into the containers

Figure 19: Artefacts of water storage in Pipeline, Buru Buru and Ongata Rongai (from left to right); photos by author (2021/22).

of the household. Since delivered water is significantly more expensive, mitungi handcarts are more prevalent in middle-income areas. In all cases, people use jerry cans and other small containers – such as buckets, old paint containers, and larger super drums of 100-250 L – to store water. The prevalent use of jerry cans extends to estates and households with piped connections or boreholes but where single units do not have larger water tanks, either due to financial or spatio-architectural reasons. In informalized settlements, jerry cans fill up large chunks of the already small homes, while in underserved (lower-)middle-class areas they fill balconies, kitchens, bathrooms, stairways and other common areas (observations; resident interviews; Chakava et al. 2014; Sarkar 2022). Mitungi are thus not only crucial for non-connected households but also for 'grid-dependent middle-income neighbourhoods [that] are now more marginalized by water flows than are some of the poor neighbourhoods' (Schramm and Ibrahim 2021: 355). Jerry cans and the diverse practices they require – fetching, delivery, carrying up stairways, filling up when water comes, stacking, emptying into larger containers, etc. – have become crucial infrastructures for many Nairobians.

On the other side of the storage spectrum are large-scale water tanks made of polyethene with the most common sizes being between 1000 and 3000 L for single household use. Placed in yards, underground, on flat rooftops or elevated metal structures, plastic water tanks are the most visible artefact of domestic water storage in middle-and upper-class neighbourhoods (‣ Figure 19). Water tanks either are used by individual households or are shared within buildings with multiple units. In addition, homes may feature smaller tanks in their attics, or above their bathrooms, to ensure direct availability and water pressure in-house. Each building, and each household, has a very specific water storage dispositif with varying sizes and numbers of tanks, connections to underground or ground-level tanks, pumps, responsibilities for filling and potential cleaning, additional use of jerry cans and different water sources. For cases with piped connections, on the days with supply, water usually runs into a larger underground or ground level tank and is then pumped up to smaller ones. In case of water shortages, residents or property owners can order water via trucks that fill up tanks via large water hoses. Given the weight of thousands of litres of water, tanks require a stable foundation or structure. New residential developments usually have designated spaces for water storage underground and on flat rooftops, while older properties often place them in gardens or have retrofitted metal structures on pitched roofs (observations; resident interviews; key informant interviews). In all cases, water tanks demand investments of several thousand KES as well as space and alterations to architectures.

In recent years, Nairobi has also experienced a surge in private and public boreholes that has led to diminishing groundwater levels (Oiro et al. 2020). Boreholes always necessitate massive water tanks connected to other tanks within buildings or, in the case of multi-unit compounds, directly linked to outlets in single households. No matter if water comes from pipes or trucks or boreholes, domestic water storage with large tanks is performed in complex assemblies of various storage artefacts, pipes and other technical equipment as well as human practices of plumbing, pumping, filling and more. Together with property owners, house helpers, caretakers and others, urban residents with the financial and spatio-architectural capacity to use large tanks are constantly infrastructuring their own water security. There are, however, cases where residents are largely removed from the labour and intricacies of water storage, when – for example, in luxury high-rises or gated communities – the property management takes complete responsibility (observations; resident interviews; key informant interviews). Yet, Nairobians across the city are actively involved in the usage of water tanks on a household level, and – as for jerry cans – those have become crucial infrastructures in the city's waterscape.

The prevalence and diversity of storage artefacts and practices show how, against the uneven geography of supply, water storage has become a nearly unifying feature of Nairobi's urban-infrastructural lives. However, beyond narratives of connected versus non-connected or formal versus informal, individual water storage dispositifs tell stories about multilayered inequalities and contestations. When low-income Nairobians lack the means to store, they are more vulnerable to water shortages, and the privileges of large-scale storage represent general socioeconomic inequalities in Nairobi (Gerlach 2008; Sarkar 2022). While socioeconomic factors are important, they do not tell the full story. Space and structural integrity of architectures define how and how much water can be stored – a 10 m^2 shack or an older building not designed for rooftop storage cannot hold a lot of stored water. The proximity and regularity of water supply is crucial as well households not connected to the grid but close to a reliable water point have less need to store than households on upper floors of apartment buildings with defective piped supply. Lastly, tenure status comes into play, and Nairobi has high rates of renting (KNBS 2018). While homeowners can adapt their water storage dispositif to their needs, most tenants have agency over small-scale, in-house storage only. Since alterations and expansions of domestic water storage can lead to contestations between households and property management, this may decrease solidarity and further detach people from each other (Bize 2017).

‘My stuff is just always charged’: Domestic electricity storage in Nairobi

To nuance and expand the notion of domestic storage as infrastructure in Nairobi, we turn to the city’s electro-infrastructural configuration. Kenya’s 2019 *Energy Act* mandates the government to ‘ensure all households are electrified’ (EED Advisory 2020: 20). The electrification of the country lies largely in the hands of the Kenya Power and Lighting Company (KPLC), or for short Kenya Power, the country’s only large-scale electricity distributor, operating a national grid and some off-grid infrastructures. As the only offtaker in Kenya, the utility sources its electricity largely from the Kenya Electricity Generating Company (KenGen), and some smaller suppliers. Kenya’s landscape of providers is currently diversifying, as are its modes of electricity generation (e.g. the expansion of solar and wind power), but the country’s networked power supply has been, and will likely remain, dominated by hydropower, geothermal and fuel-based power plants (key informant interviews; EED Advisory 2020; USAID 2016). Domestic consumers in Nairobi, however, have little to no direct relations with KenGen and the different modes of power generation. When it comes to individual connections, service provision, metering and billing, households are solely in contact with KPLC.

Figure 20: Artefacts of electricity storage in Eastleigh, Buru Buru and Ongata Rongai (from left to right); photos by author (2021/22).

Unlike the water deficit in Nairobi, 'Kenya does not suffer from shortfalls in available [electricity] generation' (Taneja 2018: 5). A key issue, however, has been the lack of connections. The 2010s have seen a steep increase in connectivity rates with a reported 70 % of the country's population connected to the grid in 2017 (Smith S 2019; Taneja 2018). For Nairobi, more than 90 % of the population uses electricity as their main source of lighting (KNBS 2018). According to Njoroge et al. (2020); this number mirrors connection rates in the informalized settlement of Mathare, yet half of the selfreported connections in their study were unofficial, meaning without a KPLC meter. While upper- and middle-income Nairobi experiences a near to universal access to electricity, residents of informalized settlements might still not be connected or resort to informally provided or shared access modes due to lacking infrastructure, high connection fees, and sabotage (observations; resident interviews; key informant interviews; Karekezi et al. 2008). Nevertheless, compared with Nairobi's water configuration, and considering network connectivity only, the electro-infrastructural geography of the city is not as uneven, and at first glance individual electricity dispositifs appear to be less heterogeneous.

In the form of localised and large-scale blackouts as well as planned and unplanned interruptions, Nairobi experiences 90,000 power outages every year (Taneja 2018). KPLC explains these outages by natural causes, sabotage and vandalism (key informant interview with KPLC) but failing equipment and accusations of mishandling and corruption by KPLC have been mentioned as well (Ombati 2022; Taneja 2017). Faced with a constant risk of outages, caused by an assemblage of human and material failures, Nairobians across the city are constantly working towards electricity security. On the one hand, backup generators are prevalent in affluent areas (observations; Taneja 2018). On the other, even those with generators – but particularly those without – are partially substituting interrupted supply by storing electricity. When roaming the streets and buildings of Nairobi, one can spot people charging devices at work or in public places to reduce costs or due to missing or cut-off connections at home. The domestic space is, however, the site where most of the charging the *storing* of electricity – is performed (observations; resident interviews). As one respondent in Ruaka explains:

> 'It's not really a conscious thing that I do, but I never want to be in a situation when the lights go out at home and my phone is at 4 %, and my laptop at 12 % ... my stuff is just always charged.'

With a large proliferation of smart phone ownership in Kenya, and considering Nairobi's digitalisation (Guma 2021; Silver L and Johnson 2018), charging phones, laptops and other smart devices has become a routine habit. For those with the financial capacity and the need, or desire, to be connected as much as possible, small power banks require additional attention, so that devices can be charged when the lights go out. For a long time, so-called *uninterruptible power supply* (UPS) batteries – backup systems installed between a socket and an electric device, for example desktop computers – were used in offices and other commercial spaces but adaptations of this technology have made it to households. In affluent areas, as an alternative to generators, households might use inverters connected to in-home battery systems:

> 'When Kenya Power is working, then it charges the batteries, and then when the power goes out, it automatically switches . So, we have the light and the refrigerator, and a couple of outlets for charging devices.' (resident interview in Rosslyn).

Individual dispositifs of electricity storage vary significantly, and households with more financial means are able to invest more and, thus, store more. While socioeconomic inequalities in Nairobi permeate into the electric *storage city*, lights that are chargeable via cables or internal solar panels have spread across all strata (‣ Figure 20). Starting from small torches to nightstand lamps to bright outdoor lighting, lamps with in-built batteries are prevalent artefacts in many households (observations; resident interviews).

What all alterations of domestic electricity storage have in common is that they do not mimic continuous, full-power supply but provide a base level for electric necessities (e.g. light) and a temporally limited *fix* until regular, networked supply is restored. With some exceptions, however, electric storage artefacts in Nairobi are yet again 'intermediary infrastructures' (Millington 2018) in between households and a networked system. As urban life increasingly depends on electronic, digital communication and work, the artefacts used and the daily routines of charging – automatically or deliberately – have become important to the electro-infrastructural functioning of Nairobi as of today. Yet, batteries play also an increasingly crucial role in (urban) energy transitions in Kenya and elsewhere. With a global push towards renewables, e-mobility and smart technologies, electricity storage technologies are poised to become even more prevalent in the large and small infrastructures of nations, cities and households (cf. Gold and Foldy 2021; Ngugi and Munda 2021; Republic of Kenya 2019; Xylia et al. 2019).

While an in-depth exploration of battery-supported electricity generation by households in Nairobi is beyond the scope of this paper, we want to highlight that the city and its surroundings have experienced a surge in small-scale domestic solar-power, with which homeowners move away from the networked city. Scope and technicalities vary but solar-power systems are often linked to in-house battery systems (‣ Figure 19) similar to water tanks for boreholes – and households usually keep the pre-existing connections to KPLC – either with solar as the backup or vice versa (resident interviews; key informant interviews; cf. EnDev and SNV 2021). Should this trend continue, we are likely to see an increase in domestic storage capacities. Through non-generative uses and minor storage, Nairobi's electric *storage city* is already entangled with networked supply. Through a further 'splintering from below' (Kooy and Bakker 2008), triggered by individual power generation, the artefacts of domestic electricity storage and daily practices of plugging cables, turning switches and monitoring charging levels are now becoming an increasingly important part of the everyday infrastructuring of some Nairobians beyond the network. No matter if in relation to a networked city or its post-networked counterparts, the *storage city* of Nairobi with its heterogeneous, individual dispositifs is already here and likely to grow.

4.3. **Storage as infrastructure:** Key points, implications, and open venues

Our situated exploration of domestic storage needs to be read and understood within multiple transformations that are currently reshaping Nairobi, such as the increased volatility of water supply due to anthropogenic climate change, ongoing energy transitions, the increasing application of smart technologies and rapid urbanisation (EnDev and SNV 2021; Guma 2021; Myers 2015; WASREB 2018). These processes are reconfiguring Nairobi's 'infrastructure space' (Easterling 2016) and residential spaces as well as the conditions of and relations between the networked, post-networked, and *storage city*. As we have shown, however, domestic storage is already shaping residential architectures, urban spaces and everyday practices, all while it is simultaneously being shaped by place-specific infrastructural supply configurations, available materials, intended uses for stored resources, and individual situations (space, finances, architectures, need and desire to store, tenure status, etc.). Despite the diversity of storage artefacts and practices, it is evident that many Nairobians are constantly infrastructuring the availability of water and electricity by investing in, caring for and using various containers. Looking at all those activities that are hardly subject to formal rules and regulations, Nairobi is not simply a splintering or fragmented networked or post-networked city but, simultaneously or even more so, a city unified in its everyday task to contain resources that are usually flowing or otherwise moving through 'pipes, cables, wires and tracks.'

All the above considered, it becomes evident that storage of water and electricity and potentially of other resources – is an elemental part of urban life and infrastructural functioning. The deployed artefacts and performed practices form an 'intermediary infrastructure' (Millington 2018) through which urban households either mimic the idealised, universal supply of the networked city, or find temporal *fixes*, or even enable a post-networked city. The domestic storage of water and electricity thus works as a *buffer* – in-between users and systems but also as an enabling *buffer* for the actual functioning of networked and non-networked systems and individual supply situations which ultimately makes urban life possible in Nairobi. This enabling, imperative role of domestic storage for urban-infrastructural functioning elevates it beyond the status of an appliance or tool. According to Shove (2016: 246), appliances inhabit a mediating role between infrastructures and people, and constitute 'the sensitive tips of infrastructures,' but – although they might affect supply and demand patterns – they are not imperative to urban-infrastructural functioning *per se*. Further, seeing storage containers in Nairobi as 'ordinary tools' that only help to perform 'infrastructural work' would negate the 'proliferation of infrastructure' into domestic spaces and everyday practices, as laid out by Meehan (2014) for water barrels and buckets in Tijuana. Artefacts and practices of storage are arguably located somewhere between systems and household, between our traditional understandings of infrastructure and of appliances or tools. Based on our investigation, we argue however that – at least for the case of water and electricity in Nairobi – domestic storage is more than appliances or connecting tips or stopgap-tools. Storage is infrastructure, and not just as a backup for acute shortages, interruptions or other crises but as an everyday 'point of contact' (Millington 2018) between households and various supply systems that all depend on it.

The constant and literal visibility of storage in Nairobi – juxtaposed with its relative invisibility in planning, policies and academia – is everything but a symptom of infrastructural failure. Indeed, it is an important part of infrastructuring contemporary cities. Storage 'becomes a highly visible and charged element of the socio-material apparatus of household infrastructure' (Bize 2017: 1) that also shows how inequalities within HICs have diverse effects on different people. Individual water and electricity storage – in its quantities and qualities – depends on the supply dispositifs of households and their spatial, financial and architectural situations. Hence, individual storage is its own sociotechnical dispositif, constituted by various, often interconnected containers, other technological artefacts and human actors within and beyond the household. An urban-infrastructural condition with various individual dispositifs emerges from practices and artefacts that all demand space, alterations to architectures, a slot in daily routines, and other practices of charging, plumbing, pumping, filling, plugging, fetching, cleaning, etc. This urban-infrastructural condition – the *storage city* – does not replace or stand in conflict with the networked city or post-networked city but forms intertwined relationships. While the networked city and post-networked city stand for mutually exclusive yet potentially overlapping urbanisms that revolve around universal, sociotechnical networks or the lack thereof, the *storage city* is embedded in both, binds them together within households and their storage artefacts, and – ultimately – enables urban-infrastructural functioning across the networked/ post-networked spectrum.

Implications for a 'critical urbanism of the networked city' and city making

Graham and Marvin's (2001) postulated goal of a 'critical urbanism of the networked city' remains on the forefront of urban studies, especially because of expansions beyond the networked city notion. With universal network coverage becoming a 'crumbling objective' (Munro 2020) in many southern cities, we advocate for more academic engagements with infrastructural moments and spaces of storage, confinement, containment and similar phenomena or notions.

For domestic storage of water and electricity, many questions remain open and leave plenty of venues for further investigations, in Nairobi and elsewhere. The materialities and artefacts of storage warrant further research on how and why they are produced, designed, sold, appropriated, maintained, and disposed. In Nairobi, for example, local but internationally connected economies of storage-artefact retail are highly prevalent. The specific activities, the everyday practices of households in ensuring and caring for storage need further unravelling as much as (power) relations, negotiations, potential contestations within, between and beyond households around storage need to be untangled. Additionally, domestic storage stands in relation to other forms of infrastructural storage, for example water tanks of vendors or large reservoirs of utilities. How different scales of storage are connected or rely on each other is as unclear as the specific implications of domestic storage for cohesion, fragmentation and (re)distributions within cities. Lastly, domestic storage can and should be investigated for other resources than water and electricity, such as other forms of energy, digital data and files (e.g. on phones and laptops), or money. When expanding the notion of the *storage city* towards other resources, we should be aware of the entanglements of different systems of supply and storage (Castán Broto and Sudhira 2019). For example, water storage for multistorey residential buildings in Nairobi depends on electricity supply, as water needs to be pumped to rooftop tanks, and thus 'water is powered' (resident interview in Ruaka). Ultimately, for present and future cities especially but not only in the global south researching storage can provide new insights and recommendations for urban making through infrastructures. Recent provocations build on critical analyses of urban infrastructures in Africa to provide propositions to explicitly influence 'decision-making processes with a diversity of possibilities for action grounded on situated knowledges and practices' (Baptista and Cirolia 2022: 936; cf. Lawhon et al. 2023). Accordingly, the notion of the *storage city*, and further related research, may provide material for various disciplines of city-making – from design (e.g. of containers) and architecture to urban planning and governance – to reimagine and ultimately deploy place-specific infrastructural articulations beyond networks and flows.

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Figure 21: Rooftop with water tanks in Pipeline, in front of Nairobi's skyline; photo by author (2023).

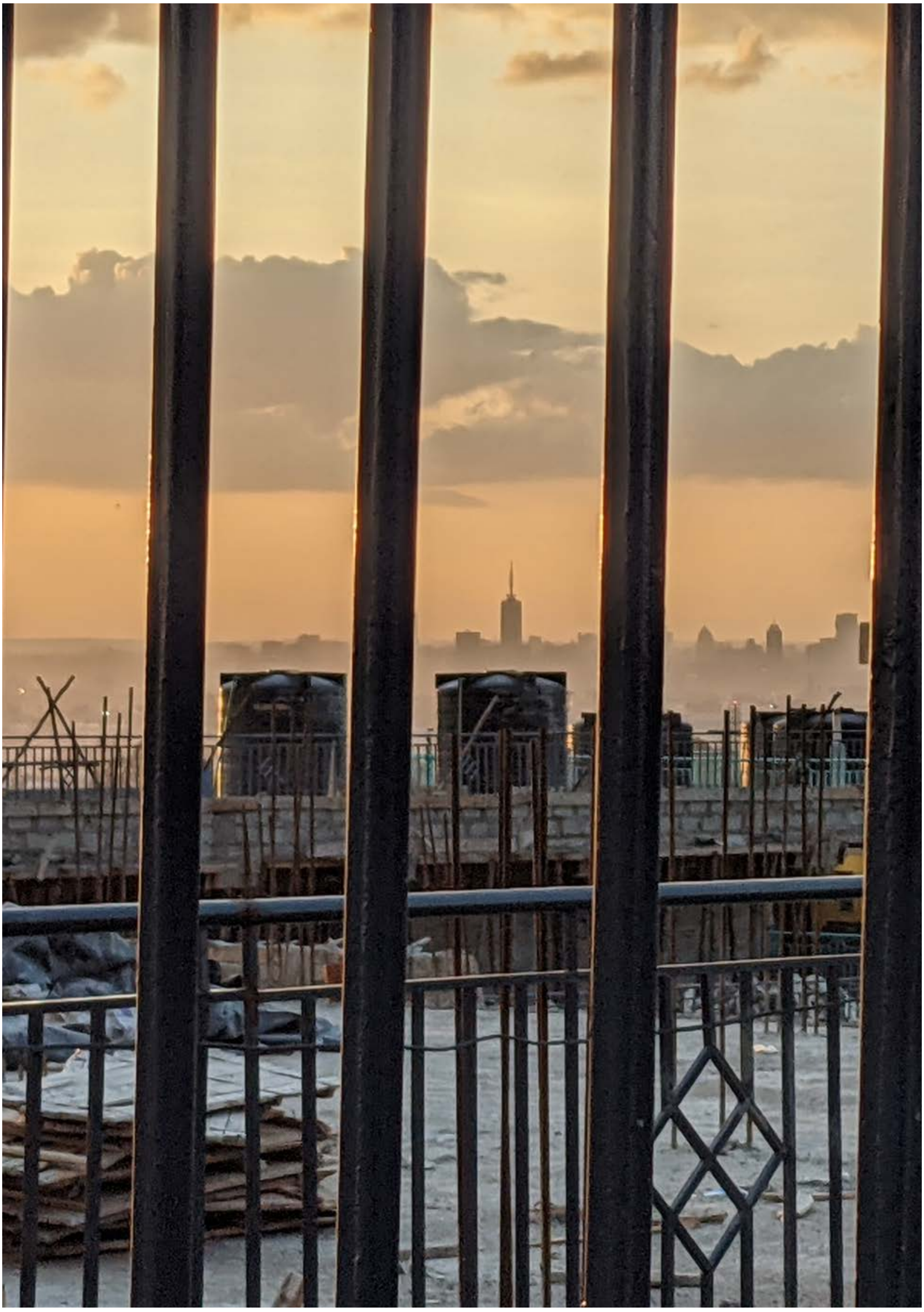

Figure 22 (above): Jerry cans on a handcart and next to it in Westlands; photo by author (2021).

Figure 23 (below): Jerry cans for sale in Zimmerman; photo by author (2024).

ABSTRACT At first glance, there is hardly anything more boring and mundane in the urban landscape of Nairobi than the plastic jerry can, or *mtungi* in Swahili (pl.: *mitungi*). An inconspicuous *thing* that is constantly used, re-used, and re-purposed but remains somewhat invisible in its ubiquity. Its most common and important function however is to contain, store, and hold water. Yet, given Nairobi's erratic and heterogeneous waterscape, mitungi do not just hold water for vendors and households. Rather, they hold the entire city together. Based on a longstanding connection to Nairobi as well as empirical research in 2021–2023, I present mitungi as more than just boring things or receptacles, but rather as incredibly multiple devices for engagements with African/southern urbanisms. Ultimately, my reflections argue for a joyful and unapologetic fascination with the supposedly mundane as an approach to engaging with contemporary cities, spaces, and infrastructures.

5. Mitungi as …

Thinking about urban space and infrastructure with the jerry can

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On a rainy day in 2018, in the backseat of an Uber. I am stuck in Nairobi's infamous rush hour. As cars and trucks fight for every inch of road space, people on foot zigzag between the cars. A young woman carries two bright yellow canisters filled to the brim with water across the street before disappearing behind one of the many roadside *hoteli* (restaurants).

'This whole city runs on containers,' I think to myself, making a small note on my phone. Years later, sparked by this tiny moment, my ongoing dissertation project examines mundane containers and everyday storage as infrastructural necessities in Nairobi (‣ Chapter 4), a city where – in the words of Wangui Kimari (2019: 150) – most of its citizens 'have been their own infrastructure for almost a century.'

In addition to the deployment of various practices, tools, labor, artefacts, networks, and various other human and non-human actors, being one's own infrastructure in contemporary Nairobi requires the use of myriad physical and virtual containers: large water tanks, batteries, cooking gas cylinders, cell phones, M-Pesa accounts.

In what follows, I focus however on *mitungi* (sg.: *mtungi*), the mostly bright yellow plastic canisters that plaster the city's urban landscape, its streets, backyards, balconies, kitchens (‣ Figures 22-29). In doing so, I present some of the uncountable stories and roles that the mtungi can be described by: as standard, as infrastructure, as a node, as a thing in time and space, and ultimately as an approach to urban research in general.

All of these elaborations argue for joyful explorations of the urban mundane that continue the quest of quotidian investigations into the 'Infrastructural South' (Silver J 2023). Postcolonial urban studies and the 'infrastructural turn' have been instrumental in revealing a plurality of urban-infrastructural configurations that are not failing but are rather always incomplete, not messy but rather heterogeneous, not just informal but rather incremental and pragmatic (e.g. Guma 2022; Jaglin 2016; Silver J 2014, 2023). The mtungi serves here as a point of reference to advance these discourses, but also to remind us of the inherent and persistent injustices that permeate the urban space and infrastructures of Nairobi and other southern cities.

5.1. **... standard**

In *swahili sanifu*, in proper Swahili, the term mtungi refers to a pot, usually made of clay (Ali n.a.). In Nairobi of today – among other connotations – mtungi is synonymous with the term jerry can, also called *debe* or otherwise in various vernaculars (Akallah and Hård 2020).

The jerry can, or jerrican, was originally a standardized 20-liter gasoline canister made of metal, usually steel, invented in 1930s Germany and heavily used by the *Wehrmacht* (Simonsen 2010). During and after World War II, the jerry can – getting its name from an Anglophone slang of referring to Germans as *jerrys* – conquered the world as it was adopted and popularized by British and American armed forces (RCLSA 2016). In its military beginnings, the jerry can was designed

Figure 24: Two jerry cans at a newly erected borehole in Silanga, Kibera; photo by author (2021).

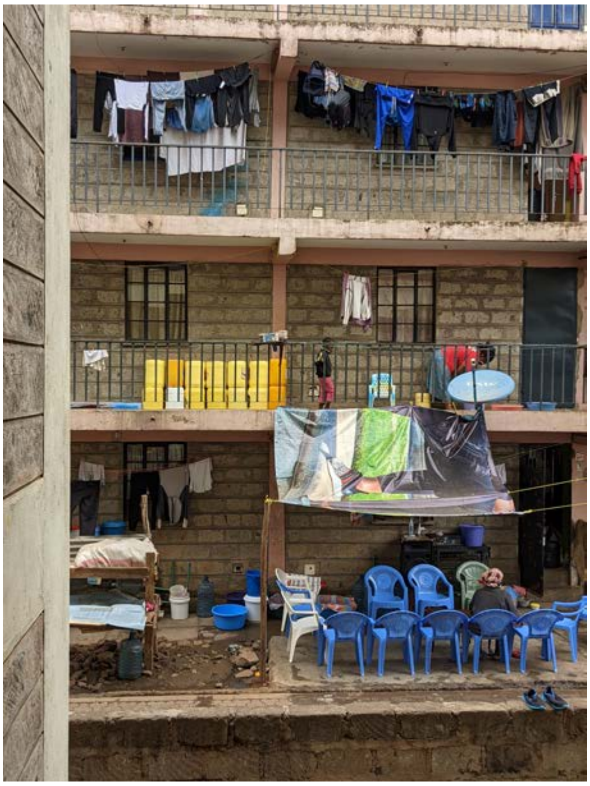

Figure 25 (left): Jerry cans in a kitchen in Canaan Estate, Kibera; photo by author (2021).

Figure 26 (right): Jerry cans on a balcony in Canaan Estate, Kibera; photo by author (2021).

specifically to be a boxy, uniform, and easy-to-manufacture artefact with a handle that allowed for easy transport and storage of liquids (Simonsen 2010).

In the second half of the twentieth century, the jerry can evolved beyond its metallic and militaristic origins and reached even the most rural areas of the so-called global south. There, and probably in many other geographies, the plastic jerry can become *the* storage and transport artefact for domestic water use, and it subsequently improved water access as much as it impacted gendered water practices (Sutton 2000).

'We call them *Kuffour gallons*,' said a friend from Accra, further explaining that, during the presidency of John Agyekum Kuffour in the 2000s, water shortages became so prevalent that the increased necessity to store water in plastic jerry cans led Ghanaians to name them after their president (cf. Alba et al. 2022).

Different places have different names, styles, stories, and place-specific usages, but my own travels and many accounts of colleagues confirm the ubiquity and prevalence of jerry cans as a quotidian container of water and other liquids across many geographies, especially but not only in southern cities. In the often-heterogeneous and often-fragmented infrastructural configurations of these cities, you can find the jerry can across different spaces, geographies, and strata.

Unsurprisingly, jerry cans – or specifically, mitungi – are an incredibly common artefact in public and private, commercial and domestic spaces across Nairobi also. Many differ from the classic boxy design but are round and bulky repurposed cooking oil canisters. Some still hold cooking oil; others hold gasoline or *muratina* (alcoholic beverage). Yet, the vast majority of Nairobi's mitungi – boxy or bulky – are used for water. To fetch it, to store it, to hold it.

Mitungi exist in various sizes and volumes in Nairobi, but the 20-liter one is the norm. A unit and receptacle upon which many household activities and local economies depend on. Prices by water vendors, for example, are usually calculated in mtungi. Two to five Kenyan Shilling for a self-fetched mtungi. Twenty or more for a delivered one. Ultimately, and quoting the work of Amiel Bize (2020: 478) on the East African fuel economy, the importance and function of mitungi 'inhere in their standardization as much as in their ability to contain liquid.' A metric by itself.

Similar to the shipping container becoming a symbol of standardized and globalized trade in the twentieth century (Levinson 2016), the jerry can has quietly evolved outside its Western origins into a ubiquitous but inconspicuous standard *from below*, from the South, from and for many local economies, domestic activities, and infrastructural articulations.

5.2. **... infrastructure**

Late 2021, more than a year after the outbreak of the global Covid-19 pandemic. Together with colleagues from Germany and Kenya, I am visiting a borehole in the informalized settlement of Kibera (‣ Figure 24). Erected by the Nairobi Metropolitan Services as an impromptu COVID relief intervention, the borehole is providing free water to some in the *kijiji* (village) of Silanga. Next to it, countless women and children are queuing to fill their countless mitungi with water.

'At the beginning everyone, the entire world, was like washing hands. Wash it, wash it,' I am told there, reminding me of our initial fixation on and glorification of waterbased hygiene practices as a means of containing the spread of SARS-CoV-2.

Also, throughout the city, the pandemic's hardship and a sense of heightened uncertainty – a sudden crisis on top of several other protracted crises – brought water availability into the spotlight (Schramm et al. 2023). Yet, water availability in Nairobi – as in many to most urban areas around

Figure 27: Vendor handcart with jerry cans in Pipeline, Embakasi; photo by author (2023).

the world – is not just about turning on a faucet. Rather, it is fetching, ordering, negotiating, paying, carrying, storing, borrowing, and many other water practices (Alda-Vidal et al. 2018; ‣ Chapter 4). In all of this, the mtungi reigns supreme. Most of this would not be possible without the mtungi. While – and I am paraphrasing Prince Guma (2022) here – infrastructure in many southern cities is incomplete rather than broken, the mtungi is yet constantly trying its best to complete it, to 'suture' it (de Boeck and Baloji 2016). A Sisyphean task, an always-incomplete endeavor by itself.

In Nairobi, you can get water from metered taps or unofficial standpipes. From the utility, or largely unregulated water providers. From a gravity-fed network, from a borehole, from opaque sources. However, 24/7 water supply with a centralized and equitable system is currently a pipedream since Nairobi's utility can only cover two-thirds of the daily demand. Moreover, this inadequate supply disproportionately affects poorer households and informalized areas, which often depend on sources besides and beyond the network (Mutono et al. 2022; Schramm et al. 2023). What all the various modalities of water access have in common however is the broken promise of *modern* infrastructure to provide consistently, universally, and directly.

In the everyday moments and spaces of broken promises – of spatial or temporal hydraulic disconnection – the mtungi fills the gaps. The gap between a water kiosk and your home. Between a mobile water vendor's source and his customers. Between the time water came through the pipes last week and the next scheduled water time. Between neighbors when they borrow water from each other.

With its in-between-ness, with its ambiguous role as a transport and storage artefact, the mtungi becomes part of a wider hydro-infrastructural configuration and, by itself, *de facto* infrastructure (‣ Chapter 4). Given the erratic and heterogeneous configuration of the city's water supply with its various inequalities and insufficiencies (Kimari 2019; Wamuchiru 2017), mitungi not only carry and hold water for households. They hold the entire city together

They hold Nairobi together by suturing and stabilizing its sociotechnically amalgamated waterscape. By being a metric that is universal, adaptable, and reliable. By entangling a variety of material and immaterial urban flows that connect people, economies, and geographies beyond the city. By providing an aesthetic, or rather poetic, of infrastructure (Larkin 2013) that transcends socioeconomic and other categories in a city so often portrayed as fragmented and segregated.

5.3. **... node**

On a rather dry day in March 2022, the sun is beating down as my friend BM and I stroll through Kariokor, just east of Nairobi's central business district. The streets are lined with small plastic tanks and barrels, so-called *super drums*, buckets, emptied milk containers, and mitungi (‣ Figure 28). So many mitungi.

Mitungi are sold all over the city. In small shops, stalls, kiosks. But Kariokor is *the* epicenter of the local to regional mitungi business.

Just as BM is kindly translating between me and an elderly mitungi saleswoman, a *boda boda* driver (motorcycle courier) stops abruptly next to us. Strapped to the small machine are a comically large number of empty plastic cooking oil canisters.

'He collects them from restaurants in town and sells them to me. We wash them and prepare them before selling them again,' the elderly vendor explains later in Kikuyu.

Figure 28: Jerry cans for sale at Kariokor market; photo by author (2022).

Many others in Kariokor are involved in this economy of plastic water storage containers. There are brand-new, boxy mitungi made in Nairobi's industrial area from polyethylene imported from Asia, molded by local companies such as General Plastics or Nairobi Plastics. There are many repurposed canisters from restaurants, other businesses, and households. There are trucks loaded with empty mitungi that are transported and sold all over Kenya. 'All the way to Turkana,' one of the vendors claims, referring to Kenya's most northern and peripheral county. There are retailers, *boda boda* drivers, *fundi*, truckers, wholesalers, and regular customers. There is cooking oil residue, there is water splashing, there is money changing hands, there is plastic welding. A cacophony of human and non-human actors, practices, materialities, and resources.

Eventually, many of the mitungi at Kariokor will end up in homes all over Nairobi, where they will be filled with water, emptied, filled again, stacked, cleaned, filled again, and so on. Until they fall apart. They will be used to fetch and store water from the network or a nonnetworked source. They will change hands. They will connect water sources to water uses.

This mundane, ubiquitous artefact – this incredibly 'boring thing,' to evoke Susan Leigh Star's (1999) infrastructural vocabulary – is a tiny but crucial and interstitial node that entangles, within itself and through the practices it necessitates, a world of relations, infrastructures, flows.

Together with its bigger siblings the super drum and the water tank, the mtungi is 'where' networked and non- or post-networked infrastructures meet since everyone in Nairobi relies on them (▸ Chapter 4). It is 'where' local to global flows of polyethylene, water, cooking oil, and money meet. It is 'where' the rhythms and practices of infrastructural everyday life in an African city make visible larger spatialities and temporalities such as hydrological flows, colonial planning legacies, climate change and its daunting impact on water availabilities.

As much as the mtungi holds Nairobi together, it also connects it to a larger world that unfolds within it. Within but also beyond the 20 litres of its plastically enclosed Euclidean space.

5.4. **... a thing in time and space**

It is late 2023 as I am presenting drafts of this text at a conference, a workshop, in front of colleagues. There, and throughout my academic path, I have been surrounded by relational understandings of socially constructed space, or spaces. Lefebvre (1991), Castells (1999), Massey (2005), Löw (2008), etc. Conversely, the mtungi is a blatant reminder of good old physical, Euclidean container or vector space: x, y, z. A somewhat standardized volume that holds space, occupies space, and organizes space.

Yet, the mtungi is much more than that. It is a thing that – among many possibilities – allows me to think about an ever-expanding pluriverse of spatialities, spatial figures, and topologies. I am reminded, for example, of Annemarie Mol and John Law's (1994) notion of 'fluid space,' which suggests thinking about spaces, networks and objects in less stable ways but rather with blurred boundaries. I am thus wondering 'where' the mtungi begins and ends, what constitutes the mtungi. Is the mtungi as fluid as the fluids it so often contains? Fundamentally, mitungi share much with the *fluid* Zimbabwean bush pump as 'an object that isn't too rigorously bounded, that doesn't impose itself but tries to serve, that is adaptable, flexible and responsive' (de Laet and Mol 2000: 226).

With its fluidity and multiplicity, the mtungi also provides a stage for the entanglement, conflict, and discussion of various spatial figures, such as territorial space, network space, trajectorial space, and place. Those figures constitute the topological catalogue of the ongoing re-figuration of socio-spatial order(s) – from the everyday to the geopolitical – as described by sociologists Martina Löw and Hubert Knoblauch (2023). Respectively, the mtungi provides an entry point to some of such figures: network spaces of regional water flows and material networks of polyethylene; territories like the demarcated one of Nairobi's water utility or the fuzzy ones of private water vendors; places such as the home or household, or Kariokor as *the* market for water storage items. Finally, the mtungi reveals tensions and relations between these figures. For example, the idealized yet promise-breaking water network is dependent yet simultaneously undermined by water storage at very distinct domestic places. So much so, that the prevalence of mitungi at balconies is used by potential tenants in Nairobi to identify water supply issues before renting (Ashioya 2022). The mtungi thus tells us about a re-figuration of urban infrastructures and the changing locus of infrastructural responsibilities from the territories and networks of the state and its proxies towards the places and networks of households, property owners, and the private sector.

Independent from specific spatial figures and spatial theory, the mtungi may further expand our view beyond both, physical and socially constructed space towards a fourth dimension. In regards to the currently unfolding 'temporal/temporary turn' in spatial disciplines (Chang 2021; Temenos and Lauermann 2020), the mtungi provides again an entry point for the exploration and discussion of countless temporalities and rhythmicities. From grand histories and natural processes such as the longue durée of hydraulic infrastructures with their (deliberate) shortcomings in (post-) colonial cities or the alteration of hydrological flows through anthropogenic climate change (Kimari 2019;

Wamucii et al. 2021), both providing the volatile conditions in which the mtungi thrives. To specific moments in time or 'infrastructural events' (Carse 2017), such as a global pandemic, that highlight the importance of individual water storage and mitungi (Wamuchiru et al. 2022). To seasonal rhythms of water availability or the circadian rhythms of everyday water practices (Kasper 2022) that depend on jerry cans. The mtungi speaks to and about all those temporalities.

Spatially fluid and multi-temporal, the mtungi offers a multiplicity of spatialities and temporalities for researchers and city dwellers to tap into. Through the mtungi, issues of urban-infrastructural inequalities become visible, not only and always for informalized or otherwise marginalized places, but throughout the city, throughout various locales and times.

5.5. **... approach**

The jerry can – this 'humble technology' (Rijke-Epstein 2021) – provides a very material, blatantly mundane entry point for diverse yet place-specific investigations into the urban and its infrastructures.

As my always-incomplete elaborations have pointed at, the case of the Nairobian mtungi shows the not-so-humble pluriverse of largely unexplored conditions, phenomena, time-spaces, space-times, and sociotechnical intricacies of urban Africa (and elsewhere) that the mtungi still holds.

More so, trying to understand contemporary cities and spaces in Africa and elsewhere with a fascination of the supposedly mundane, the supposedly boring, is an approach that mitungi have given me, or rather hold for me.

They have allowed me to sharpen my perspective and approach to the study of urban space and infrastructure towards the quotidian without ignoring other scales. They help to examine broader landscapes and their ongoing re-figuration, for example for place-specific waterscapes, changing hydro-social relations, and larger value chains of plastics. They help to think critically about the locus of infrastructural responsibility. They tell stories about spatial figures, and how they may conflict in the domestic realm and in street markets. They can tie together different discourses and perspectives: postcolonial urban studies with its interest in the ordinary (e.g. Beier 2023); new-materialism-inspired research about mundane artefacts or *things* of cities (e.g. Beauregard 2015); STS-influenced infrastructure studies and their fascination with the sociotechnical (e.g. Munro 2020); the metabolisms of urban political ecology (e.g. Keil 2005); and the growing body of literature on storage and its geographies (Randle 2024a).

Standing on the shoulders of decades of debates on postcolonial, sociotechnical, and urban-metabolic readings of cities and infrastructures in Africa, the mtungi – and thus many other *boring things* that are invisibly ubiquitous – can provide a fresh entry point into the intricacies of quotidian infrastructuring, assembling, and worlding of cities from below (Alda-Vidal et al. 2018; McCann et al. 2013; Simone 2001). At the same time – through its materialities, histories, and applications – it is holding questions of localized and globalized injustices. By embracing this, we can discuss place-specific expressions and the usefulness of rather classical descriptors – such as informality, scarcity, and fragmentation. Even more so, the fluidity and universality of the mtungi helps to identify and discuss multi-faceted articulations of the urban and its infrastructures that so often elude orthodox, myopic readings of southern urbanism.

Ultimately, the mtungi is not only an object of investigation, a container, a standard, an infrastructure, and a node. Rather, in all its ordinariness and simplicity, it represents a heavily grounded approach and deliberate position for joyful explorations of the urban. This is not so much about the jerry can itself but rather a plea for more research, more fascination with anything allegedly boring and banal; material or not.

Also, and especially, as urban scholars, we tend to overlook easily what is in front of us. What is ubiquitous. What is invisibly visible. What is actually ordinary. And what larger narratives unfold from there.

Engaging with all this may initially be a largely descriptive, analytical, and academic task. Yet spatial practices in their various disciplinary forms can draw on it to understand and reimagine the city. To redesign it. To plan it through and with the mtungi, the battery, the *mkokoteni* (handcart), the donkey, the super drum, the metal detector, the *monobloc* chair, the lightbulb, the soda crate – to name but a few examples from Nairobi.

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DATA AVAILABILITY STATEMENT Due to the nature of the research, supporting qualitative data is not publicly available to protect the privacy of interlocutors.

Figure 29: Backyard with dog and jerry cans in Eastleigh; photo by author (2022).

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Figure 30 (above): Parts of Kilimani during an early evening power outage; photo by author (2022).

Figure 31 (below): Rechargeable lighting devices in a household in Ongata Rongai; photo by author (2022).

ABSTRACT Renewable energy transitions, technological advances, and geopolitical disruptions have brought various forms of energy storage to the forefront of sustainability and infrastructure debates. Conversely, the sociotechnical intricacies of everyday electricity storage by urban residents have received less attention in these discussions, although batteries have become an essential part of everyday life, especially in cities with heterogeneous infrastructure landscapes. In Nairobi, for example, batteries have become quotidian artefacts that form the basis of broader battery landscapes composed of different batteries and their materialities, idiosyncratic household electricity *dispositifs*, a broader landscape of private and public actors, and (lack of) regulation and governance. By proposing and using the notion of the *batteryscape* for these arrangements, this paper elaborates on the infrastructural significance of everyday household electricity storage for sustainable and just energy infrastructures. More specifically, it addresses issues of energy justice – largely, but not only, in terms of distributive injustices – and the heterogenization of individual as well as citywide electricity arrangements. Reflecting on limited state regulation and governance of domestic battery use and disposal in Nairobi, a nuanced reading of ongoing, battery-enabled energy transitions with their micro-materialities and everyday practices in African cities is called for in order to make pragmatic proposals for sustainability transitions, urban infrastructure planning, and the governance of both.

6. Nairobi's *batteryscape*

Everyday electricity storage, energy justice, and infrastructural heterogeneity in urban Africa

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6.1. **Introduction:** Cities full of batteries

Energy transitions, technological advances, and geopolitical ruptures have brought energy storage to the forefront of political and academic debate: LNG terminals, hydrogen storage, pumped hydro, etc. As with other technologies, the specific case of electrochemical energy storage – i.e. electricity storage with batteries – is currently dominated by techno-managerial disciplines and discourses of the global North and East on green transitions, e-mobility and smart cities. Batteries undoubtedly play 'an increasingly central role in climate and energy futurities' (White-Nockleby 2022), and 'it is likely that the lithium-ion battery … will do the heavy lifting in a clean energy transition' (Turner 2022). Other types of batteries – such as lead-acid or alkaline – still have important applications, but technological advances and the 'new lithium economy' (Fletcher 2011) have catapulted the wide range of lithium-ion batteries (LIBs) to the forefront of electrochemical energy storage. However, batteries have been an integral part of energy landscapes for more than a century, playing 'a little-appreciated yet pivotal role in enabling the systems of transportation, communication, and electrification that reshaped the modern world' (Turner 2022). Since 'the advent of cell phones and portable electronics' in the 1990s (Kubrak 2022), batteries – especially but not only LIBs – have become an everyday part of sociotechnical life everywhere, and electricity storage is carried out with multiple artefacts and practices; especially in cities with more heterogeneous and/or erratic energy landscapes, i.e. much of urban Africa.

While LIBs have garnered significant attention in the modern electricity storage discourse, they coexist with other battery technologies due to different applications and performance characteristics. Often, lead-acid batteries remain dominant in applications that require reliable, cost-effective power, such as motor vehicles, ATMs, and critical facilities such as hospitals (Turner 2022). In contrast, LIBs are used where lighter weight and higher energy density are priorities, but – as my findings show – they are also increasingly used for so-called static, non-mobile storage. This coexistence reflects a broader trend of diversifying storage and battery types to meet different needs (Sun et al. 2020). Instead of a replacement of 'old' battery technology, we are witnessing a heterogenization of battery applications and typologies and thus of our energy landscapes. However, electricity storage is still a relatively open arena for sustainability research and for urban infrastructure planning and governance, just as the limited field of battery studies has largely focused on so-called 'developed' countries (Best 2023). For many geographies and fields, 'batteries are a black box' (Turner 2022).

In order to shed more light into the 'black box' of battery use and its significance for the governance of heterogeneous infrastructure configurations, or HICs (Lawhon et al. 2017), I ground my following investigation in the domestic realm of Kenya's capital, Nairobi, with approximately 5 million inhabitants in more than 1.5 million households (KNBS 2019). Like many urban spaces, Nairobi has become a city full of batteries, found in homes, offices, ATMs, cars, pants pockets, handbags, and – increasingly – on dumpsites. But Nairobi is also a unique case, given several developments, such as a huge increase in electrification across Kenya but the persistence of power cuts; a proliferation of digital work and finance; the rise of individual solar systems and independent power providers (IPPs); and a push toward e-mobility. All of these developments, as I show, are linked to a massive increase in battery imports (i.e. doubling between 2018 and 2022; ▸ Figure 33), the increasing everyday use of batteries to secure one‘s electricity supply, and ultimately the heterogenization of Nairobi‘s energy landscape.

Given the pre-existing inequalities in energy access and reliability in Nairobi (de Bercegol and Monstadt 2018; Ferrall et al. 2022), and considering how new technologies tend to ‘reproduce geographies of energy inequality’ in southern cities (Munro and Samarakoon 2023), I examine how the benefits and burdens of increased battery use and reliance in Nairobi are distributed equitably among its residents, or whether they simply reproduce or even exacerbate ‘infrastructural injustices’ (Silver J 2021; Ziipao 2020). Using individual households and their energy *dispositifs* as a point of inquiry, I discuss their relationship to a broader political economy and discourses of energy transitions. By proposing the notion of the *batteryscape* – that is, a place-specific assemblage of different batteries and their materialities, idiosyncratic energy dispositifs, involvement of private and public actors, and regulation and governance – this paper provides a critical account of everyday household electricity storage in Nairobi. Ultimately, I show how domestic electricity storage affects the heterogeneity of a situated energy landscape and its energy (in)justices, and discuss how all of this is currently or could be governed in a sustainable way.

6.2. **Conceptualizing the batteryscape:** Heterogeneous infrastructures and energy justice

Often located in the infrastructural interstices between individual households and larger systems, many batteries have become more than just the ‘sensitive fingertips of existing infrastructures’ or parts of appliances (Shove 2016). In their significance for individual and planetary energy futurities and for electric presents, they have are an ‘increasingly important part of the everyday infrastructuring’ and of urban-infrastructural arrangements (▸ Chapter 4). In particular, batteries *firm* the transition to ‘unruly, intermittent, and unpredictable’ renewables at the grid scale (White-Nockleby 2022). They *enable* rural electrification, as well as the installation of micro-grids (Nsengimana et al. 2022; Pedersen and Nygaard 2018). Batteries are being conceptualized and used as *backups*, or rather *buffers*, for households in unreliable electricity landscapes, because they provide a temporary *fix* to interruptions – e.g. as an alternative to generators – or because they *enable* the use of multiple electricity sources (Rateau and Jaglin 2022; ‣ Chapter 4). Finally, they are increasingly part of individual solar photovoltaic (PV) systems around the world (Fett et al. 2021; Ransan-Cooper et al. 2020). With their multiple uses and capabilities (*firming*, *enabling*, *buffering*, *fixing*) at different scales – from the grid to the home to electric vehicles to mobile phones – batteries promote the heterogenization of energy landscapes by allowing users to tap different sources (e.g. grid and PV) at different times and places.

Heterogeneous energy landscapes – that is, place-specific energy configurations defined by a 'diversity of actors and socio-technical plurality' rather than a monolithic, centralized system or grid (Verdeil and Jaglin 2023) – are characteristic of many African cities. In these cities, residents often use and combine multiple energy and/or electricity sources and related devices – from power banks to cookstoves to grid connections – with 'a great diversity of socio-technical *dispositifs* and spatial features of households' practices' (ibid.). Infrastructural heterogeneity has received scholarly attention in recent years, as it may allow for a rethinking of how post-networked or southern infrastructures are planned and governed, and these debates have emerged specifically from empirical engagements with African cities (Lawhon et al. 2023; Verdeil and Jaglin 2023), which are often characterized by persistent 'infrastructural injustices,' meaning the inequitable distribution of access, reliability, benefits, and burdens of different basic services and across different geographies and socioeconomic strata (Silver J 2021; Ziipao 2020); as is the case with Nairobi's energy landscape.

At the same time, the field of energy justice scholarship, rooted in debates about environmental and climate justice, has emerged to provide a holistic and multi-scalar approach to the study of situated energy landscapes (van Uffelen et al. 2024; Yang et al. 2023). Often deliberately departing from Rawlsian or other Western conceptions of justice (Tornel 2023), energy justice as a conceptual and analytical tool revolves around questions of 'who gets what, and the processes and procedures that govern how we decide the principles of that distribution' (Sovacool and Dworkin 2015). Concerned with the entire energy value chain of 'resource extraction, production, transmission, distribution, consumption, and waste disposal' (Tornel 2023), energy and environmental justice encompasses multiple scales, from the planetary to the body (Canelas and Carvalho 2023; Walker 2009). Because of this diversity and multiplicity, energy justice is often defined rather loosely and inconsistently, but as a scholarly approach, it typically focuses on the costs/externalities, benefits, and processes of energy projects and infrastructures (Sovacool and Dworkin 2015; van Uffelen 2022). For heterogeneous urban energy landscapes, this means also examining the myriad, often mundane, infrastructural technologies and practices at the household level, such as battery use, and how they may promote or jeopardize the equitable and just distribution of energy benefits and burdens.

Merging the notion of infrastructural heterogeneity with an energy justice lens to explore the potential impact of batteries on Nairobi‘s unjust energy landscape, I propose the notion of the *batteryscape*. To spatialize issues of energy (in)justice, scholars have used the notion of (urban) energy landscapes, which reflects ‘the specificity of urban energy systems and the heterogeneous spatial arrangements that emerge within particular places’ (Castán Broto 2019). This can include major infrastructures and governance arrangements, but of course all kinds of batteries as well. Given the specificities of batteries, their ubiquity, and their centrality to ongoing transformations, it is necessary to specifically examine situated battery landscapes – *batteryscapes* – with their heterogeneous arrangements. Therefore, rooted in the notion of the energy landscape, I define the batteryscape broadly and openly as a situated assemblage of myriad and diverse batteries and their materialities, household dispositifs with their idiosyncratic electricity storage practices and devices, and the broader ecology and political economy of actors in the electricity and battery sectors, as well as state actors and their policies and regulations.

Ultimately, the batteryscape represents a spatially, conceptually, and materially specific convergence of the broader energy landscape with the ‘storage city’ (‣ Chapter 4), the latter being the landscape of domestic storage artefacts and practices that include not only energy but also water, food, data, etc. The batteryscape thus speaks very pointedly to and about both conceptual arenas, the more-than-local relations of energy landscapes and the intricacies of everyday domestic storage, while remaining alert to ongoing transformations and persistent injustices at multiple scales. Doing so, I argue, is necessary to nuance our understanding of how batteries are currently reshaping heterogeneous energy landscapes and how we can ultimately ensure environmentally and socially sustainable governance of these arrangements. After all, the basic normative premise of this paper is that households in Nairobi and elsewhere should benefit equally in their electricity security from the *firming*, *enabling*, *buffering*, and *fixing* capabilities of batteries, regardless of their socioeconomic situation, geographic location, or pre-existing sociotechnical dispositif. Relatedly, the spatialized environmental and health burdens of the city‘s batteryscape should also be equally distributed; on a municipal, national, and even planetary scale.

6.3. **Researching in/ on the batteryscape:** Approach and methodology

While the broader energy landscape of Nairobi, with its infrastructural inequities and persistent shortcomings, is fairly well documented (de Bercegol and Monstadt 2018; Ferrall et al. 2022; Taneja 2018), it remains unclear how the ongoing proliferation of batteries, especially LIBs, is reshaping electro-infrastructural arrangements and household situations, and the heterogeneity and sustainability of the city‘s overall energy landscape. To fill this knowledge gap, this article draws on findings from a study of domestic electricity (and water) storage in Nairobi. Recognizing ‘storage as infrastructure’ (‣ Chapter 4), the starting point is the artefacts and practices of electricity storage in domestic spaces, i.e. households, as many infrastructures are ‘integrated in the practices of everyday life’ at that scale (Rohracher and Köhler 2019). Moreover, households are ‘one of the largest contributors globally to carbon emissions’ (Allen et al. 2020), and in Kenya, households have the highest electricity demand of all user groups (KNBS 2023), unlike globally where the industrial sector is and is expected to remain the main consumer (IEA 2020).

Inspired by work of Rateau and Jaglin (2022) on domestic electricity practices in West Africa, I further approach the energy landscape in Nairobi as composed of individual, idiosyncratic

Figure 32: Pictures of the main research areas; photos by author (2021-2023) with the exception of Kibera. Kibera photo taken by Guillaume Baviere (2020); CC BY-SA 2.0.

household *dispositifs*, or settings (Akrich and Latour 1992). Here, each consumer – in my case, a household – has 'a specific set of actors, resources, material artefacts, technical knowledge, and formal and informal institutions' that define its access to and use of energy (Rateau and Jaglin 2022). This notion of *dispositif* at the household level refers to idiosyncratic arrangements of different sources of electricity (grid, solar photovoltaic, etc.), involved human actors, electrical artefacts and appliances, and electrical practices and energy uses. In larger scale, the notion of the household dispositif is mirrored in understandings of the city and its infrastructures as dynamic, sociotechnical configurations (Jaglin 2016; ‣ Chapter 4), and each technological artefact, such as a battery, has, or rather is, its own dispositif. Ultimately, then, batteries are constitutive and influential parts of the electrical dispositifs of households and entire cities, from and through their own dispositifs and capacities to co-produce sociotechnical environments. Applying a 'multi-scale perspective' (Rateau and Jaglin 2022), albeit unfolding from the domestic realm, is crucial for investigating place-specific batteryscapes, their constitutive elements, and injustices that may range from everyday artefacts and practices to governance arrangements and global value chains.

To empirically explore and analytically discuss the importance and role of batteries for and in household dispositifs, as well as for the larger energy landscape of Nairobi, I interviewed 39 households over several trips to Nairobi in 2021-2023. Given Nairobi's ongoing stratification, micro-fragmentation, and heterogenization of infrastructural realities even within single neighborhoods and estates (Guma 2021; Kasper et al. *forthcoming*; Schramm and Ibrahim 2021), respondents were purposefully recruited from a variety of household typologies and geographies, primarily in four purposively selected neighborhoods (‣ Figure 32): Eight interviews in the central, densely populated but infrastructurally overburdened Eastleigh area, home to lower to middle income groups who often work in the many Somali owned businesses in the area; seven interviews in the informalized Kibera area, with its shack architecture and where unofficial electricity connections are common, while most residents work in low-paid, precarious jobs; six interviews in the affluent and generally well-served Westlands area, with a growing number of upscale apartment buildings and many international residents; and six interviews in the rapidly growing, heterogeneous suburb of Ongata Rongai, where one can find informalized low-income neighborhoods, basic apartment buildings, and a growing number of middle-income single-family homes. In addition, I conducted about 15 interviews with representatives of utilities, government agencies, resident associations, private companies, NGOs, and CBOs, as well as solar technicians and electricians. These interviews were complemented by countless conversations, field notes, walks, and informal insights from many generous Nairobians.

6.4. **The rise of Nairobi's batteryscape:** Actors, trends, and political economy

Since its origins as a railway depot in 1899, Nairobi has been a 'self-help city' (Hake 1977), where access to basic services remains 'closely aligned with a few elites' priorities to the detriment of ordinary residents in low-income spheres' (Guma 2021). However, over the past few decades, some programs have indeed brought improvements to rural and urban Kenya. For example, the country has made an enormous leap in electrification, from 15% of the country's total population with access in 2000 to 71% in 2020. For urban Kenya, this number rose from 50% to 95% over the same period (Tracking SDG7 n.a.). The *Kenya National Electrification Strategy* aims to close the remaining gaps by encouraging private sector investment in renewable energy, off-grid electrification, and mini-grids, as well as public investment in the main grid (GoK 2018; Petrik et al. 2020). Planning, governance, and operations of the sector are largely the responsibility of government and parastatal institutions and state-owned enterprises. Under the supervision of the Ministry of Energy (MoE) and the semi-autonomous Energy and Petroleum Regulatory Authority (EPRA), two-thirds of the country's electricity is generated by the Kenya Electricity Generating Company (KenGen), high-voltage transmission is the responsibility of the Kenya Electricity Transmission Company (KETRACO), and the Kenya Power and Lighting Company (KPLC), as the sole off-taker in the market, has a *de facto* monopoly on the distribution of electricity to consumers (Petrik et al. 2020). Subnational or local government bodies play a rather minor role, and most government interventions and regulatory decisions affecting households in Nairobi are made at the national level.

Although EPRA, KenGen, KETRACO, IPPs and investors, and many others are critical to the sector, Nairobians' everyday electricity experiences are largely shaped by their relationship with and (dis)connection to KPLC. Across Nairobi's eleven sub-counties, electrification rates and the use of electricity as a primary source of lighting consistently hover between 94% and 97% (KNBS 2019). But these numbers tell us little about actual usage and reliability, and Nairobi's infrastructural realities have proven to be very fine-grained and highly differentiated even within individual neighborhoods, which is barely captured by available statistical data (Guma 2021; Kasper et al. *forthcoming*; Schramm and Ibrahim 2021). Moreover, recent electrification in Kenya has not always been achieved through official programs, but more often in less formalized ways, which can often be the result of pre-existing infrastructural injustices such as exorbitant connection fees (de Bercegol and Monstadt 2018; Smith S 2019). This can then (re)produce injustices, such as potential health hazards of informally tapping into the grid and running poorly insulated wires through the ground in informalized settlements: ‘When it rains, that‘s when the problem comes. If you stop on the wire...there‘s going to be a shock, which leads to death’ (female tenant, casual labourer, Kibera). Furthermore, across Kenya, many grid-connected households use electricity very sparingly or irregularly due to financial constraints or ‘poorly functioning or completely non-functioning supply’ (Ulsrud and Saini 2022). Nairobi experiences a staggering 90,000 power outages per year (Taneja 2018), and power outages are unequally distributed, with low-income households experiencing ‘over twice the outage duration and frequency’ than high-income households (Ferrall et al. 2022). Despite Nairobi‘s high electrification rate, a closer look reveals unjust and ‘splintered landscapes of electricity supply and use’ that are – at great parts – still ‘far removed from governmental ‘world class’ ambitions’ (de Bercegol and Monstadt 2018). The rise of the city‘s batteryscape thus needs to be understood in relation to non-battery-related injustices and inadequacies that provide ample incentives for Nairobians to improve their electricity security through off-grid means that can *buffer* or *fix* their electricity supply, or *enable* off-grid alternatives.

For households without a (reasonably reliable) electricity connection – for example, in informalized areas such as Kibera – kerosene-fueled hurricane lamps and smaller paraffin lamps (*koroboi*) have provided nighttime lighting for decades, despite their fire risks. In more affluent residential and commercial areas, diesel generators have been widely used. More quietly, lead-acid batteries have been used by some – more so by commercial users, less so by urban residents (various interviews) – to power audio speakers, lighting, and other devices for places or times without electricity. So-called *uninterruptible power supply* (UPS) batteries have also been used for decades, for example to automatically power ATMs and desktop computers during an outage. In addition, wax candles and torches with alkaline batteries have been, and usually still are, staples in all kinds of households:

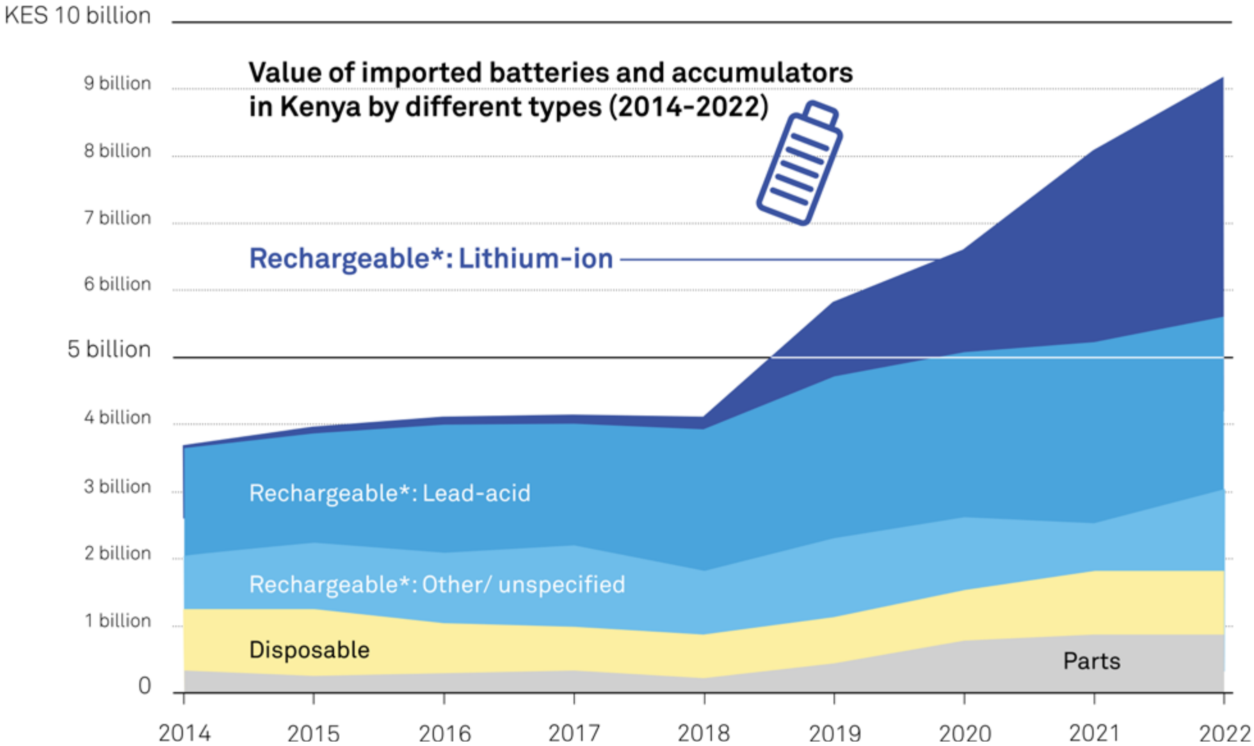
> ‘I have candles, and I have a few torches. At some point, and it was a very helpful investment, one of my neighbors gave a headlamp to me.’ (female tenant, teacher, Westlands)

Batteries have arguably been a part of many Nairobians‘ lives for decades, but with the digitization of urban lives, work, and finance, small-scale battery use has increased and diversified. For example, those who rely on digital devices and communications, or who travel regularly, may have power banks that serve as *backup*, or rather temporary *fix*: 'I always keep an extra battery charged. A power bank. That's from my experience as a journalist' (male tenant, media professional, Westlands). In general, amidst the variety of sociotechnical coping mechanisms with Nairobi's erratic and unjust electricity configuration, batteries have now taken a top spot, mainly due to the rise of portable electronics, as well as supported by two ongoing trends: solar home systems (SHS) and electric vehicles (EV).

As Kenya is a testbed for tech innovation (Guma 2021; Newell P et al. 2014), SHS have become a widely available alternative or addition to grid connections. SHS and their battery systems are currently exempt from import duties and VAT, and through certified training courses, the expertise to install SHS is widely available. Having expanded beyond electrifying underserved communities, SHS have – more recently – become part of Nairobi's diversifying electricity landscape, especially among single-family home owners in the outskirts: 'A majority of new [SHS] sales are people who are under the grid. They are connected to Kenya Power but still want an off-grid option' (CEO, KEREA). Since grid feed-in is not possible now or in the near future, virtually all SHS have batteries, which are increasingly made up of LIBs. Lead-acid batteries have remained dominant due to their generally lower prices, but – depending on availability, current market prices and the specific needs or dispositif of each household – LIBs have also become a viable option, partly driven by claims from sellers that LIBs are more economical and environmentally friendly in the long term.

In addition to the SHS trend, Nairobi is currently experiencing a push towards e-mobility. Several companies are working to electrify motorcycle taxis, public transport vehicles, and other modes of transportation. KPLC has introduced a special tariff for e-mobility and plans to install charging stations across the city (Lawi 2023; Ngugi and Munda 2021), and more e-bikes and e-motorcycles can be seen on the streets, especially for 'last mile' delivery services (Pollio et al. 2023). Although EV batteries are typically LIBs that are technologically slightly different from LIBs used for so-called static, non-mobile electricity storage, some players are testing hybrid systems for mobility and home use, and EV companies such as ROAM offer home storage products. *Vice versa*, local LIB companies, such as Aceleron, which initially focused on off-grid or grid-connected residential applications, have shifted to the EV battery market. Industry experts interviewed stated that the increasing use of LIBs for home storage is likely to be triggered or at least supported by the rise of SHS and/ or EVs, and that the two areas – mobile and static storage with LIBs – are becoming increasingly intertwined.

*Figure 33: Value (in KES) of imported batteries and accumulators in Kenya by different types, 2014-2022; data provided by KNBS ; own categorizations and graphic; battery icon by Ardiansyah (CC BY 3.0). (*Rechargeable or secondary batteries, such as LIBs, are classified as accumulators in the KNBS dataset.)*



The proliferation of batteries, especially LIBs, is further amplified by local and international NGOs, international organizations, and foundations advocating for renewable energy, SHS, and EVs. From large-scale wind farms in northern Kenya to the electrification of motorcycles in Nairobi, the political economy and actor landscape around energy transitions in Kenya is dominated by the interests of 'donor countries' and their corporations. Their interventions and investments are partly motivated by discourses around poverty alleviation, the SDGs, and climate change, but geopolitical and commercial interests are also driving forces that place Kenya and Nairobi at the forefront of technological change, energy transitions, and related commercial applications (expert interviews; Newell P et al. 2014; Ogeya and Lambe 2025). Combining this political economy with the ongoing trends toward SHS and EVs, as well as global advances in battery technology and production, it is not surprising that Kenya's annual battery imports have more than doubled in value between 2018 and 2022, from KES 4.11 billion to KES 9.20 billion (the latter roughly equivalent to $80 million based on the average 2022 exchange rate). This increase is not only driven by LIB imports, but three-quarters of all imports come from Asia, mainly China (‣ Figures 33 & 34). While the Kenya

National Bureau of Statistics (KNBS) cautions about the accuracy of the data due to common misclassifications, the trend in import data is paralleled by the increasing use of (lithium-ion) batteries from Asia in Nairobi, as reported by households and experts. In addition, other batteries such as lead-acid are still being imported at a steady rate (‣ Figure 33), and unlike LIBs, Kenya also has a small lead-acid battery manufacturing sector.

Recognizing the growth and heterogenization of battery types and applications, Nairobi‘s batteryscape is emerging as a critical terrain of its electro-infrastructural present and future, yet the massively increased import and use is met with rather little regulation, oversight, and governance. SHS and their batteries must be installed by EPRA-licensed solar technicians using equipment from EPRA-licensed distributors. The Kenya Bureau of Standards (KEBS), EPRA, and other national government bodies such as the MoE also set technical standards for electronics such as batteries, they have introduced mandatory testing of imported batteries for EV use, and there is the VAT and import duty exemption for SHS components. However, beyond basic standards and some tax incentives, the specific area of domestic or static energy storage remains highly unregulated, with little to no framework for households or property owners.

6.5. **The domestic lives and afterlives of the batteryscape:** Applications and disposal

Within a situated batteryscape that is currently being reshaped and expanded, there are a plethora of everyday uses of batteries in Nairobi that warrant further attention to grasp the implications of domestic electricity storage for energy justice and infrastructural heterogeneity. Two applications stand out: a) rechargeable lighting and b) household backup systems. Furthermore, given the more-than-situated entanglements of batteryscapes that extend beyond households and Nairobi, we need to ask where all the batteries come from and, more importantly, where and how they end up.

Domestic lives of batteries: Rechargeable lighting and household backup systems

Given the uncertainties of Nairobi‘s electricity landscape, households across all strata and geographies have invested in rechargeable lamps that are plugged in, screwed in, or have small solar panels, but which all feature LIBs. A power cut at night means that all sorts of domestic activities become cumbersome to impossible – such as cooking or, as mentioned repeatedly by respondents, children doing their homework: ‘Power cuts are almost every day when it rains … Sometimes your child is preparing for exams. … They cannot study properly with a candle’ (female tenant, vegetable seller, Ongata Rongai). As a result, more and more households have battery-powered lighting, some of which can illuminate entire rooms. Throughout the city, including in low-income areas, rechargeable lighting with LIBs is becoming a fairly ubiquitous part of the domestic energy supply, sometimes replacing candles, traditional torches, and the aforementioned, notorious *koroboi*, but often just supplementing them.

Apart from initial investments, most rechargeable lamps need regular attention, by either charging them from an outlet or placing them in the sun: ‘I try to make [charging them] a monthly ritual’ (female tenant, online salesperson, Ongata Rongai). Usually, households recharge after each use but many can tell stories about forgetting it and sitting in the dark during the next nightly power cut. Some homeowners or property managements install stand-alone solar PV lights in outside or common areas, i.e. for security reasons. A recent, less proliferated version are lightbulbs with built-in LIBs. You screw them in and use them just as regular lightbulbs, but in case the power goes, those lightbulbs keep on shining for several hours (‣ Figure 35). As power comes back, they are being automatically recharged. One of my respondents in Ongata Rongai replaced the majority of their bulbs with rechargeable ones, and stated that sometimes, ‘when we don’t have electricity, I don’t even realize it.’ For a household in Eastleigh, these bulbs ‘keep our lives going after the power goes out. Since we have three of them, everyone can stay where they are.’ Bulbs with built-in LIBs are significantly more expensive than regular ones, which probably explains why I came across them primarily in households in Eastleigh and Ongata Rongai, both areas with rather large middle-income populations.

Beyond lighting and single items only, some households use batteries for more comprehensive fixes for the uncertainties of Nairobi’s electricity supply. Being used in offices and other commercial contexts for decades, the aforementioned UPS that usually run with a lead-acid battery have permeated into domestic spaces, for example to ensure one’s Wi-Fi signal. Going a step further, some households use larger battery backup systems that they have bought themselves or their property owner had installed. Mostly in affluent areas – as an alternative to diesel generators – households might have inverters connected to in-home battery systems of various sizes, which – in case of an outage – power basics. Currently installed systems are usually not able to power all electronic appliances of the household – especially not energy intense items such as water heaters – but ‘those systems and batteries provide a base level for electric necessities and a temporally limited *fix* until regular, networked supply is restored' (‣ Chapter 4). 'It does not power the whole house, but all the lighting. Even the security lighting, and some sockets, the TV. But not the kitchen gadgets,' I was told this by a homeowner in Ongata Rongai. Her immediate neighbors, whom I spoke with later, were also planning to invest in one now because a member of the household needs reliable electricity supply for serious health reasons, showing how a simple (battery) *backup* can be much more than just a convenient *fix* for interruptions, but can have a direct impact on bodies and health.

The scope and capabilities of backup systems are expected to increase since a) investing in larger systems is currently more of a financial question than a technological one, and b) battery technology is advancing rapidly with newer, smaller, and cheaper technologies on the horizon (Crownhart 2023; EPO and IEA 2020). As of today, systems are based on either lead-acid batteries or – less commonly but increasingly so – on LIBs, depending on need, use, and finances. More so, their specific political economy features a wide range of actors; from international corporations to local companies, actors in the growing EV sector, social entrepreneurs and NGOs in the e-waste sector. For example, the e-waste company EWIK is even producing their own small-scale, UPS-like backup systems, made from salvaged and repurposed LIB cells, that they sell to a wide range of residential customers – not just affluent ones – and even corporate clients: 'We have a lot of applications for these things, commercially and domestically' (CEO, EWIK).

Looking at rechargeable lighting and backup systems showcases that households usually less affected by outages are also better able to *buffer* or temporarily *fix* disruptions with stored electricity. When it comes to lighting alone, households with greater financial capacity are able to invest more in rechargeable lamps, which ultimately allows them to more easily shield themselves from disruptions of one's cooking, homework, or other important activities. This may securitize their household through small PV lights at night, it may enable children to better educational performances, and it may provide all kinds of other benefits that do not extend to households with less financial resources and fewer battery-powered lamps. These discrepancies ring even more true for backup systems. Often touted as more sustainable and more silent than diesel generators, the spectrum of backup systems and UPS is primarily a product range for middle to upper income residents. Not only are these items expensive, but installing a backup system requires additional wiring and modifications to a home's electrical system. In a city full of tenants (KNBS 2018), this is usually in the hands of property owners, leaving less storage agency to tenants, even if they were able invest in it.

Origins and afterlives of batteries: Production, disposal, and recycling

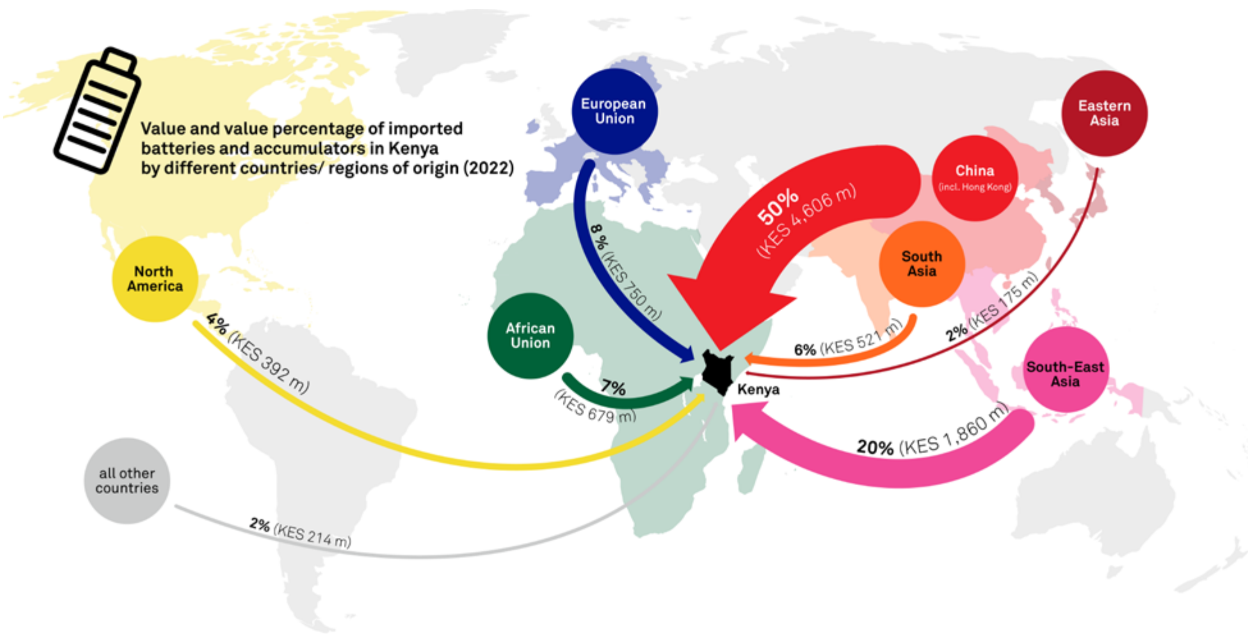
As of today, Nairobi – like the rest of Kenya – is not a significant location for battery production; especially not for LIBs. Basically, all LIBs used in Nairobi are either coming as part of items or devices (e.g. in phones or cars), as battery systems made of several battery cells and a battery managements system (BMS), or – which is likely to be least common – as single battery cells that are then used to locally assemble batteries/ battery systems with a BMS. The latter option of local assembly is however still highly dependent on foreign battery cells, which usually come from Asia (‣ Figure 34), like most electronic items or devices with batteries as well as most ready-made batteries and battery systems: 'We work with suppliers mostly from Asia that supply the cells, the battery management system' (Engineer, ROAM). Accordingly, potential problems of LIB production – e.g. in resource extraction or manufacturing – are not a local issue for Nairobi's current batteryscape. The same cannot be said for lead-acid batteries.

Although there is only one manufacturer of new lead-acid batteries in the whole of Kenya, namely Associated Battery Manufacturers in Nairobi's industrial area, which produces about 1.6 million batteries per year for the East African region (ABM n.a.), its production facility is negatively affecting the health of workers and is responsible for highly concerning lead pollution that threatens residential areas (Otieno et al. 2022). More so, as the recycling of lead-acid batteries is both technologically easier than for LIBs and somewhat regulated due to their high toxicity (Gottesfeld et al. 2018, cf. Turner 2022), larger companies such as Chloride Exide have their own recycling programs with monetary incentives for households and collectors. With an established but largely informalized lead-acid battery recycling sector, such operations pose significant health risks to both workers and nearby residents, especially children (Were et al. 2012; Ondayo et al. 2016), and a major pollution incident at a lead-acid smelting plant in the Kenyan coastal city of Mombasa in the 2000s is a reminder not only of the risks of un(der)regulated recycling, but also of the resulting environmental/ energy injustices, as it is often marginalized populations who are most affected (Mwanza 2020). Still, lead-acid battery production and recycling in Nairobi has a rather established landscape of actors and available information as well as some, albeit often ignored, regulations. Conversely, the massive influx of LIBs is currently met by limited end-of-life options, which brings us to Nairobi's biggest dumpsite.

April 2023 in Dandora, Nairobi's notorious waste-picker neighborhood next to the city's only official but overflowing dumpsite of the same name, which provides jobs and income for many thousands. Together with Solo, the president of a local waste pickers' association, I visit a number of e-waste vendors in the area. Most specialize in one type of e-waste: water heaters, cell phones, motherboards and other circuitry, etc. Some shops also sell salvaged phone batteries, some have power banks, but batteries – particularly LIBs – are rather an afterthought here. Virtually everything in the broad spectrum of e-waste is repaired, resold, recycled, and reused. Everything except LIBs. A few vendors mention businesspersons who buy LIBs irregularly, but they are reluctant to provide details, let alone contacts. Repeatedly, vendors show me their collection of batteries from phones and all sorts of other devices – sometimes buckets of them – while asking me if I want to buy them, because 'nobody wants to buy them.' Dandora is where many LIBs go to die, while lead-acid ones get a second or third life in the wider Dandora ecosystem. Eventually, all unsold LIBs end up back at the dump where they were collected in the first place.

With LIBs now at the top of battery imports (‣ Figure 33), a growing number of batteries – with all their materials such as lithium and cobalt or nickel – end up in landfills, buried with and under all sorts of other non-recycled garbage. Nairobi's growing batteryscape is currently finding much of its final and ultimately geological expression in growing pockets of LIBs that pose health and environmental risks (Mrozik et al. 2021). While most affluent residents with their many batteries live far removed from the realities of Dandora and the city's many informalized dumpsites, thousands of low-income residents and waste workers in and around these spaces are

Figure 34: Value and value percentage of imported batteries and accumulators in Kenya by different countries/ regions of origin (2022); data provided by KNBS; own categorizations and graphic; battery icon by Ardiansyah (CC BY 3.0).



the recipients of unsalvageable LIBs and their toxins that largely come from Nairobi's affluent areas; not to mention the even more toxic issue of lead-acid battery disposal and recycling that often happens around these spaces too. When I ask Solo where most of the e-waste in Dandora, including all kinds of batteries, comes from, he simply says, referring to a well-known upscale area, 'mostly Westlands and those places. They just throw stuff away.'

Before LIBs end up in Dandora, however, there is an emerging landscape of actors trying to extend their lives. As of 2024, Kenya has not implemented a specific e-waste law or any other policies that actually regulate the disposal and recycling of LIBs. A draft e-waste bill that has been circulating through the Kenyan Parliament and with relevant stakeholders since 2013 but is not yet ratified and does not include specifics on how to deal with LIB waste. Without targeted regulation but with only ambiguous legislation, such as the *Sustainable Waste Management Act 2022* (Mugendi et al. 2023), the informal sector has been at the forefront of LIB recovery and repurposing. Several household respondents in Ongata Rongai, Eastleigh, and other middle-income areas reported bringing e-waste to some collectors sometimes or that those informal collectors irregularly ask for e-waste at the doors, including batteries and battery-powered devices: 'There are these people who buy broken, unused products … We take [electronics] there … So, when I take it there, I go back with something' (female tenant, online salesperson, Ongata Rongai). In addition, some companies that sell batteries or SHS have take-back schemes and WEEE Centre, an e-waste NGO, has set up collection bins in supermarkets across Nairobi. While not widespread or mandatory yet, some collected LIBs are then tested and potentially refurbished or reassembled by informal technicians but increasingly also by actors such as EWIK, WEEE Centre, and Aceleron.

> 'We collect a lot of batteries from households, offices, facilities like hospitals, NGOs, embassies … We do not dispose them immediately … Whenever we collect these batteries, we charge them for two days … Then we have a load that we test with … If the battery cannot stay with that charge, it's going to discharge immediately. That's how we identify usable and non-usable batteries. From that point we sort out and we take them to our partners.' (CEO, EWIK)

However, LIB refurbishing or reassembling has its limits. Only single cells that safely hold an appropriate amount of charge can be re-used, and eventually any LIB cell will reach a point when it cannot be used anymore. At that point, due to the technically complicated nature of LIB recycling, there is nothing that can be done with these batteries in Kenya, nor in the whole region:

‘At least for Eastern Africa, there is no recycling facility for lithium batteries’ (E-Mobility Lead, Siemens Stiftung). Instead, many of the collected LIBs and cells are then simply sitting in warehouses, some get thrown away eventually and might end up in Dandora after all, since ‘there is no program to dispose of these batteries’ (independent solar technician). With no program, no regulations, and no recycling sector currently emerging, depleted LIBs and cells could only be exported again to Asia or Europe for appropriate recycling but this is barely happening. WEEE Centre is currently not collecting enough LIBs to make export of broken LIBs economically feasible and EWIK only works irregularly with exporters from South Asia that – depending on global prices – buy broken LIBs in bulk, usually by container.

While all efforts to refurbish, reassemble and recycle LIBs in Nairobi are undoubtedly laudable, they do not match the massive increase in LIBs and LIB-powered products that now dominate Nairobi‘s batteryscape. In the absence of strong economic incentives and/ or regulatory requirements, the majority of LIBs, as well as the many devices and systems that contain LIBs – rechargeable lights, some SHS, power banks, etc. – are currently simply stored or ‘hibernating’ (Opinde et al. 2024) in household drawers and warehouses, but are also increasingly ending up in landfills. When asked what they (would) do with broken batteries or battery-powered devices, most households interviewed were rather clueless. Some irregularly hand them over to informal collectors, but many admitted to simply throwing them away, not knowing what might or might not happen to them.

> ‘Someone told me that there’s a box for electronics outside Carrefour [supermarket] … Before I knew that I just threw it away with the regular trash.’ (male tenant, media professional, Westlands)

6.6. **Discussing the batteryscape:** Governance, (in)justice, and heterogeneity

In the heterogeneous configurations of electric African urbanisms, and in other kinds of urban-infrastructural realities ‘on, off, below, and beyond the urban electric grid’ (Munro 2020), batteries have become a universal feature. Amidst the infrastructural diversity of Nairobi, they *enable* and *firm* the emergence of ‘off-grid electric urbanism’ (Munro and Samarakoon 2023) through SHS, small solar lights, and various other PV applications, and they are becoming a complement, not just a supplement, to generators, classical torches, *koroboi*, and other tools that can provide a *buffer* or temporary *fix* for erratic grid supply. Yet, the proliferation and importance of batteries in Nairobi is largely ignored by authorities and regulators, as evidenced by the lack of official governance or regulation of domestic electricity storage and LIB waste, as well as the repeated and incessant cases of health hazards associated with lead-acid battery production and recycling. More so, as long as batteries of different sizes and types are not recognized in their infrastructural importance, urban energy futures will be largely shaped by a profit-oriented private sector, not by future-oriented propositions for just energy landscapes.

Currently, limited governance is leading to injustices since every building, every household is largely alone in their electricity storage. This highlights that the batteryscape is not flat, but different levels of power and responsibility exist between its various actors, including and in-between urban residents. After all, not all batteries are the same. Battery types and uses vary in their scope and technicalities, and thus in their potential impact on multi-scalar environmental and societal (in)justices. While each household with its specific electrical dispositif also has its own, idiosyncratic dispositif of electricity storage, the two discussed battery applications – rechargeable lighting and backup systems – signify however a continuation and expansion of unjustly available benefits in Nairobi's energy landscape, instead of providing benefits equally to all urban residents.

The urban elite and some middle-income households, especially homeowners, tend to use simply more, but also larger and more sophisticated battery applications. In this way, they benefit from a technological advancement and shield themselves from electrical insecurity. Conversely, the urban poor – who already have less access to and security of electricity supply – have comparatively less to gain from the rise of LIBs, and are more likely to use smaller or lower quality batteries, or more toxic but cheaper ones such as car batteries, if at all. They are also much more exposed to the burdens of disposal. While Nairobi's batteryscape is currently being reshaped most by LIBs, it is important to recognize the role that lead-acid batteries still play, e.g. as an enabler of many SHS or backup systems, and as a health hazard for marginalized workers and urban residents. Beyond socioeconomic differences, and specifically within communities and even individual households, benefits and burdens are also variegated. For example, the benefits of battery use are reflected in the everyday lives and bodily experiences of those engaged in domestic chores and nightly activities, or those dependent on electricity for health reasons. Also, the corporeality of waste collection and recycling can very much affect the bodies of the many men and women in Dandora, at lead-acid production plants, and other affected locations.

The current proliferation of LIBs in Nairobi is producing localized issues but their largely unregulated use and disposal speaks to and about *cosmopolitan* energy injustices also. While it was beyond the scope of this paper to trace the (raw) materials and production processes of LIBs used in Nairobi, the extractive and polluting nature of lithium mining has been well documented (Blair et al. 2023; IER 2020). The vast majority of LIBs used in Nairobi come from production sites in Asia (‣ Figure 33), which likely source some of their raw materials from the African continent, such as the notorious rare earth metals from the Congo (Kara 2023). And when it comes to lead-acid batteries, not only does the production and recycling sector in Kenya repeatedly fail to protect workers and communities, as discussed above, but it is also linked to a global lead economy that is largely based on these batteries and is responsible for '5.5 million premature adult deaths … and 765 million lost intelligence quotient points among children' (Luby et al. 2024).

Overall, the ongoing surge of LIBs in addition to and not just as a replacement for lead-acid batteries – in Nairobi and elsewhere – requires brutal exploitation of natural resources and human bodies; through the extraction of lithium, cobalt, nickel, and more; through energy-intensive and transport-intensive production processes; through harsh to illegal working conditions in mining and production; and finally through unregulated and wasteful disposal. While batteries, especially LIBs, are touted as a cornerstone of green energy transitions and for electrifying rural or otherwise marginalized areas (Agese 2023; Kebir et al. 2023; Komiyama and Fujii 2021), the injustices of Nairobi's batteryscape reveal that the *firming*, *enabling*, *buffering* and *fixing* capacities of batteries benefit most those who are already electrically privileged. Talking with sector experts, many highlight the potential of batteries, especially LIBs, for providing equalized electricity security to all. While some actors are thinking about 'hand-me-down' systems through which lower-income households would eventually get second- or third-hand batteries, the pre-existing injustices of Nairobi's electricity landscape cannot be addressed by such a system either. As Munro and Samarakoon (2023) have shown for off-grid solar in other southern cities, also the storage urbanism of variegated batteries does not provide benefits equally but is – once again – primarily helping those with enough financial resources and/or homeownership.

Lastly, when we acknowledge domestic 'storage as infrastructure' (‣ Chapter 4) and batteries as increasingly crucial for urban life, Nairobi's batteryscape highlights a further 'individualization of infrastructural responsibilities,' a 'splintering from below,' and an increasingly fine-grained fragmentation of infrastructural realities (Kasper et al. *forthcoming*, Kooy and Bakker 2008). The combination of both, the persistent use of lead-acid and the current rise of LIBs, not only signifies a diversification of Nairobi's batteryscape, largely driven by a favorable political economy around energy transitions and an unreliable electricity infrastructure. Rather, these trends and applications also contribute to a heterogenization of Nairobi's overall energy landscape. For heterogeneous and further diversifying energy landscapes, batteries are poised to play a central role for and within individual electricity dispositifs (cf. Turner 2022), as they *enable* individual households to tap into different sources; from grid access modes (formalized or not) to off-grid power generation (primarily PV in various forms and scales). Also, given the ongoing digitization in Nairobi and elsewhere, the 'electric city' (Burdett and Rode 2012) and its digital offspring have become *de facto* battery dependent. Not only dependent on myriad LIBs in phones, laptops, and other devices, but increasingly dependent on heterogeneous and place-specific batteryscapes made up of backup systems, UPS, solar lights, power banks, SHS, bulbs with built-in batteries, EVs, but also constituted and shaped by a growing landscape of actors and regulations, or lack thereof.

6.7. **Conclusion:** The future of the batteryscape

Evoking and utilizing the notion of the batteryscape enables a targeted exploration into energy landscapes and injustices that either are the result of or strongly entangled with the ongoing rise of batteries in urban life. Lead-acid batteries, as well as disposable alkaline ones, have been part of urban-infrastructural lives for decades, and their production, use, disposal, and recycling are already associated with significant environmental and energy injustices. With the proliferation of SHS and backup systems, their domestic applications remain more than just a cheap alternative to LIBs, but also an integral part of energy dispositifs of some households with the means and need for individualized energy security, and globally – especially for southern geographies – demand for them is expected to grow due to energy transitions, population growth, and unreliable electricity supply (cf. Turner 2022). At the same time, fueled by these same trends, as well as the global lithium economy and the dynamic political economy of Kenya's energy sector, LIBs are a driving force behind the ongoing heterogenization and reconfiguration of energy geographies and injustices in Nairobi. While the persistent use of lead-acid batteries as well as the current proliferation of LIBs for domestic use in Nairobi are symptoms of both a global push for energy transitions and an unreliable electricity configuration, this proliferation also represents an unjust distribution of benefits and burdens.

Sustainable energy transitions around the world, which often rely on energy storage, have repeatedly shown their 'dark side' (Canelas and Carvalho 2023) in that they often unjustly and negatively affect marginalized humans and non-humans, rather than providing benefits in a just and *cosmopolitan* way. Similarly, injustices within unreliable and/or hybridizing electricity configurations in many southern cities are well-documented (Verdeil and Jaglin 2023). My findings from Nairobi's batteryscape thus link the concerns of authors who have demonstrated the negative impacts of electricity storage in different contexts and scales (Canelas and Carvalho 2023; Kara 2023; Mrozik et al. 2021; Turley et al. 2022), and those who have flagged the problems and injustices within heterogeneous electricity infrastructure configurations (Verdeil and Jaglin 2023). Undoubtedly, there is (untapped) potential in batteries for more just energy futures, but the case of Nairobi's batteryscape shows that any potential for advancing distributive energy justice through domestic electricity storage is not being realized. Rather, existing injustices are reproduced and even exacerbated by the storage urbanism of batteries.

Finally, while energy storage and its multi-scalar technicalities have become a political arena and widely debated topic, my exploration of Nairobi's batteryscape is meant to serve as a call to further investigate the everyday artefacts and practices of energy storage. Examining how households (and other users) contribute to heterogenizing, situated energy landscapes through their use of different batteries can help unpack the benefits and burdens of infrastructural articulations that increasingly include LIBs, but also rely on lead-acid batteries. In order to further unpack the 'black box' of batteries (Turner 2022) and their significance for urban-infrastructural (in)justice, we should be aware of the bodily scale and how everyday battery use affects and is experienced differently by urban residents and their bodies, e.g. due to disabilities, gender, age, health status, education, knowledges, socio-cultural factors, etc. In addition to other qualitative explorations of situated batteryscapes, the limitations of this paper also highlight the need for more quantitative data on battery use and individual energy dispositifs in southern cities. Such research can provide critical insights into debates about infrastructural heterogeneity or hybridity, energy justice, sustainability transitions, southern urbanism, and related topics. Ultimately, however, research on the present and future of diverse batteryscapes is necessary to promote and shape their much-needed planning, regulation, and governance for a just and sustainable future.

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Figure 35: Light bulbs with built-in batteries for sale at a supermarket in Nairobi; photo by author (2023).

ABSTRACT This paper examines the sociotechnical and socioecological dimensions of water storage across scales in Nairobi, Kenya. The city's piped water supply has historically struggled to keep up with growing demand, resulting in a heterogeneous waterscape that features a multitude of storage arrangements, from massive dams to small jerry cans. Using qualitative methods, including household and expert interviews in different neighborhoods, the study unravels multiple scales and types of water storage, tracing water's journey from natural reservoirs in the Aberdares to large dams, intermediate storage tanks, and finally household containers. It identifies storage as a critical yet under-researched component of urban infrastructure, highlighting its role both as an enabler of variegated supply and access, and as a (re)producer of the inherent inequalities of place-specific infrastructure configurations. However, by proposing and applying *storage as a multi-scalar analytic*, I advocate a non-problematizing, non-normative understanding across scales that recognizes the *stabilizing*, *disrupting*, and *creating* capacities of any storage arrangement. Ultimately, I argue that integrating a pragmatic, multi-scalar recognition of storage into the planning, design, and governance of urban infrastructure offers opportunities to enable more equitable and sustainable waterscapes.

7. From dams to tanks to jerry cans

Storage as a multi-scalar analytic

submitted: Kasper M (*under review*) From dams to tanks to jerry cans: Storage as a multi-scalar analytic for understanding Nairobi's waterscape. Submitted for review to *Environment and Planning E: Nature and Space* on 20 January 2025.

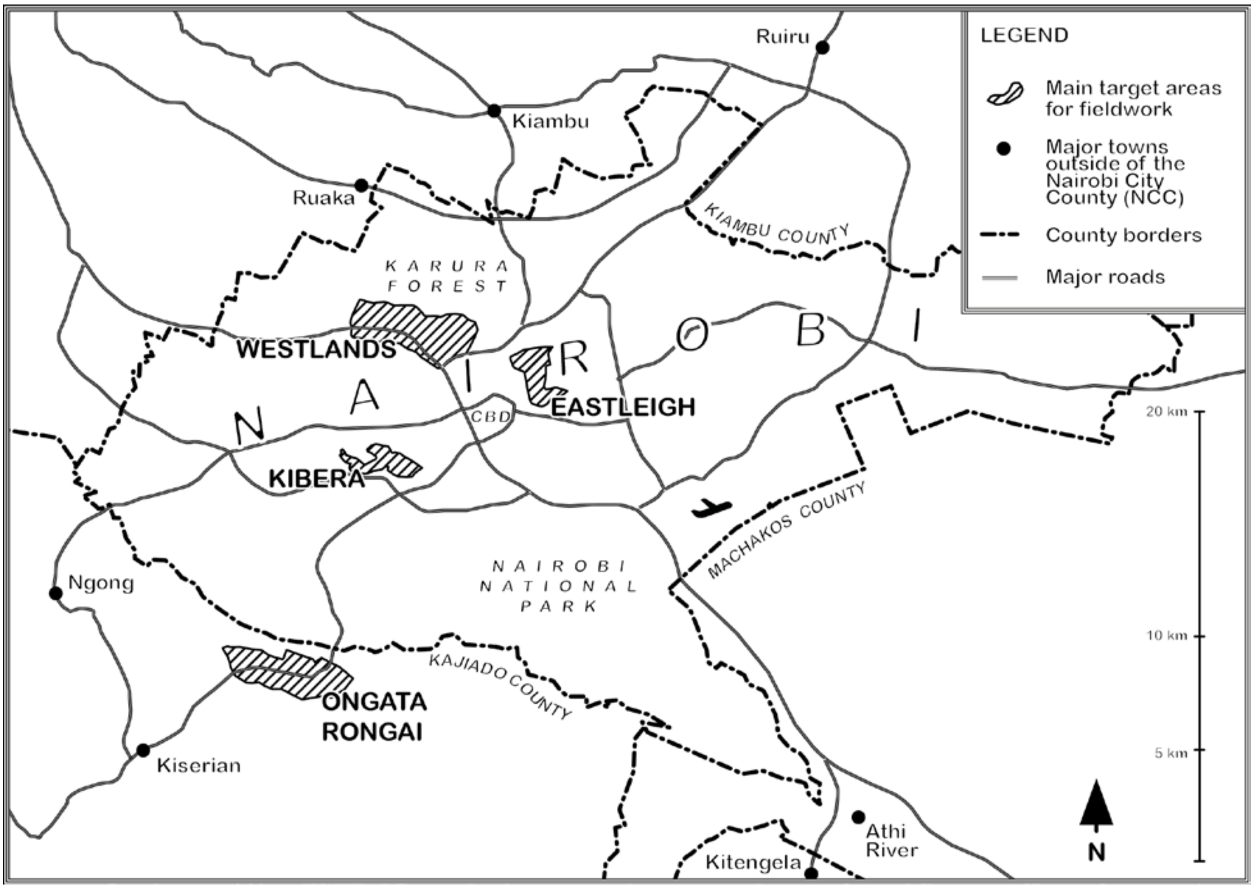
> 'Nyrobi has with great judgment been selected as the site for the principal workshops … There is a fairly good supply of water but a reservoir and tanks will have to be constructed.' (Molesworth, 1899: 23)

Since its colonial origin as a railway depot in 1899, the city and residents of Nairobi have been tasked with storing a 'fairly good supply of water' in reservoirs, tanks, and many other storage arrangements. Although the climatic conditions of the region provide ample precipitation, the city's waterscape has always been one of great inequality. Throughout its history, many residents have relied on themselves to ensure access to infrastructure and basic services, while governments have struggled to keep up with population growth and increasing water demand (Kimari 2019; Akallah 2019). The aging water network and the always-insufficient storage capacities of the utility, as well as the intermittency and unreliability of piped supply, are met with various on-the-ground strategies and alternative supply modes, resulting in a highly heterogeneous infrastructure configuration and the emergence of a 'storage city' (‣ Chapter 4) full of water tanks, so-called super drums, jerry cans and various other 'containers' that plaster Kenya's capital.

Small-scale or minor water storage at the household or building level is common in cities around the world (e.g. Acevedo-Guerrero 2022; Alba et al. 2020; Shah R 2024). Typically, storing water in or around domestic spaces results from a lack of direct piped supply, intermittent or unreliable network supply, insufficient pressure, use of non-network modes such as tankers or rainwater harvesting, cultural reasons, quality concerns, or individualized water treatment (cf. Slavik et al. 2020). But domestic water storage is often only one of many interrelated ways in which urban residents secure their supply (Dakyaga et al. 2024; Schwarz 2021) and water storage at larger scales, from the community and neighborhood to the municipal and regional, remains an obligatory backbone of most waterscapes; massive dams, smaller reservoirs, water 'naturally' stored underground, community ponds and tanks, etc. (Bishara et al. 2021; Cornea at al. 2016; Randle 2022). As Li and colleagues (2023) have shown however on a global scale and specifically for the African continent, actual per capita water storage in dams and reservoirs has been declining in the twentifirst century; and Nairobi seems to be no exception, as its population has more than doubled since the late 1990s, but its large-scale water storage has definitely not. Yet, storage at all scales is crucial to any urban waterscape but the different yet interrelated scales of storage – from dams to tanks to jerry cans – are rarely discussed together. Less even so in a way that does not simply problematize some, especially more quotidian, forms. This provides an unexplored avenue for using *storage as a multi-scalar analytic* for understanding situated waterscapes, and thus for further theorizing about the 'storage city' and about the '*tool power*' (Meehan 2014) of myriad storage arrangements as *stabilizing*, *disrupting*, and *creating* parts of infrastructure configurations.

The elaborations on water storage arrangements in this paper are largely based on qualitative research in Nairobi between 2021 and 2024. Here, the starting point was to 'delve into household dynamics and practices' (Fragkou 2024) and to appreciate mundane artefacts such as plastic water tanks and jerry cans as a 'fresh entry point into the intricacies of quotidian infrastructuring' (▸Chapter 5). To do so, I conducted 39 in-depth household visits, including conversations with at least one and up to three people per household. I conducted most of the interviews in four purposively selected neighborhoods: the historically central, dense and vertically rising *Eastleigh* area with its overburdened water grid; the informalized *Kibera* with very few direct and official connections to the utility's network; the affluent and usually well-served *Westlands* area with a growing number of upscale apartment buildings; and the emerging, heterogeneous suburb of *Ongata Rongai* with its own water utility but very similar water supply problems to Nairobi (▸Figures 32 & 36). The interviews were supplemented by observational and informal forms of data collection, and more than twenty so-called expert interviews with representatives of water utilities or government agencies, NGOs, residents' associations, private sector companies, and such like. In addition, this paper draws on data from a mixed-methods study conducted in 2021-22 (see: Kasper et al. *forthcoming*; Schramm et al. 2023). Finally, I reviewed documents, plans and policies of government actors and agencies, as well as media reports, in order to bring

Figure 36: Map of the Nairobi City County (NCC) and main target areas for fieldwork. Map by author based on Google Maps.



the interviews and explorations into context with the historical and contemporary conditions of large-scale water storage in the wider Nairobi region.

7.1. Storage as a multi-scalar analytic

Juxtaposed with the invaluable literature on infrastructural flows, circulations, mobilities and other kinds of movement, infrastructures of storage have long been comparatively understudied (Millington 2018; Randle 2022). Yet any kind of movement and flow depends on moments, spaces, and technologies of slowed circulation, stoppage, and storage, which are not only 'consistent with the internal logic of capitalism' but also crucial elements of infrastructure networks (Simpson, 2019). Relatedly, the everyday storage of water by households in cities with inadequate or intermittent networked water supply is a *de facto* part of their infrastructure, ensuring citywide flow and circulation (Acevedo-Guerrero 2022; Millington 2018; ‣ Chapter 4). Moreover, as Randle (2022: 2287-2288) has pointed out in reference to US reservoirs, water storage facilities in or for cities 'can be understood as sites that produce space by enabling uninterrupted water circulation.' But not all of these sites are equally prominent, instead 'storage is often located in marginalized spaces, or centralized in ways that make it less visible to consumers' (Bize 2017: 1). Recognizing the importance of various (water) storage arrangements in the co-production of urban waterscapes and infrastructure configurations (Randle 2024a; ‣ Chapter 4), we are challenged to take seriously *storage as an analytic* for urban and infrastructure research. This does not mean abandoning the 'city of flows' (Kaika 2005), but rather enriching it conceptually and empirically. In order to do this, I draw on literature from two related but distinct strands of research: *One*, often inspired by science and technology studies (STS) and/or postcolonial critique, research on the everyday, sociotechnical, rather minor parts of heterogeneous infrastructure configurations; and *two*, the field of urban political ecology, concerned with the urbanization of nature as well as socioecological power relations that play out at multiple scales, from the body to the city to the planetary.

Water storage as a problematized, sociotechnical hybrid of the everyday urban

Emerging from research on large technological systems and from STS-inspired infrastructure studies, urban-infrastructural articulations are now widely recognized as sociotechnical, place-specific, and dynamic hybrids or configurations. While the technological parts of infrastructure

– e.g. pipes, antennas, protocols, roads, etc. – are critical to ensuring the delivery of basic services, urban residents – with their quotidian labor, everyday practices, and vernacular knowledge – are equally important in shaping and stabilizing urban infrastructures (Andueza et al. 2021; Furlong 2016). Moreover, in the wake of the 'southern turn' in urban studies (McFarlane 2008), infrastructural settings in many cities – such as Nairobi – are also recognized as assemblages of diverse modes of supply and access, multiple technologies, a fluid spectrum of (in)formalities, and many actors involved, as opposed to idealized but rarely occurring fully centralized and universal networks (Dakyaga et al. 2024; Smiley 2020). When such infrastructural heterogeneity is coupled with the unreliability of yet-existing grids, 'storage facilities crop up at the household level to manage the uneven supply of, say, electricity or water' (Bize 2017: 1). Various batteries, buckets, gas cylinders, tanks, and other containers then play mediating and stabilizing roles, and thus 'ease the pressure on the network rather than disrupt its regime' (Jaglin 2016: 191). These capabilities are the result of the inherent '*tool power*' (Meehan 2014) that resides in technological artefacts – e.g. storage containers – as active parts of the ongoing making of (urban) infrastructures, embodying and entangling social relations, shaping spaces and rhythms, holding power, and exuding politics (Loftus 2006; Shove 2016). However, the 'social life of storage' (Bize 2017) is not only *thingified*, but rather 'a socio-technical hybrid of human storage practices ... and its artefacts' (‣ Chapter 4). Urban residents' water storage practices are often highly routinized behaviors and hard-to-break habits that require multiple activities beyond simply filling containers, such as regular cleaning, operating pumps, and interacting with plumbers (Burt and Ray 2014; Kundu and Chatterjee, 2021). Notably, gender can play an important role here (Acevedo-Guerrero 2022; Sarkar 2022), and containers of different sizes and materialities may be used for different types of water and may even have cultural or religious meanings (Cornea et al., 2016; Lavie et al., 2020).

Yet, much of the literature on small-scale water practices, particularly in southern cities, largely problematizes domestic water storage. Many texts or accounts assert but only some provide evidence (e.g. Copeland et al. 2009; John et al. 2013), that water quality in household containers deteriorates significantly due to organic or inorganic contamination and/ or due to design/ material flaws or alleged mishandling by users, including lack of regular cleaning. In addition, as Acevedo-Guerrero (2022) has demonstrated, household water storage can be a 'a place of fertility' for virus-carrying mosquitoes. Other concerns include leaks and overflows, the burden of additional investments and recommended treatment equipment/ procedures, and the social impacts of water storage as a highly individualized response to water supply issues that affect broader communities (Furlong, 2016; Schwarz 2021;

Slavik et al. 2020; Tamari and Ploquet 2012). In light of the often-unequal waterscapes in which household storage is prevalent, many have pointed out how small-scale, everyday water storage is both a signifier and an additional catalyst of infrastructural inequalities (e.g. Dakyaga et al., 2024; Shah R 2024), since the types and sizes of water containers are usually highly dependent on financial and spatial resources, homeownership, and many other factors.

Large-scale water storage and the urbanization of nature

Arguably, 'water management systems built around the idea of holding water in reserve are ancient' (Randle 2022: 2284; cf. Miller 1980). But the urbanization of nature – that is, the taming and provisioning of nature(s) in form of water, energy, and other resources for the urban – reached new dimensions with industrialization and early modernity, so much so that the 'modern' city is often hardly possible without large tracts of land that we flood and where we store water for later use in cities. And all of these major storage arrangements, as Bijker (2007: 109) notes for dikes and dams, are 'thick with politics.' This is particularly the case for massive, man-made water storage bodies, as Kaika (2005) shows for the dams and reservoirs of nineteenth-century London and 1930s Athens. Similar accounts from around the world highlight the often contested, brutal, and displacing expansion of infrastructures into urban hinterlands: For example, the massive and iterative expansion of New York City's upstate reservoirs, mostly in the early twentieth century (Sante 2022); the highly contested Narmada dam projects in three Indian states since the 1980s (Nilsen 2008); and – explained in more detail below – the legally flawed construction of the Thika Dam north of Nairobi, also known as the Ndakaini Dam, in the 1990s (‣ Figure 6).

Certainly, large-scale dams, reservoirs and other artificial water bodies can serve multiple functions; for agriculture (Ogilvie et al. 2019), for flood control and flow management (Bijker 2007), and, of course, for electricity generation (Mahanty et al. 2024). In addition, communities or non-utility organizations may also use smaller reservoirs and massive tanks to secure or manage supply (Ahmed No and Sohail 2003; Bishara et al. 2021; Cornea et al. 2016). However, the supply of water for use and consumption in contemporary cities is yet dependent on massive storage facilities, whether of a more classical infrastructural form, such as dams, or in the form of natural and/or groundwater storage, which has itself become an area of intervention and so-called *environmental infrastructuring* in recent decades (Ojani 2023; Perry and Praskievicz, 2017). Regardless of the specific form or technology, major water storage usually serves the purpose of sustaining 'the existing socioeconomic order of things, including the existing economic and cultural patterns of water use' (Kaika 2005: 164) and thus stabilizing (power) relations; while also holding the potential for adaptation and change (Randle and Linville 2024). Relatedly, the rich literature on urban political ecology reminds us that infrastructural configurations and their various parts are always a terrain of constraining as well as enabling power relations that – in the words of Swyngedouw (1996: 14) – 'swirl out and operate at a variety of interrelated geographical scale levels.'

Storage as a multi-scalar analytic

In light of the above, it seems promising to study urban infrastructures through the lens of water storage by utilizing *storage as a multi-scalar analytic*. From a sociotechnical and heterogenous understanding, everyday water storage is a compelling entry point to explore wider relations, infrastructural inequalities, and a 'variegated geography of power' (Meehan 2014: 222), but the fluidity of water also calls for a multi-scalar perspective (Foli 2024). Water storage itself occurs at multiple scales and with multiple containers in which 'water is stored in order to manage peaks and troughs in demand at the next point in the 'supply chain'' (Shove and Chappells 2001: 53). But researching water storage along various scales should not become just be descriptive exercise only, but rather a search for logics, orders, and processes. Moving beyond the usual problematizations of (some) water storage – e.g. as a health hazard at the household level, or as an interim solution, or as a highly politicized tool of urban expansion – we need to ask what shapes situated storage arrangements at multiple scales, what stories these arrangements tell us, and what role storage plays in its larger configurations, relations, and ecologies. To do so for Nairobi's waterscape, I follow the flow of water from one storage scale or point to the next. Beginning with terrestrial water storage in forests and underground, to the dams in Nairobi's hinterland, to the city's many intermediary tanks, and finally to all the small tanks, super drums, and jerry cans that co-constitute Nairobi's 'storage city' (▸ Chapter 4).

7.2. **Water tower, aquifer, and dams:** The history and status of large-scale water storage in the wider Nairobi area

Nairobi was founded by the British colonizers in 1899 as a railway depot because of the area's character as a 'place of cold water,' largely fed by three main rivers, the Mathare River, the Nairobi River, and the Ngong River (▸ Figure 37). Today, however, these heavily polluted rivers play a negligible role in water supply, while the city receives most, though not all, of its water from several dams and reservoirs north of Nairobi that feed the pipes of the Nairobi County Water and Sewerage Company (NCWSC), the municipal utility responsible for the Nairobi City County (NCC). Yet, before reaching any man-made structures, all water originates from two 'natural' places: the Aberdares Mountain Range and, more generally and broadly, the Nairobi Aquifer System (NAS). Unfortunately, however, for both the Aberdares and the NAS, the future of their water storage and (re)production capacities is under threat.

At least 90% of all piped water in Nairobi has its origins in the Aberdares Mountain Range with its demarcated forest reserve (Akallah 2019; ‣ Figure 37). Partially gazetted as a so-called *water tower*, the Aberdares attract, store, and ultimately release the majority of the water later consumed in Nairobi. Due to their elevation, topology, geology, and tree cover, the Aberdares not only receive some of the highest annual rainfall in Kenya, but also filter and store much of this water for continuous, slow release into the NAS and the many rivers that feed Nairobi's major dams and reservoirs. Yet, their hydrological function is threatened by ongoing deforestation, anthropogenic climate change, and unsustainable water extraction, including diversion to dams and reservoirs. While comprehensive studies of hydrological impacts are currently lacking, reports and studies, as well as accounts from local communities and experts, point to changing, less regular rainfall patterns and falling local levels of groundwater (Gichua et al. 2020; Kilonzi and Ota 2019; Mwangi B et al. 2023). So much so that the Kenyan government is now 'investing in nature and building "green infrastructure" upstream of gray infrastructure,' largely in the form of on-farm water storage pans to increase water infiltration in the area (Schmitz and Kihara 2021: 132); basically, artificial surface storage to support natural water storage in the soil and deeper strata.

Some water from the Aberdares and other sources then seeps into the aforementioned NAS – particularly at 'fault lines/zones, impounded lakes and wetlands, and flood plains' (Oiro et al. 2018: 874) – and is stored underground. With NCWSC largely relying on dams and reservoirs, water stored in the aquifer plays however a rather marginal role in utility supply, despite a recent increase in state-sponsored boreholes (interview, NCWSC 2021; Schramm et al. 2023). Yet, according to interviews with the national Water Resource Authority (WRA), the NAS – particularly some of its parts below the NCC – is experiencing highly unsustainable abstraction rates. While they have always been part of the city's waterscape (Akallah 2019), the number of private boreholes in Nairobi has skyrocketed since the introduction of a citywide water rationing program in the 2000s that is still in effect today. Officially, there are over 8,000 licensed boreholes

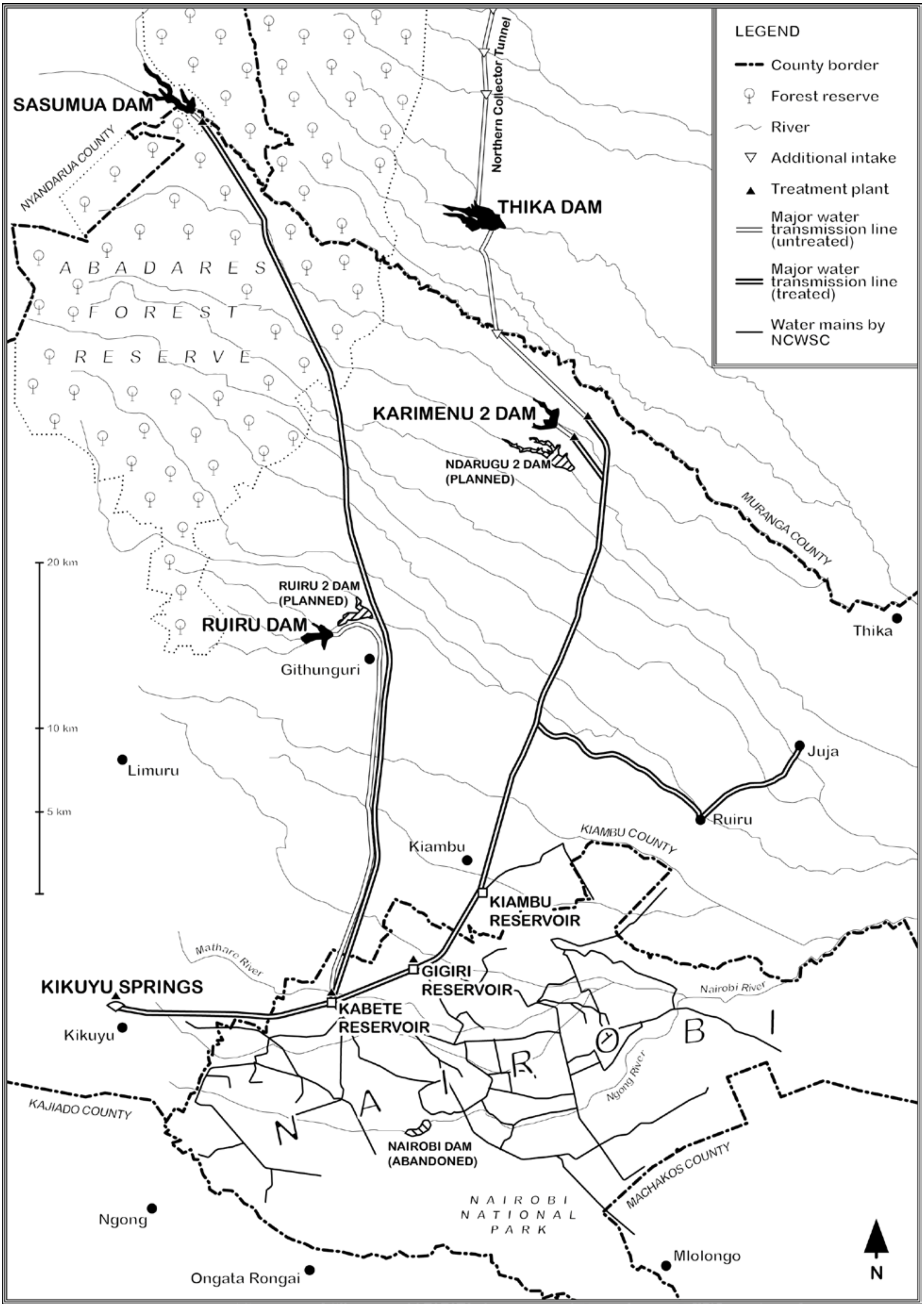


Figure 37: Schematic map of the major dams, reservoirs, and transmission lines for Nairobi's piped water supply. Map by author based on the following sources: AWSB and Aquaclean 2016; AWSB and ESC 2016; AWSB and GIBB 2014; AWWDA n.a.; Mutono et al. 2022; GoogleMaps; Syagga and Olima 1996.

in the city, mostly serving individual compounds or estates, especially but not only in the more affluent parts of Nairobi, and largely in addition to, not as a complete substitute for, piped supply (interview, WRA, 2021). Unofficially, there are likely many thousands more that are neither licensed nor monitored, and partly due to their rise, water levels in parts of the NAS have fallen massively, with more and more boreholes running dry. Current abstraction rates combined with reduced recharge have resulted in 'a groundwater-level decline of 4 m on average over the entire aquifer area and up to 46 m below Nairobi [and] a net groundwater storage loss of 1.5 billion m^3' since the 1950s (Oiro et al. 2020: 2635). If this trend continues or even accelerates – which seems likely given Nairobi's growth and foreseeable shortfalls in piped supply – groundwater abstraction from the NAS will reach its hydrological breaking point by mid-century (interview, WRA 2021). While in other geographies of the planet the preservation and artificial recharge of natural water reservoirs – i.e. the environmental infrastructuring of water storage – has become part of supply-side water management strategies and imaginaries, efforts to appropriately recharge natural water storage bodies, such as aquifers, exist only rudimental for the wider Nairobi area, i.e. as the aforementioned on-farm water storage pans.

Conversely, major water storage with man-made structures has been part and parcel of Nairobi's waterscape since its earliest days, starting with a small dam in 1900, followed by the Kabete Reservoir with treatment plant in 1938, and then the Ruiru Dam, which was constructed in the 1940s (Nilsson 2016; Nyanchaga 2016). All of these colonial infrastructures largely benefited the city's mostly white elite and tell a 'story of constant search for more water to supply the ever-thirstier city' (Nilsson 2016: 492), which continued with the 1950's constructions of the later abandoned Nairobi Dam south of the informalized settlement of Kibera and the still operational Sasumua Dam more than 60 kilometers north of Nairobi in what is now Nyandarua County (‣ Figure 37). After Kenya's independence in 1963, the Sasumua Dam was expanded, but – because most of the city's grid-supplied water flowed through the aging Kabete Reservoir, where it was treated – the 'capacity of the Kabete scheme had become critically insufficient [and] water shortages became increasingly common almost throughout the 1970s and the early 1980s' (Nyanchaga 2016: 114), as some of my older interviewees vividly remember:

> 'By the 90s latest, everyone had to have a tank because you couldn't rely on it [regular water supply] anymore.' (resident interview, Westlands, 2022)

In the 1990s, Nairobi's large water supply deficit was tackled by the city's largest water infrastructure project to date, the aforementioned Thika Dam, located around 40 kilometers north in Muranga County (▸ Figure 37). Co-financed and co-constructed with international funds and companies, the Thika Dam required 450 hectares of highly arable land, disrupted local (water) ecologies, displaced hundreds of families, and impacted livelihoods through the 'splitting up of families, inequitable distribution of compensation money within households, insufficient total compensation and loss of earning capacity' (Syagga and Olima 1996: 75). Nairobi's ever-increasing thirst for water was to be quenched by storing an additional 70,000,000 m^3 of water with the Thika Dam and adding pipelines, new treatment plants, and smaller reservoirs. The more than doubling of Nairobi's total water supply to now 460,000 m^3 per day was undoubtedly important and promised to solve the city's water problems for decades to come. However, not only were the needs of the affected rural population largely disregarded at the time, but by 2022 the daily demand stood at 820,000 m^3, once again completely overwhelming the supply, which had only slightly increased to 525,000 m^3 (interview, NCWSC, 2022). This persistent massive gap between supply and demand has been largely addressed by the aforementioned water rationing program, which NCWSC calls 'equitable distribution,' but which is actually known to be rather inconsistent, unreliable, and inequitable, favoring affluent areas (resident interviews, various locations, 2021-2023; Mutono et al. 2022). When I spoke to representatives of both the NCWSC and the Athi Water Works Development Agency (AWWDA), which is responsible for financing, building, and operating major water infrastructure in the greater Nairobi region, they acknowledged and highlighted the pressing need but also their efforts in developing more large-scale infrastructures:

> 'We need to implement more projects to get more water and then also do more storage, so that we are able to serve the population by maybe 2030 … Whatever we are giving [now] is not reliable.' (interview, AWWDA, 2021)

In line with Kenya's agenda to increase its nation-wide water storage capacity and the 2011 *Master Plan for the Development of New Water Sources for Nairobi and Satellite Towns* (AWSB 2011; Ministry of Water 2021), AWWDA has been pushing for new dams and collection infrastructure, largely funded by foreign and private capital. Until 2023, the most important project was Phase 1 of the Northern Collector Tunnel (NCT), which diverts water from several rivers to the Thika Dam and subsequently increases Nairobi's water supply by 120,000-150,000 m^3 per day. In addition, the

Karimenu 2 Dam is another, albeit smaller, piece in the never-ending puzzle of quenching Nairobi's thirst, as it can store an additional 26,500,000 m³ of water, but most of which is allocated for piped supply to the burgeoning suburban towns of Ruiru and Juja, and less the NCC (‣ Figure 37). Both the NCT and the Karimenu 2 Dam were eventually opened in 2023 and appear to be delivering the promised quantities of water (AWWDA 2023; Wanjala 2023), and additional dams are planned (‣ Figure 37) but will only provide an as yet undeclared portion of their water yield to the NCC.

All projects, whether already in operation or in the pipeline, are once again impacting local communities by requiring the resettlement of many hundreds of families and disrupting the livelihoods of many more, and all of them – in addition to being severely delayed – have been facing resistance from local residents as well as publicly raised claims of lack of public participation, unclear communication, and missing compensations (Clerk of the National Assembly 2023; Kamau 2023; KBC 2021). Moreover, with international investors and corporations involved – such as Deutsche Bank, China Exim Bank, and the French-owned Sogea-Satom – these projects also represent the ongoing financialization of water supply in Nairobi and Kenya (cf. Williams 2021). Especially since – after years of lobbying and on the heels of opening the NCT and Karimenu 2 Dam – AWWDA, as the developer of all this infrastructure, has only recently been granted the right to become a bulk water supplier (interview, AWWDA, 2021; Capital Business 2024), selling water

Figure 38: Borehole towers with tanks in Kibera, Rosslyn, and Kitengela; photos by author (2022).

to affiliated utilities, instead of 'just' being a non-revenue-generating state agency. Given that Nairobi's current water supply is already based on 'a system of service provision increasingly oriented towards value extraction and commercial viability rather than basic needs and rights' (Williams 2021: 1889), it remains to be seen how future investments in large-scale infrastructures will shape not only the major storage arrangements with their socioecological relations in Nairobi's hinterland, but also the many other yet smaller storage arrangements, to which we turn in the following.

7.3. **On corners, towers, rooftops, or underground:** The many intermediary water tanks of Nairobi

When we continue to follow the of water from the dams via transmission lines towards the NCC, we first reach various utility reservoirs, such as those in Kiambu and Gigiri, or the aforementioned Kabete Reservoir. From those three reservoirs the water is piped to more but usually smaller reservoirs, used by NCWSC to manage flow and gravitational pressure throughout the network – e.g. for water rationing – not so much for longer-term storage (interview, NCWSC, 2022). Elsewhere in the world, communities or non-utility organizations may also use reservoirs and large tanks to secure or manage water supply as a commons, but in Nairobi, there are rather few intermediary water storage arrangements – not utility, not really individual – that do not serve mainly privatized or commercial purposes. Nevertheless, all water tanks of the city, which sit somewhere between water sources and households, play a crucial but charged role in the city's waterscape, whether they are located on street corners, on small towers and rooftops, or underground.

The semi-public tanks of water points

With only three-quarters of households in Nairobi having some form of direct access to piped water (interview, NCWSC, 2022),[13] many depend on other sources. Moreover, even those with access to the network often have to supplement the intermittent or inadequate supply: 'Sometimes you just have to buy water from the vendors' (interview, Eastleigh resident, 2022). Thus, particularly in

[13] The form of direct access to piped water supply can be a metered, single-household connection as well as shared connections or standpipes. Moreover, the figures provided by NCWSC do not indicate how frequently used or reliable these household connections actually are.

informalized settlements with few grid connections, water points can be found on every other corner, and they are the main water source for 86 % of households in Kibera (cf. Kasper et al., 2022).[14] Not only is the importance of water points similar for other informalized settlements in Nairobi (Chakava et al. 2014; Sarkar 2022), but they have also become a ubiquitous feature of dense, low-to-middle income residential neighborhoods with multistorey apartment buildings. Walking through the streets of Eastleigh and other burgeoning neighborhoods, water points are a common sight and 20 % of households in Eastleigh rely on them as their main source of water and a further 27 % uses them at least regularly (cf. Kasper et al. 2022). Throughout the city and within neighborhoods, the specificities of water points can vary widely however: They draw water from the grid officially, or unofficially, or from a borehole; there are points run by NCWSC, others by youth groups or NGOs, but many are simply small private businesses. What the majority of water points in Nairobi have in common, however, is their reliance on water tanks, which tend to be polyethylene-based, black, cylindrical containers of many thousands of liters that are simply placed on the ground or put on built structures (‣ Figure 39). Polyethylene tanks are often a prerequisite for setting up water points, as they allow water points to be less dependent on the intermittent and unreliable nature of piped supply, whether official or not, or on other sources that are rarely consistent either.

The towering (metal) tanks of boreholes

As discussed, boreholes have become highly common and, in some instances, they are used to serve infrastructurally marginalized areas in Nairobi (Chakava et al. 2014; Schramm et al. 2023)[15] but – as has been the case since colonial times (Akallah 2019) – boreholes and their recent increase are largely driven by real estate developers, property owners, and homeowners. Today, it is hard to find a large-scale property development, especially an upscale one, without a borehole (interview, Cytonn, 2023; interview, private property developer, 2023), and boreholes have also become popular for all types of residential compounds, from affluent Westlands to dense and central Eastleigh to slum upgrading projects such as Canaan Estate in Kibera (‣ Figure 38). In many cases, boreholes are a retrofit solution for eroding, networked supply, and may serve not only a

[14] Specifically, privately run water points are the most common source, with 68 % of households using them as their main source in 2022, followed by 13 % for official points run by NCWSC or other government actors, and 5 % for points run by NGOs or CBOs.

[15] For example, much of the water supplied and sold by SHOFCO in Kibera comes from a borehole with an elaborate treatment system and massive storage tanks located in the *kijiji* (village) of Gatwekera, in the southern part of Kibera.

single property but also provide an additional income stream for the owner by selling excess water. Again, specific arrangements vary, but no borehole functions without storage: ‘So, you pump during the day, you have to store the water in an overhead tank, and then you can use the water anytime you want’ (interview, Davis & Shirtliff, 2021). Since it is not sensible to turn on a borehole pump for every single use of water, and since borehole water in Nairobi should to be treated before use (interview, WRA, 2021), all boreholes have massive storage tanks of up to 100,000 liters and more, usually towering above the actual borehole. Unlike most other water storage tanks, which since the 1980s have typically been made of imported polyethylene (interview, Kentainers, 2023), most borehole tanks are cubic steel tanks because they can withstand the pressure of that much water better than polyethylene tanks. However, borehole towers with polyethene tanks, which tend to be less expensive, can also be seen, especially in the low-to-middle income suburbs of Nairobi (‣ Figure 38). Ultimately, while the actual borehole and its pump are critical to accessing water from the NAS, the many thousands of licensed and unlicensed boreholes in Nairobi can only supply water to urban residents because of their tanks.

The underground and rooftop tanks of single buildings or compounds

While the tanks for water points and boreholes represent non-networked water supply, even water piped from NCWSC dams and reservoirs to grid-connected households is usually stored again before it actually reaches taps or faucets. Given the intermittent nature of the grid supply for virtually any connection,[16] with water coming through the pipes for only a few, often nightly, hours two or three days a week (if at all), water tanks for residential compounds and buildings are a common necessity. Developments built in recent decades often have underground cement tanks (interview, Zima Homes, 2022; interview, private property developer, 2023), although some use polyethylene tanks that are either buried in the ground or simply placed in yards, gardens and other common areas. These tanks are then typically fed through metered connections and some property owners install additional booster pumps to draw more water from the network than the base pressure would provide:

[16] According to the NCWSC, there are only a few places exempted from the water rationing program, such as major hospitals, the international airport, and military bases, which are of particular importance and are therefore supplied 24 hours a day.

‘They are doing it illegally … You get these fellows pumping direct, interfering with the flow. They are using the big pressure machines, so we cannot compete with them we just wait let them finish.’ (interview, Eastleigh resident, 2022)

The use of booster pumps is banned since it increases uncertainties and inequalities in the already challenged network, and NCWSC tries to identify and cut connections that use them (interview, NCWSC, 2022). That said, similar to boreholes, these pumps only make sense if you have enough capacity to store all that water. Moreover, underground or base tanks can also be filled by other means, i.e. privately operated water tankers, called *bowsers* in Nairobi, which have been common in the city for decades. When buildings or individual households with the necessary financial and storage capacity have not received enough water from the network, bowsers can be called to manually fill the tanks, which can often be a contentious issue between property owners and tenants over who pays for the additional water (resident interviews, Eastleigh & Westlands, 2021-2022). In general, the filling and maintenance of building-scale tanks often involves a variety of actors, from property managers and caretakers to service providers such as bowser operators and plumbers, to all kinds of residents. As a result, tanks and their everyday use and operation are often at the center of dissatisfactions and disputes around water quantity and quality:

Figure 39: Water tanks in Kibera, Eastleigh, and Ongata Rongai; photos by author (2021/22).

> ‘The water is not okay … The plot owner has installed small tanks underground, and he has as well erected water tanks on the roof. So, when the water comes, it flows into the small underground tanks from where [the care taker] pumps it to the rooftop tanks. That water is not always clean because the tanks are not washed at all, especially the small underground tanks. We use the water from the rooftop tanks until it is depleted. Then we just have to wait until the next time the water is pumped up. Now, when it depletes between before the water comes again, you have to buy water.’ (interview, Eastleigh resident, 2022)

This brings us to the rooftop water tank. Sometimes hidden or partially covered, but mostly just standing around (‣ Figure 39), these tanks – usually also cylindrical polyethylene ones – are critical infrastructures for the ever-growing number of multistorey apartment buildings of all income levels and geographies. Even older, one- or two-story single-family homes or townhouses usually have retrofitted structures on their often-pitched roofs that can hold a tank of a few thousand liters. Their citywide prevalence is not only caused by intermittent supply, but also by limited water pressure from the gravity-fed network, as NCWSC is only mandated to provide water up to five meters above ground (interview, NCWSC, 2022). Yet, the reported experiences of urban residents across the city cast doubt on whether the mandated pressure is actually achieved. Thus, even if water rationing were to end, rooftop tanks are needed to provide water supply and pressure to buildings of a certain height. To do this, water is pumped – either automatically or, more commonly, by someone turning on an electric pump – from grid-fed base tanks, borehole tanks, or other sources to the rooftops, where it is then stored in tanks that either serve the whole building or individual households: ‘Usually like 3,000 to 5,000 liters per tank … with like 500, 600 liters per unit’ (interview, Zima Homes, 2022). Building-specific arrangements vary and can be confusing for all actors involved.[17] Rooftop tanks are thus often ambiguous in terms of responsibilities for oversight and maintenance, and they are again a common subject of dispute between neighbors and/or property management, especially when they leak or need cleaning.

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[17] For example, I visited a building in Eastleigh where each apartment had two tanks on the roof, one filled from the networked supply and the other from an additional borehole, but how and why this arrangement had been put in place remained a mystery to tenants and the caretaker alike. Unfortunately, the property manager/owner of the building was not interested in talking to me to explain this dual setup.

7.4. **Tanks, super drums, and jerry cans:** The universality and heterogeneity of domestic water storage in Nairobi

While the many intermediary tanks are critical to ensuring supply across Nairobi, households deploy, invest in, and maintain even more water storage arrangements. The specific reasons for storing water at the household level vary, but usually it is the lack of a direct connection to the household, intermittency of supply (from the grid and/ or from the building's own tanks), low pressure from the grid, or the (additional) use of off-grid supply such as water delivery or rainwater harvesting. Typically, and throughout Nairobi, each household has an idiosyncratic combination of immediate and/ or long-term reasons for storing water themselves, as well as an idiosyncratic set of artefacts, practices, and actors involved, which – as with water supply and access in Nairobi in general (Kasper et al. *forthcoming*) – may vary from building to building and even from household to household. The heterogeneity of domestic water storage in Nairobi is juxtaposed by its undeniable universality, but there are further nuances that deserve attention, as the following three vignettes suggest.

Vignette 1 – Tanks, pumps, and pipes in Ongata Rongai

I meet Edith and her husband Matthew at their single-family home in the growing suburb of Ongata Rongai, just outside the NCC (‣ Figure 36). Along the dirt road lined with other single-family homes that leads to their home, workers from the local water utility, Oloolaiser Water, are laying new pipes.[18] The water supply to Edith and Matthew's home has been incredibly unreliable ever since they moved here with their three children in 2008. Now Matthew shows and explains to me – with visible pride and incredible attention to detail – their arrangement of three polyethylene water tanks outside their house (the largest in the front yard, two smaller ones in the back), an additional tank in the attic, two pumps, and countless pipes (‣ Figure 40). Additionally, they have two water dispensers in the house, for which they buy purified water in cannisters since they do not drink tap water due to quality concerns. They have gradually invested in and, with the help of plumbers, installed more and more tanks and ancillary infrastructure; including one tank just for rainwater harvesting because 'the best preparation you can make is to harvest rain water and store

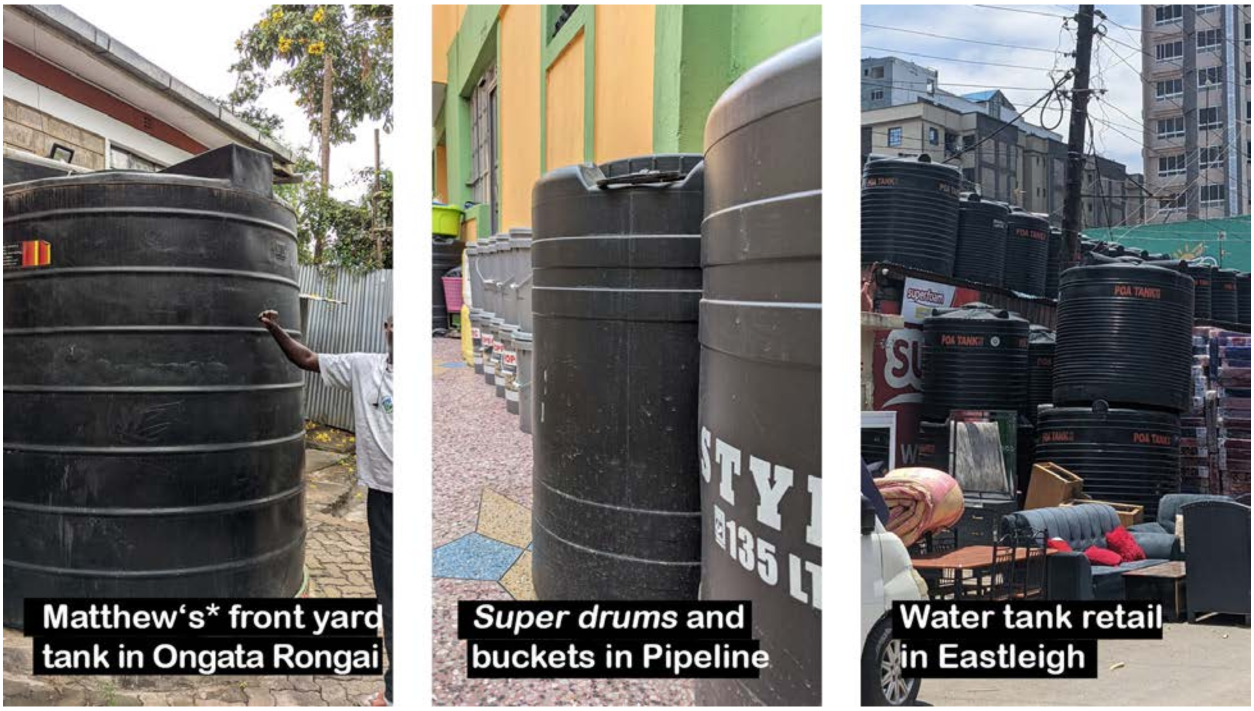
[18] Despite the different water provider, the supply situation and individual coping strategies in Ongata Rongai are very similar to those in Nairobi County, with highly intermittent and unreliable supply and the use of many other water supply modes beyond the Oloolaiser Water network. Moreover, the situation described in the vignette mirrors many other situations I have encountered in the Nairobi outskirts, whether inside or outside the administrative boundaries of the county, and regardless of which water supplier has the official mandate for the area.

it in big tanks. Otherwise, there is no schedule, you will not know whether water will come or not for the next three weeks.' Unsurprisingly, individual homeowners in and around Nairobi, like Edith and Matthew, are an increasingly important target group and market for Kenya's water tank manufacturers. During Matthew's tour, Edith repeatedly makes little jokes about his obsession with the tanks and pipes, and she reveals how he and his friends often chat and brag about the number, sizes, and brands of their water tanks. Later in my fieldwork, I hear similar stories about how water tanks are a common topic of conversation among male homeowners in Ongata Rongai and other suburbs. While many water-related practices, especially in low-income areas of Nairobi, are often the domain of women, the technicalities and investments of water storage can be heavily dominated by men. At one point, Edith – who has heard Matthew's explanations at least one too many times – interrupts him impatiently and leads us inside for some *chai*, we sit down and our actual conversation begins.

Vignette 2 – Locking your super drums and jerry cans in Eastleigh

Before meeting Julius in central Eastleigh, I take some time to stroll around the area, spotting many elevated boreholes in backyards and coming across a shop selling all sorts of household goods lined up on the street; assorted furniture, mattresses, water tanks of various sizes produced by

Figure 40: Various water storage and tank situations in Ongata Rongai, Pipeline, and Eastleigh; photos by author (2021/22). (name changed.)*



Poa Tank (‣ Figure 40). Sales points and advertisements for water storage containers of all kinds are a common sight in Nairobi, and they speak to the universality of water storage needs across the city; even, or perhaps especially, in central, grid-connected neighborhoods like Eastleigh, which is not only a major retail and commercial hub and residential area, but also has a long history of infrastructural neglect. The worsening water situation was a major reason for Julius and his small family to recently move from their apartment in Eastleigh to Outer Ring Road after more than ten years: 'There's a water crisis here ... It's not enough. You have to buy jerry cans ... And then you don't have enough space to store those jerry cans.' Many in Eastleigh and other dense areas full of apartment buildings can relate. Even if your building has its tanks, the limited supply from the network (and the common reluctance of property owners to buy additional water, i.e. from bowsers) forces many tenants to invest in and fill their own storage containers; usually super drums of 100-250 liters and small jerry cans, but also all sorts of other buckets (‣ Figure 40). You can fetch additional water yourself or have it delivered by handcart, but where to actually store it, where to put your water containers, is a common conundrum in the often very small apartments. When Julius and his family lived in Eastleigh, they had several jerry cans and two super drums: 'One for drinking water was inside the house [apartment] and the other for washing and toilet water was outside.' Keeping water and containers outside, in common areas such as corridors, can then become a contentious situation, and Julius, like many others, has stories of neighbors stealing water or whole containers: 'You have to buy a chain and a lock, and then you lock, even the jerry can.' Rather than helping each other out amidst water supply issues, individual water storage in apartments buildings in Eastleigh and elsewhere can often be a source of tension and suspicion as everyone struggles to secure water for their households.

Vignette 3 – The multiplicity and labor of water storage in the small homes of Kibera

Somewhere in Kibera's *kijiji* (village) of Kianda, I am sitting with Agnes and her neighbor Miriam in one of the countless *mabati* (iron sheet) homes of one of Nairobi's largest informalized settlements. Dimly lit by a single light bulb and separated by sheets, the small space also stacks in just one corner nearly a dozen of 20-liters, yellow jerry cans, mostly repurposed cooking oil canisters. Some in Kibera have the financial and spatial capacities for super drums but Agnes as well as Miriam both do not have one. No matter with or without a super drum, virtually every household in Kibera stores all their water at home, usually indoors, since virtually no one has a direct connection or tap but relies largely on water points: 'I just buy from someone who gets his water from *kanjo*[19] or from anywhere he finds … Also, even when rain comes, we fetch from the rain. Just putting a basin out.' Most water storage artefacts in Kibera are thus more than just sedentary containers but are rather used as multiple devices to fetch, to harvest, to share, and to store. Yet, in addition to the opaqueness and untreated nature of most water sources, domestic water storage is a key reason for concerns around water quality and health hazards. NCWSC and some NGOs I talked to claim that the way people store water in Kibera and elsewhere is actually the main reason for contamination with organic and inorganic matter. Aware of that, however, Agnes, Miriam, and the many others I talked to in Kibera all have rigid cleaning routines for all their containers – way more regular than the cleaning of large storage tanks in more affluent areas – and stored water is usually used up quickly: 'Some people even have 50 jerry cans … But even that 50, it even not lasts a week … Then, when we want to go and buy another water, we wash them using a scoring pad and soap.' Agnes and Miriam say that dirty water is the problem, not storage, and most people in Kibera boil or otherwise treat their water before consumption. However, access to and adequate storage of potable water remains a critical issue in Kibera, and both access and storage are – in Kibera's current water configuration – entirely dependent households' super drums and jerry cans.

As the vignettes show, domestic water storage and the need to care for it is universal throughout the city. Among my respondents, there are a few exceptions in up-market rentals for which the property management takes over all responsibilities. But, especially in these homes one would find purified water canisters for drinking that are purchased and stored, and the alleged reliability of water supply in up-market rental housing is not always guaranteed, as Carol – who has just moved to Westlands – reports:

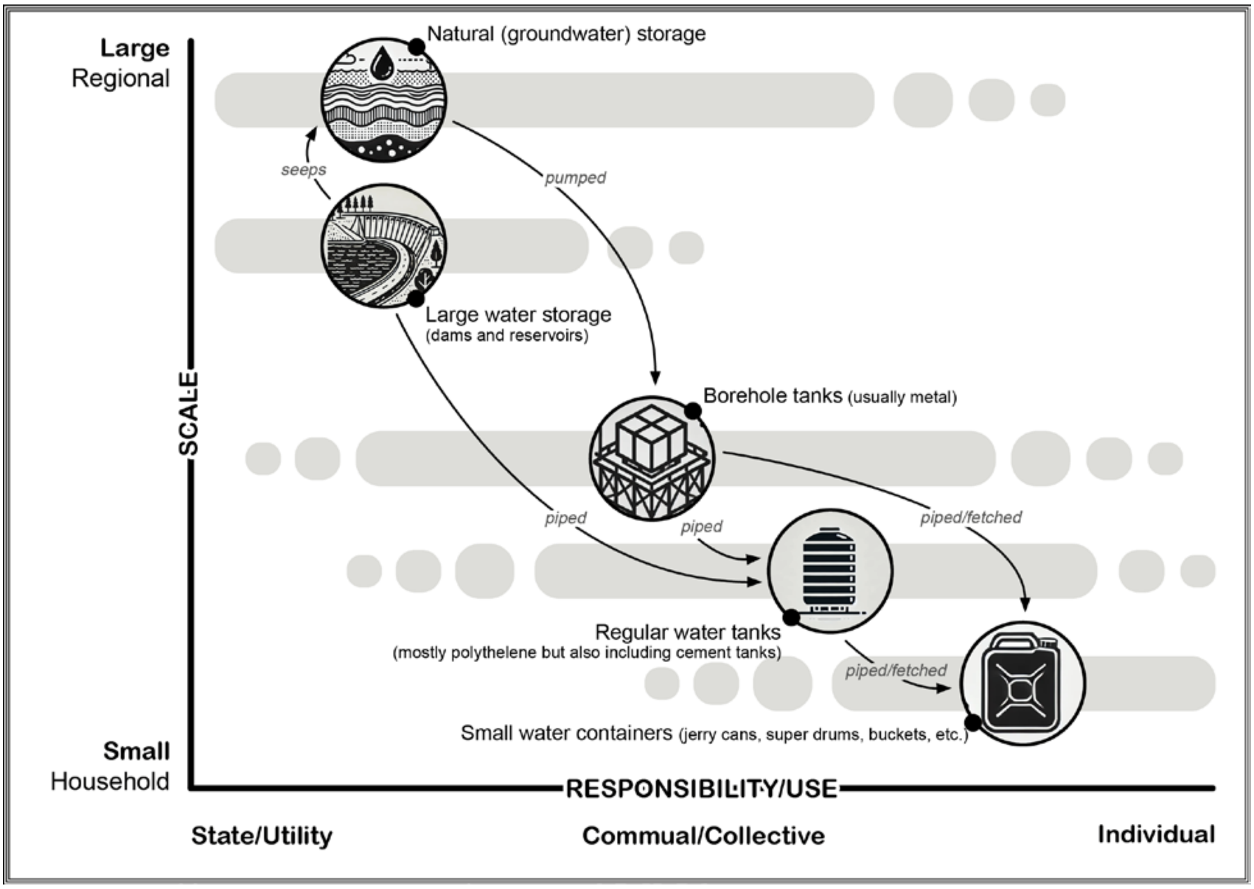
> 'I don't think there has been any week when I did not call the water guys to fill my tank … Every apartment has two tanks, one on the bottom and one on top … Luckily, we have an automatic pump … I had to put this up myself, though.' (interview, Westlands resident, 2023)

Although universal, not all domestic water storage in Nairobi is the same, and the landscape of all these storage containers and their respective practices – the 'storage city' (‣ Chapter 4) – is not

[19] *Kanjo* is a colloquial term for the Nairobi City Council. Because NCWSC was part of the Nairobi City Council until its privatization in the 2000s, many people in Nairobi still refer to NCWSC water as ‚council/ kanjo water'.

flat. Rather, the ability to continually invest in and upgrade their storage arrangements is not only a representation of the financial, spatial, and knowledge capacities of some – as in the case of Edith and Matthew – but it also reproduces differences in water storage and access. The time-consuming task of fetching water with jerry cans and the tedious, regular cleaning of small storage containers illustrate how much time infrastructurally marginalized groups have to invest in their water storage practices. Additional investment is also required if your building lacks adequate storage facilities and you have to make room for all kinds of containers in your home, as Julius in Eastleigh did. All of this takes up time, money and space for the urban poor, whereas those in fully managed housing have little to worry about in terms of storage, and homeowners have the ability to adapt and upgrade their storage arrangements according to their own needs. However, the role of water storage in Nairobi's multi-scalar water infrastructure configuration is not only one of reproducing infrastructural injustices. Beyond this rather classic problematization of domestic water storage, additional social, material, ecological, economic and thus techno-political relations emerge from these arrangements, to which we turn in the following discussion.

Figure 41: Water storage arrangements in Nairobi by scale and common responsibility/ use; including interrelations of water flows. Graphic by author with icons generated by ChatGPT.



7.5. **Stabilizing, disrupting, creating:** Discussing the multiple tool power of water storage across scales

As all the different storage arrangements – from the Aberdares to the jerry can – show, before any water reaches anyone in Nairobi, all of it – whether it comes from the dams, through boreholes, or from any other source – has been stored, at least for some time, in multiple, often intermediary 'containers' of different sizes and materialities, situated somewhere on the fluid spectrum of infrastructural responsibilities, between the broader public, the communal and the private (‣ Figure 41). In particular, the multiple water tanks of boreholes, water points, buildings, and sometimes households play an important role in 'buffering' (Schwarz 2021) the mismatch and arrhythmia between supply and demand. Tanks – especially the many polyethylene ones – are thus one of the most integral artefacts of the city's waterscape, but the myriad of micro-containers at the household level as well as all the labor, time, care, and investments of urban residents in using and maintaining them, are equally important in 'holding the city together' (‣ Chapter 5). All these sociotechnical and socioecological assemblages of containers, water(s), materialities, and human involvements are nonetheless also indicators of socio-spatial stratification, infrastructural inequalities, and socioecological alterations. But using *storage as a multi-scalar analytic* helps us to explore and theorize less normatively what all these storage arrangements actually do to their related urban spaces and wider ecologies. Building on Randle's (2024a: 6) observation that 'storage assemblages order landscapes,' often far beyond their original sites, I argue that, across scales, the '*tool power*' (Meehan 2014) of sociotechnical and socioecological water 'containers' is expressed in three effects that shape the relations in which each storage arrangement is enmeshed in, namely *stabilizing*, *disrupting*, and *creating*:

- Stabilizing: My findings from Nairobi underscore how (water) storage arrangements are incredibly important for stabilizing infrastructural configurations by making resources, in this case water, available beyond natural rhythms and/ or infrastructural interruptions. Whether used as a 'buffer' for regular interruptions (Schwarz 2021), a 'back-up' for anticipated shortages (Burt and Ray 2014), or a suturing gap-filler for any 'spatial or temporal hydraulic disconnection' (‣ Chapter 5), water storage arrangements stabilize the infrastructural configuration of which they are parts. The flow of water from the Aberdares to each household, and thus the current commodification and privatization of water in Nairobi, is ensured by all the dams, tanks and jerry cans, and the human practices around them. Against the many disruptions, inadequacies, and inequalities of the city‘s waterscape, the case of water storage in Nairobi shows how even supposedly ‘dysfunctional’ systems can be, and are constantly, stabilized by sometimes mundane, sometimes massive, but often intermediary infrastructures (cf. Furlong 2014). However, storage stabilizes not only the circulation and availability of water, but also broader sociotechnical and socioecological relations. Water storage at the building and household level reinforces the inequalities of Nairobi‘s waterscape, as the state and its proxies can rely on the tool power of tanks, super drums, and jerry cans, as well as the storage efforts of urban residents, to ensure that everyone gets water, albeit very unequally. Even more, the ‘buffering’ capacities of water storage, especially for those with plenty of capital and storage, ensure that much of Nairobi‘s more affluent parts are oblivious to the water-infrastructural realities of the urban majority, thus stabilizing the city‘s infrastructural and socioeconomic fragmentation. Notably also, the storage of water in dams or above boreholes stabilizes the highly sustainable economy of water abstraction from natural water bodies with dire ecological consequences. All in all, while all the different scales of water storage ensure that contemporary Nairobi gets at least some of its thirst quenched, they play an equally important role in stabilizing unsustainable socioecological relations.

- Disrupting: Building on Bize‘s (2017: 6) observation in Nairobi‘s High Rise estate (Kibera) that individual water storage leads to ‘increased detachment and decreased solidarity among residents’ (cf. Furlong 2016; Schwarz 2021), my observations also point to altered, even disrupted socialities among urban residents. Conflicts, tensions, and detachments are particularly, but not only, visible in dense and infrastructurally neglected areas such as Eastleigh, where everyone is trying, mostly individually, to store water as safely and as much as possible (cf. Kasper et al. *forthcoming*). Think of Julius locking up his super drums and jerry cans, and think of large underground tanks filled with illegal booster pumps. The latter also disrupts NCWSC‘s calculated supply and network-wide water flows, leaving those further down the pipes with less and less water. Similarly, borehole tanks allow disruptive extraction of groundwater, altering hydrological flows and conditions below and beyond the NCC; and the large dams in the north affect and continue to disrupt more than-local-ecologies, hydrologies, and communities. While all of these examples have rather problematic connotations, I suggest that the disruptive effects of water storage on social, ecological, and infrastructural relations may also hold the potential for positive change (cf. Randle and Linville 2024), depending on who, where, and how exactly storage is deployed.

- Creating: In addition to the impact on pre-existing relations and networks, the deployment of (water) storage across scales results in a plethora of new flows and relations. Undoubtedly, water storage creates new ecological relations by providing aquatic habitats for fish, birds, mosquitoes, *E. coli*, and other non-human life across scales, which may or may not have health implications for humans (Acevedo-Guerrero 2022; Schafer & Mihelcic 2012). Due to Nairobi‘s highland climate, some of these relationships are not as pronounced as in other geographies, but contamination of storage containers with organic and inorganic matter is still a major concern for many, as evidenced by the rigid cleaning routines of households in Kibera. The materiality of storage facilities can then also affect water quality, but even more so, entire economies and supply chains are constituted around them. Apart from the cement-based construction of dams and underground tanks, an uncountable number of tanks, drums, jerry cans, basins, buckets, and more in Nairobi are largely made of petroleum-based, imported polyethylene, which is molded into various container shapes and sizes by several Kenyan companies. This results in globalized material and economic networks and triggers further localized economic activities around the cleaning/ maintenance of tanks as well as reuse, e.g. the ubiquitous use of cooking oil cannisters as jerry cans. In addition, the entire water vending sector is *de facto* dependent on storage arrangements. Through all these economic activities as well as the everyday storage practices of households, new social relations and socialities emerge; one‘s relationship with neighbors and caretakers can be constituted through the use of water storage, since this is ‘where’ individual domestic activities converge. Moreover, storage arrangements also give rise to new relationships between homeowners, as men in particular tend to talk about and compare their different arrangements and investments. All in all, recognizing each water container as a ‘crucial and interstitial node that entangles, within itself and through the practices it necessitates, a world of relations, infrastructures, flows’ (▸Chapter 5), all of these storage arrangements ultimately lead to place-specific storage urbanisms by creating a new variety of ecological, material, economic, and social networks.

Looking at the *stabilizing*, *disrupting*, and *creating* capacities of water storage arrangements, it becomes clear that these are also nodes where socioeconomic power is enacted and relational power indifferences between different actors become visible (cf. Dakyaga et al. 2024). In Nairobi, this has largely benefited the already affluent class while only providing the bare minimum to marginalized populations. But instead of primarily problematizing water storage arrangements, an appreciation of their diverse, sometimes confusingly antithetical *tool powers* might help to rethink how dams, reservoirs, tanks, super drums, and jerry cans can be deployed and incorporated more thoughtfully into infrastructural plans and imaginaries.

7.6. **For a 'pragmatic turn' to storage**

Using *storage as a multi-scalar analytic* provides valuable insights and a new perspective for understanding situated yet heterogeneous urban waterscapes. For Nairobi, the inability of utilities and the state to store and release enough water through large dams and reservoirs affects and even creates storage arrangements further downstream. In a never-ending attempt to compensate for this inability, the necessary urbanization of nature keeps disrupting Nairobi's hinterlands. Moreover, even based on the projections of the current master plan for water infrastructure (AWSB 2011), Nairobi's population growth and water demand will continue to outpace its water storage projects. With little choice and little government enforcement, urban residents, property owners, and the private sector thus deplete the 'natural' water storage beneath their feet through tank-enabled boreholes, with consequences for larger ecologies and the water-infrastructural future of Nairobi. Water storage by vendors, property owners, and individual households also plays a significant but ambiguous role in stabilizing the inequalities of supply and consumption that characterize Nairobi's contemporary waterscape, as storage arrangements are not merely technical solutions, but are deeply embedded in everyday urban life and socioecological to political relations in Kenya's largely privatized water economy.

Yet, the heterogeneity of domestic water storage in Nairobi also illustrates how residents actively shape infrastructure through their daily practices and investments, which represent both adaptation strategies and manifestations of infrastructural inequality, but also offers possibilities for intervention if we acknowledge the diverse *tool power* of storage arrangements. After all, 'the water order is not fixed, but in flux, constantly generative of new technologies and possible alternatives' (Meehan, 2014: 222). Minor water storage must therefore not (only) be a problematized interim solution on the way to an idealized, universal and 24/7 network coverage, but it can help us to discuss and rethink 'how forms of solidarity can be established across heterogeneous provisioning systems' (Alba et al. 2020: 18). Rather than treating water storage as a mere technicality in infrastructure planning, or as a supposedly irrelevant or even counterproductive household activity, we are challenged to use storage not only as a multi-scalar analytic, but also as a multi-scalar guide to nuance and expand 'technology as a space of possibility' (Schramm and Ibrahim 2021). Planners, policymakers, and utility officials must recognize the capacity of water storage arrangements to *stabilize*, *disrupt*, and even *create* sociotechnical and socioecological relationships and networks far beyond their immediate surroundings. More so, new designs and approaches are needed that are rooted in and adapted to the storage realities of cities like Nairobi. Such a 'pragmatic turn' (Jaglin 2016) towards storage involves recognizing how different scales of storage interact and influence each other, from the household to the large dams and groundwater reservoirs that are so rarely visible in our everyday urban lives. Ultimately, this provides us all with an enormous range of possibilities for further research, design, policy, planning, and everyday infrastructuring.

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DATA AVAILABILITY STATEMENT The survey data referenced in the text is available as an open data set on Zenodo; see: Kasper et al. 2022.

8. Discussing

Storage as an analytic and a propositional space

Figure 42: Advertisement for SHS with 'green energy storage systems' in Kileleshwa, Nairobi; photo by author (2022).

After several visits to Nairobi with 39 enriched household interview, more than 30 so-called expert interviews, and countless other impressions and collected materials, resulting in four papers and many other tangible and intangible outputs, the main research question of this thesis still deserves attention and some form of resolution. So, 'what roles and significance do practices and artefacts of water and electricity storage play within heterogeneous infrastructural configurations and in everyday life in Nairobi?' In light of my empirics and analysis, I attest that they possess incredibly central yet variegated roles, not only for idiosyncratic household dispositifs and individualized responses within infrastructural configurations that are arguably unreliable and unequal, but also for the totality of these configurations, which depend critically on the decentralization of storage in the midst of their own heterogeneity (cf. Bize 2017).

Traditional and ethnocentric, largely Western perspectives of the *modern urban* and its infrastructures would likely label both, the water and electricity configurations in Nairobi primarily as 'failed' or 'dysfunctional' only, and yet, as Hyman and Pieterse (2017: 437) expressed for urban Africa in general, 'swathes of urban settlements and the built environment do in fact function.' For Nairobi, one major reason that the city does *in fact function*, albeit with plenty of infrastructural injustices, is: storage; particularly the often-overlooked, mundane and inconspicuous storage arrangements of urban households. All the containers of water and electricity, and all the practices, materialities and relations they assemble, are – and always have been – inherent parts of the city's infrastructural modernity. Just try to imagine Nairobi – or be that any other city with similar infrastructural conditions – without any water tanks, super drums, and jerry cans. With its current water configuration, it is simply impossible, since there is no mode of water supply that does not depend on it (‣ Chapter 7). Similarly, although not as drastically important 'for life' (‣ Chapter 2.2), minor electricity storage with all kinds of batteries and appliances has become instrumental to Nairobi's various urban ways of life too. Not even speaking of the enormous number of batteries in uncountable mobile devices, the domestic storage of electricity – from small lights to comprehensive systems for whole buildings – is providing much needed energy security in a city that is often dubbed the *Silicon Savanah*, and in a country that tries to spearhead energy and mobility transitions on the African continent towards a more electrified and allegedly sustainable future (‣ Chapter 6).

Storage 'as part of heterogenous infrastructure configurations'

While storage has played a (pre-) historic role in human habitation (‣ Chapter 2.4), the hegemony of universal and centralized networks in idealized readings of infrastructure for contemporary cities may have clouded perceptions of storage as inherently important and persistent until today; and that not only in the form of major storage sites of utilities, the state, and corporations (cf. Kaika 2005; Simpson 2019; White-Nockleby 2022). As my findings show, mundane and minor storage arrangements are infrastructure too, at least in contemporary Nairobi, and most likely in many other urban settings around the world. This is true not only for today's cities but, I argue, for many urban futures as well, due to the expected likelihood of increasing disruptions to taken-for-granted flows and circulations due to anthropogenic climate change and necessary transformations (cf. Marsden et al. 2024; Randle 2024a). In past, present and future, the domestic storage of water and electricity in Nairobi is thus crucial to the city's HICs, co-constituted by many individual and variegated household dispositifs of supply and storage (‣ assumptions in Chapter 3). The heterogeneity of the wider 'system,' as well as intermittent or unreliable supply, results in a plethora of decentralized storage arrangements, which are, however, not only a result of or response to the conditions of the respective technical supply infrastructure – networked or not. They are also an assemblage of human actors and their practices (e.g. urban residents and technicians), natural processes (e.g. seasonal rhythms and trees falling on power lines), legal and regulatory factors (e.g. import tariffs, building codes, or the lack of such), governance arrangements (e.g. nationwide, as for electricity, or regionally/county specific, as for water), technological and design factors (e.g. for battery manufacturing), material and immaterial flows (e.g. polyethene imports, capital, or technical knowledge), and a wider political economy (from the resellers of cooking oil cannisters to 'donor' countries). Each storage arrangement – whether a small LIB in a light bulb, or a large dam – is thus a node and result of myriad larger relations (‣ Chapters 5 & 7), underscoring the hybrid character of storage as a sociotechnical and socioecological assemblage of practices, containers, and 'stuff' (‣ Chapter 2.4).

However, there is another dimension to the hybridity of storage, namely that each storage arrangement, its respective infrastructure configuration, and its wider networks stand in reciprocal relations to each other (‣ assumptions in Chapter 3). Storage is not only constituted, it also constitutes – or rather, it *stabilizes*, *disrupts*, and *creates* (‣ Chapters 7 and 8.1). Contrary to individual storage dispositifs as mere reflections of HICs, all of the city‘s storage arrangements are also enabling agents. Small-scale storage is a prerequisite for urban residents to cope with intermittent supply and to be able to tap into a variety of supply sources (‣ Chapters 6 & 7), thus allowing for and resulting in technological heterogeneity in supply modes; which in turn leads to heterogeneity in the actors, practices, natures, etc. involved. Moreover, by applying *storage as a multi-scalar* *analytic* (‣Chapter 7) we can see that, in the case of Nairobi's waterscape, infrastructural heterogeneity depends on storage arrangements at different points and scales; and with storage, its artefacts, and auxiliary services attracting economic interests and enabling economic activities – mitungi retailing, water tank manufacturing, water vending, battery importing, SHS installing, e-waste recycling, etc. – there is a large landscape of actors benefiting from the storage-enabled heterogeneity of Nairobi‘s water and electricity infrastructure. At the same time, the state and its proxies – such as NCWSC and KPLC – can rely on, but also ignore (‣Chapter 8.1), domestic storage to cover spatial and temporal gaps left by idealized but simply not existing, universal grid supply.

Ultimately, I argue that on the one hand, storage – at all scales, but especially the myriad quotidian arrangements of households – stabilizes 'dysfunctional' systems of supposedly ever-flowing resources such as water and electricity (cf. Furlong, 2014). On the other hand, it co-produces and re-produces the infrastructural conditions – i.e. heterogeneity, fragmentation and intermittency – that make its existence necessary in the first place. Building on Jaglin‘s (2014: 436) observations that all kinds of infrastructural configurations and dispositifs are 'situated in institutional and organizational environments that have a certain inertia,' storage needs to be understood as a key reason for such systemic inertia. While Nairobi‘s 'infrastructure space' (Easterling 2016) is undoubtedly dynamic and constantly reshaped by minor and major forms of infrastructuring (‣Chapter 2.1), the historically persistent inadequacies and injustices in water and electricity supply are only possible because of, among other things, storage. In these cases, storage co-produces a place-specific 'resistance to change or resilience, which constrains what is possible' (Jaglin 2014: 436). Arguably, domestic storage has a more ambiguous portfolio of qualities and effects than simply maintaining the infrastructural status quo (‣Chapter 8.1), but its role in HICs in particular is not just to *be part of them*, but rather to be an important enabler and stabilizer. With this role, or rather 'agency' (Latour 2005), storage is an important agent also for broader relations and qualities of the city, such as socio-spatial fragmentation and individualization (Kasper et al. *forthcoming*), energy and environmental injustices (‣Chapter 6), newly emerging socialities and economies (‣Chapters 5 & 7), and much more. Ultimately, this results in a distinct articulation of urbanity – the 'storage city' – that is neither flat nor homogeneous (‣Chapters 4, 6 & 7), but through its own heterogeneity provides the opportunity for nuanced perspectives for critical investigations and for propositions in areas such as planning, design, and governance (‣Chapters 8.1 & 8.2).

8.1. **Storage as an analytic**

When I began to think about this project in 2020, I initially found a largely scattered and somewhat underwhelming landscape of literature and theory dealing with storage, especially from an infrastructural perspective and with the everyday urban in mind (▸Chapter 2.4). But in recent years, and arguably with a little more digging on my part, I have noticed an increase in storage-related publications and conversations that address storage more specifically, conceptually, and theoretically.[20] More so, as a global pandemic, several geopolitical and violent conflicts, and the first drastic effects of anthropogenic climate change reshape our planetary conditions, the previously idealized, uninterrupted, yet selected and selective flows of people, materials, knowledge, and capital between global cities and networked societies (cf. Castells 2008 [1996]; Sassen 1991) have recently come under more academic, public, and political scrutiny than ever before. Keeping 'stuff,' diversifying sources of supply, preparing for shortages, stockpiling essentials, having a backup; all that seems imperative and part of the zeitgeist, at all scales, from the household to the nation-state.[21] At the same time, in various 'mutating modernities' (Silver J 2023) of the global south, storage had never ceased to be an important part of infrastructural lifeworlds and the everyday urban. Water storage is nothing new to Nairobians. Although some parts and echelons of the city only began to engage with it again in the late twentieth century due to the erosion of piped supply (▸Chapter 7), many communities in Kenya's capital have always stored water (Akallah and Hård 2020). Similarly, electricity storage is not particularly contemporary either, although it has arguably increased in importance and prevalence (▸Chapter 6), in Nairobi and elsewhere.

And yet, suspending 'the circulation of 'stuff' for the purpose of its later use at some undefined point in the future' (▸Chapter 2.4) seems to have gained a new centrality and, in some cases, political weight in infrastructure planning, imaginaries, and technological applications: from massive state interventions in water and energy storage to the rather mundane keeping of excess

[20] Respective publications are referenced throughout this thesis, but related conversations also include panels at international conferences, such as the panel on „Storage: Infrastructures, Politics, Imaginaries“ (at the 2022 meeting of the Society for Social Studies of Science), where I presented early findings from this thesis, or on „Storage as (critical) infrastructure“ (at the 2025 KRITIS conference), co-organized by myself with Andrea Protschky.

[21] The assumption of a sudden increase in the importance of storage might be a biased and ethnocentric assessment based on my own experience, upbringing and socialization in a time and geography when and where the universal supply of resources such as water and electricity and the continuous expansion of connectivity seemed unquestionable, i.e. Western Europe in the 1990s and 2000s.

food and toilet paper at home.[22] While this wide range of storage types may, at first glance, bear little resemblance to the practices and artefacts in this thesis, I argue that highlighting storage and deliberately using *storage as an analytic* – multi-scalar or not (‣ Chapter 7) – for our understanding of all kinds of infrastructures, and their broader relations and meanings, is timely and promising. More than that, I hope that the empirics and analysis of this thesis provide inspiration and points of reference (‣ Chapter 9).

From flows to storage, and back again

Confronted with a relative lack of literature and theories on storage, I developed a keen, nearly stubborn interest in deliberately thinking about urban space and infrastructures through the moments, spaces, and artefacts of slowed down or completely stopped circulation. At first, and wrongly, I thus viewed and positioned storage and circulation as rather antithetical, as opposites, as obstructive counter-logics that must be in conflict with each other. But through my empirics and further readings it became more than clear that there is no storage without circulation, and no circulation without storage. The flows of water in Nairobi are only possible because of a situated interplay between circulatory/distributive and storage infrastructures at all scales and for all kinds of sources (‣ Chapter 7); and for electricity to flow through Kenya's national grid and reach most households in Nairobi, energy is extracted from storage arrangements that are usually massive in scale and socioecological as well as sociotechnical in nature. Prime examples are geothermal energy 'naturally' stored underground and hydraulic energy stored in dams, both of which account for more than 50% of the country's installed power generation capacity (EPRA 2024). All other ways of delivering energy to households with some degree of consistency also require energy storage: major and/or minor; by the state, utilities, companies, or private citizens; stored in charcoal, LNG, batteries, etc. (cf. Koohi-Fayegh and Rosen 2020; Marsden et al. 2024). Otherwise, intermittency is inevitable. So, in the multiple efforts to supply basic resources to households in Nairobi, the storage of both water and electricity at the domestic scale is just one way, albeit an infrastructurally necessary one, of ensuring that individual intermittency is minimized. Any kind

[22] Specific examples include floating LNG terminals in northern Germany to replace Russian gas imports (Brauers et al. 2021); 'green' hydrogen production and storage in Namibia for later export (Halloran et al. 2024); moving some of the data storage for the mobile app TikTok from China to the U.S. (connectCX 2025); *prepping* for all kinds of contingencies as a largely Western phenomenon (du Plessis and Husted 2024); storing food in refrigerators, pantries, and other spaces (Afriyie et al. 2023; Marshall 2023); and building massive and controversial dams along the Nile and other multilateral waterways (Etichia et al. 2024).

of supply shortage or interruption is *de facto* due, in part, to a lack of adequately buffering storage; somewhere between the source and the consumer, somewhere on the scale from public/major to individual/minor (‣ Figure 41).

That being said, the reciprocal relationship between storage and circulation as a synergistic pair that ensures the supply and availability of 'stuff' has been well elaborated and nuanced by other authors, particularly in relation to commodity storage and the circulation as well as accumulation of capital.[23] It was beyond the scope of my research, and never its intention, to explore the relationships between capital and domestic storage. And yet, my research has shown that any storage arrangement must be understood as a relational node within (urban) infrastructures, acting as a mediator of flows such as water and electricity, while also enabling, or rather *creating*, further circulations and relations; which may be material, ecological, social, spatial, or in the form of capital. Examples here are the multiple socioecological relations and newly created socialities and economies that emerge from multi-scalar water storage and its containers (‣ Chapters 5 & 7); or the injustices of battery use that can *swirl out* from the body to the planetary (‣ Chapter 6); or in congregated form as the 'storage city' as a relational assemblage of storage dispositifs and their relations to networked and non-networked infrastructures (‣ Chapter 4).

In the face of all the circulations and relations involved in any storage arrangement and any domestic dispositif, my empirical and analytical journey, which began with a deliberate turn away from flows and circulations, ends where it did not want to go. The domestic storage of water and electricity in Nairobi can only be understood through flows and relations that are, on the one hand, already embedded in the flows of *stored* 'stuff' and, on the other hand, also emerge from or relate to *storing* practices and *storage* artefacts (‣ Chapter 2.4). Consider the value chains and material flows of battery production and water tank manufacturing (‣ Chapters 6 & 7). Think of

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[23] Banoub and Martin's (2020) critical analysis of the storage of Newfoundland saltfish and American grain in the late nineteenth and twentieth centuries shows how advantages in storage technology and practices led to new ecological relations and, more importantly, to new flows of commodities and capital. Also with a Marxist lens, Simpson (2019: 122) shows for crude oil storage in contemporary North America how stopped circulation 'is not always indicative of imperfections in supply chain design or logistics, nor is it necessarily the consequence of an interruption,' but can be a deliberate part of resource circulation and capital accumulation. Drawing on both texts and many others, Randle's (2024a) wide-ranging literature review on the 'geographies of storage' further demonstrates how the notion of 'spatial fixity in relation to storage arrangements is revealed to be surprisingly slippery,' but rather that storage itself needs to be understood as self-circulating – think of the jerry can and its 'role as a transport and storage artefact' (‣ Chapter 5) – and ambiguous. Ultimately, storage as the temporarily suspended circulation of 'stuff' for 'the purpose of its later use at some undefined point in the future' (‣ Chapter 2.4) – be it saltfish, oil, water, or electricity – is a necessary component of making said 'stuff' available to consumers and ensuring the generation of value as well as the accumulation of capital..

the internationalized political economy of energy transitions in Kenya that transports and drives technologies and imaginaries of electricity storage (‣Chapter 6). Consider the social relations created or disrupted by water storage artefacts (‣Chapter 7). Ultimately, in moving *from flows to storage and back again*, we can enrich our ideas of the 'city of flows' (Kaika 2005), the networked or post-networked city (Coutard and Rutherford 2016), heterogeneous or hybrid infrastructures (Jaglin 2014), and related notions, not by rejecting them, but by consciously understanding and using storage as an inherently active and influential part of all these concepts and articulations.

The analytical 'tool power' of storage

Some critics of the literature on infrastructures in southern cities have cautioned that a tendency to accentuate complexity, multiplicity, and messiness might hinder more productive readings that could uncover important structures, patterns, and logics of urban and infrastructural conditions (Ahlers et al. 2014; cf. Brenner and Schmid 2015; ‣Chapter 1). Framing this critique as a question, we are asked: what does the recognition of attributes such as heterogeneity, incompleteness, and sociotechnical and socioecological hybridity actually contribute to understanding and ultimately addressing issues such as infrastructural injustice and environmental degradation? I strongly believe that critical, non-normative, and decentering engagements with infrastructures – for example, through postcolonial critique (‣Chapter 2.3), feminist critique (Acevedo-Guerrero et al. 2024), and more-than-human approaches (Barua 2023) – play a central role in revising and reimagining theories and possibilities of urban infrastructures that might otherwise not come to the fore. A case in point is this thesis on storage, which has been informed not only by 'a joyful and unapologetic fascination with the supposedly mundane' (‣Chapter 5), but also by influences such as STS-inspired infrastructure studies, postcolonial urban studies, and urban political ecology, all of which in their own ways consciously challenge and seek to decenter orthodox conceptions of the urban and its infrastructures (‣Chapter 2.3). And yet, the ambition to go beyond empiricism and descriptivism to find structures, patterns, and logics also motivates my work for this dissertation. Fortunately, the study of storage offers not only a logic of its own but, at the same time, new perspectives on structures or patterns of urban infrastructures.

Instead of perpetuating the analysis of 'Nairobi and its infrastructural articulations as full of fragmented, chaotic, and unruly contradictions only' (‣Chapter 1) – or simply as heterogeneous, incomplete, etc. – the research on storage allowed me to conceptualize and theorize across two infrastructures for a universal, albeit not singular, story of Nairobi's infrastructure space. On the one hand, storage – especially the decentralized, minor arrangements of tanks, jerry cans, and batteries of all kinds – is itself a logic, a pattern, a structure. Specifically, a multi-sited structure that ‘holds the city together’ (▸ Chapter 5); a kaleidoscopic pattern that can be found in/for every household, albeit as idiosyncratic dispositifs; and a spatial and organizational logic that orders the city, its infrastructures and architectures, and everyday activities. As much as flows, circulations, mobilities, and metabolisms, with their many valuable applications, have been dominant logics in the way urban space is structured, conceptualized, or represented, storage – that blatant reminder of physical container space (▸ Chapter 5) – is another logic that orders spaces and relations, cities and infrastructures. The urban expression of this order is the ‘storage city’ (▸ Chapter 4). On the other hand, storage also makes it possible to uncover and discuss other logics and patterns. For example, when used as an analytic, storage allows for a nuanced perspective on infrastructural questions of supply, access, their (in)equities and geographies. Water and energy security become not only questions of connectivity, access and its constraints, but also of individual capacities, locales, and responsibilities for storage. Both, to serve as a logic by itself and to allow for new perspectives, is

Figure 43: Buckets and basins full of stored water on a balcony in Eastleigh, photo by author (2022).

the analytical ‘tool power’ of storage – to invert Meehan‘s (2014) original meaning of the phrase – from which four (A. B. C, D) particularly relevant, interrelated points and principles stand out.

A

A non-normative reading of storage

First and foremost, storage is not inherently good or bad, constructive or destructive, aspirational or rejectable for urban infrastructures and the academic, political, or public imaginaries of them. At least, it should not be. However, as noted in Chapter 7, in many to most accounts from southern cities, minor water storage is largely presented as a problematic stopgap solution, and my conversations with so-called experts in Nairobi’s water sector also often addressed problems of and with domestic water storage, as something that is done wrong and leads to health problems, or as something that needs to be overcome by achieving universal network supply. Conversely, major storage was largely seen by the experts and the few households that talked about it as something positive and problem-solving, and yet – as shown in Chapter 7 – neither minor, intermediate, nor major water storage is simply positive or negative. The large storage arrangements of AWWDA and NCWSC provide the bulk of Nairobi‘s water supply, but they still affect local communities and ecologies; and while certain types of domestic storage may have negative impacts on individual health and system-wide equity, they are nonetheless a key enabler of water access for virtually every Nairobian. When it comes to electricity storage, batteries of all types and sizes are currently perceived primarily as a solution rather than a problem, at least in most public and global debates. With necessary energy transitions and dynamic changes in technology as the driving forces, many believe – with good reason – that ‘the battery is ready to power the world’ (Gold and Foldy 2021); specifically:

> ‘Batteries will help store electricity from solar panels and wind turbines. Batteries will help improve the reliability, versatility, and efficiency of the electrical grid. And batteries will power a new generation of zero-emissions vehicles, from cars to bicycles to airplanes.’ (Turner 2022)

However, as with water storage, electrochemical energy storage with batteries is not inherently good or bad. There is already extensive evidence that both global and local battery production is associated with large externalities and injustices (Kara 2023; Mrozik et al. 2021; Turner 2022), and my findings from Nairobi also point to place-specific injustices in the distribution of benefits and burdens of increased household battery use (‣ Chapter 6). Ultimately, all of this suggests that when using *storage as an analytic*, or simply when investigating any storage arrangement, we should be wary of potentially normative, preconceived notions and framings. Instead, I argue for a deliberately non-normative approach to the study of storage – regardless of resource or scale.

B

The ambiguous 'tool power' of storage

Reflecting further on both a non-normative reading of storage and the actual 'tool power' of storage arrangements, it is nonetheless evident that storage still does something to and within the infrastructural configurations of which it is not only a part, but also enables (see above). Chapter 6 shows how the multiple capacities of batteries – namely, *firming*, *enabling*, *buffering*, and *fixing* – largely help those who are 'already electrically privileged,' while others gain little but risk being affected by the externalities of battery production and disposal. More generally, Chapter 7 has shown how water storage – and, I argue, by extension, any storage arrangement – *stabilizes*, *disrupts*, and *creates* myriad sociotechnical and socioecological relations, including infrastructure configurations. Likewise, a simple receptacle such as a mtungi 'entangles, within itself and through the practices it necessitates, a world of relations, infrastructures, flows' while also having an 'ambiguous role as a transport and storage artefact' (Chapter 5).

Overall, the role that storage plays in the lives and infrastructures of Nairobi appears to be a multiple and ambiguous one, echoing Foli's (2024) observations in Accra, where a waterway and important infrastructure plays an inherently ambiguous role as both a risk and a resource, which is also narrated differently and thus shapes ambiguous politics around such infrastructures. Similarly, storage, through its interconnected but multiple scales and differentiated technologies and applications, can help urban residents ensure their access to water, electricity, or other resources, while at the same time undermining the ability of larger networks and systems, both technical and natural, to provide these resources equitably and sustainably. Such ambiguity is then reflected in the larger narratives, politics, and governance of storage arrangements, which vary significantly depending on scale, resource, and technology, and can range from total neglect or problematization – for example, domestic water storage – to political and governmental support – for example, battery use in SHS or EVs. Thus, using *storage as a non-normative analytic* is not to ignore the effects of storage, and the conditions and politics of the 'storage city,' but rather to recognize that storage can *be* and *do* multiple things at once.

C

Domestic storage and infrastructural inequalities/injustices

While a non-normative reading of storage and a recognition of its ambiguous 'tool power' helps to further decenter and critically inform infrastructure research and similar endeavors, my findings from Nairobi also warrant a more critical reflection. Household storage of water and electricity in Nairobi should not be framed in any *ad hoc* way, but my research nonetheless points to the troubling potential of household storage as a stabilizing, even exacerbating force of urban-infrastructural inequalities. With an intentional justice lens applied in Chapter 6, it becomes clear that the current 'rise of the batteryscape' is not benefiting all households equally, and may even be exacerbating disparities in energy security and related injustices. Had I applied this lens to water storage also, I am confident that similar but differently nuanced findings would emerge, since, for example, storage capacities depend strongly on the financial and spatial capacities of households. Neither the 'storage city,' the batteryscape, nor any other socio-spatial expression of domestic storage is flat (‣Chapters 6 & 7). Rather, storage is an expression, symptom, and co-producer of the current individualization and micro-fragmentation of infrastructural responsibilities in Nairobi (cf. Kasper et al. *forthcoming*), where social contracts between the state, residents, and various service providers have become fluid, fragile, and conflictual (de Bercegol and Monstadt 2018; Jeppesen 2025).

As all urban residents of Nairobi navigate unreliable, heterogeneous, and dynamic infrastructure configurations on a daily basis, domestic storage helps to secure their supply. And yet, individual storage dispositifs of different scale and articulation have, of course, different effects on broader networks and relations, and on individual supply security. For example, relatively large but still minor water storage in underground tanks and borehole tanks affect the network-wide and/or long-term availability of water for all in the interest of individualized water security; and extensive backup systems and battery-operated SHS also ensure individualized energy security while disconnecting from the national grid and the shared experience of its inadequacies. Both of these comprehensive forms of domestic storage negatively affect the metabolic, technological, and social cohesion of infrastructure configurations, while households without such elaborate storage dispositifs are left with less storage capacity and thus less availability of water and electricity, while also having less impact on their respective infrastructure configurations. Ultimately, storage may be a helpful and necessary coping arrangement for all households in Nairobi, but due to the largely individualized and privatized way in which domestic storage is currently deployed (‣Chapter 8.2), its ambiguous 'tool power' is not being utilized for more equal and sustainable provision of basic resources, but rather the opposite.

D

The spatial question(s) of storage

Because water containers – and even batteries, though to a much lesser degree – take up physical space, storage obviously becomes a spatial issue; but upon closer inspection, the relationship between space and storage is more nuanced. Chapters 4 and 7 allude to the simple conundrum of space *for* storage, and when household respondents, particularly those in low-income settings and small houses, were asked if they would like to store more water and/or electricity, many expressed interests but also identified it as partly a spatial issue, especially for water: 'I am not comfortable [with my storage] because actually the house is small … So, I have piled the jerry cans on top of each other … but it takes a lot of space' (Joshua, tenant, Ongata Rongai). Similar sentiments were expressed by several respondents in apartment buildings in lower income areas, for example in parts of Ongata Rongai and Eastleigh, and for the latter some qualitative reports from the 'Urban Waterscapes and the Pandemic' project also mention this (‣ Chapter 3.2). Conversely, respondents in informalized and dense Kibera were more ambivalent about their interest in more (water) storage, citing financial constraints and the small size of their homes, but in some cases flagging the very short distances to the nearest water point, which make more domestic storage unnecessary.

Accordingly, while 'container space' is still an important factor to consider, the spatial question of storage is not simply one of volume only. Rather, it is largely a relational and topological one. On the one hand, the need for and scope of domestic storage may depend on a household's relative location to a reliable source, such as a water point. If you don't have a direct and fully reliable supply to your home, or an easily accessible water point just outside, you tend to store as much as possible. This is especially true in multistorey apartment buildings with inadequate common water storage, where households often fill as many containers as possible when water actually comes into their homes through the building's pipes (‣ Figure 43); rather than having to carry water up many flights of stairs should water not come as expected. Here, one's storage dispositif is crucially shaped by one's spatial – horizontal and vertical – relationship to a relatively accessible source. The scale and importance of storage reveals a relational, differentiated and granular landscape of infrastructural access and (in)equality that is not only about direct, formal or informal, connections or lack thereof, but about Euclidian space for storage as well as verticality, reliability and supply rhythms. On the other hand, the spatial question of storage is also about its relative scale and position within networks or configurations, i.e. the place-specific topology of storage and infrastructural responsibilities (‣ Chapters 7 & 8.2). Ultimately, spatializing and localizing storage arrangements in architectures, urban space, and infrastructure networks helps to utilize the full potential of *storage as an analytic*, as it reveals further logics and allows for nuanced perspectives that transcend classic dichotomies such as connected/disconnected, formal/informal, and such like.

8.2. The ‘storage city’ as a liminal and propositional space

‘Our responsibility ends at the meter point.’

This was the response of my contact at NCWSC in our very first conversation in 2021, when asked if the water utility was concerned or involved in any way with any kind of private/domestic water storage in Nairobi. ‘Our responsibility ends at the meter point.’ This phrase has stuck with me ever since, as it represents the absence of domestic storage in any understandings and imaginaries of the utility and many other state and non-state actors for Nairobi‘s infrastructural present and future. It also shows how the ‘storage city’ is largely a liminal, barely regulated and rather ‘exceptionally’ planned space (cf. Bize and Schramm 2023) that weaves through Nairobi, leaving plenty of potential for proposals and interventions. Similar to the water utility, KPLC did not show much concern or interest in battery backup systems, battery-powered lighting and the like either, because their responsibility also ends *at the meter point*, at the moment when the resource in question flows from the public network to the private places of households. Such orderly separation of utility/system and consumer is indicative of the idealized, centralized systems of the networked city (Graham and Marvin 2001), which has dominated and continues to dominate state-led rationales for infrastructure provision in Nairobi (de Bercegol and Monstadt 2018; Schramm et al. 2023). However, as shown, the shortcomings of the national electricity grid and the county-wide water network necessitate various coping mechanisms, most of which involve storage, as do all post-networked or non-networked articulations of Nairobi‘s infrastructure space. Domestic storage, its practices and artefacts, thus become infrastructure (‣ Chapter 4), and the spatial question of storage becomes again a relational, topological question (‣ Chapter 8.1), specifically about the locus of infrastructural responsibilities.

Nairobi‘s infrastructural heterogeneity – coupled with intermittent supply from all kinds of sources, both for water and electricity – demands decentralization of storage to domestic/private spaces (cf. Bize 2017). Instead of a comparatively small number of major storage facilities provided by the state or utilities only, Nairobi‘s water and electricity configurations are characterized by a myriad of minor storage arrangements that are largely the responsibility of households and property owners. This spatio-infrastructural pattern, or topology, of decentralized, atomized storage enables the exacerbation of infrastructural inequities and results in systemic inertia, as the shortcomings of both networked and non-networked modes of supply are ‘masked’ and stabilized by household storage (‣ Chapters 7 & 8.1). Given the need for and prevalence of domestic storage, the locus of infrastructural responsibility lies not with the state, its proxies, or large corporations, but with individual households. Where storage is typically located and how it is distributed, e.g. before or after *the meter point*, is thus indicative of place-specific infrastructural realities and responsibilities. And yet, with the few exceptions of some NGOs in the water sector that address both basic supply and household storage in some of their programs, albeit largely unrelated,[24] the 'storage city' of Nairobi is not a concern of NCWSC, KPLC, or any government or regulatory body; especially not from a systemic or infrastructural perspective. Domestic storage of water and electricity is not a consideration, nor is it even mentioned in any of planning documents for the NCC – sector-specific or otherwise. With the minor exceptions of the basic but often ignored guidelines for water storage in the *National Building Code* (interview, Founder, Zima Homes; ‣ Chapter 4) and the technical standards and import incentives for batteries (‣ Chapter 6), the 'storage city' and thus the continuous infrastructuring of Nairobi through domestic storage is left to the uncoordinated and largely unregulated efforts of the private sector – formal or informal – and the city's residents with their individual storage capacities and dispositifs. If at all, water storage is primarily framed and addressed as a national issue on a major scale, with no reference to minor/private storage, despite the multi-scalar and interrelated nature of storage (‣ Chapter 7). Case in point here is that the National Water Harvesting & Storage Authority (NWHSA) – despite the 'storage' in its name – is not mentioned once in this dissertation because its mandate is essentially concerned only with major water storage projects on regional and national scale.[25] And while Kenya is preparing to build its first *Utility-scale Battery Energy Storage System* with funding from the World Bank and the Green Climate Fund (World Bank 2024), the ever-growing batteryscape full of minor electricity storage in Nairobi remains largely unregulated and unrecognized (‣ Chapter 6).

Ultimately, the 'storage city' of Nairobi is, for most of its parts, a liminal space largely ignored by the state, its planners and regulators, or even community-based or non-governmental actors.

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[24] Examples from my fieldwork and interviews include SHOFCO's efforts to decentralize water supply in informalized settlements through micro-grids and water ATMs, and their information campaigns on how to treat and use water stored at home. Similarly, KWAHO is involved in a water supply project, but also has projects on household water containers with filtration systems.

[25] After several unsuccessful attempts to contact the NWHSA, including unannounced visits to its headquarters in Nairobi, I gave up trying to speak to a representative. However, according to all kinds of sources, such as their own online resources and the accounts of other actors in the water sector, the work and mandate of the NWHSA has only minimal relation to domestic water supply and storage, i.e. through regulations on water harvesting at the building scale.

But given its implications for infrastructural injustices and multi-scalar, socioecological relations (‣ Chapters 6 & 7), the 'storage city' is nonetheless a highly political and important terrain, currently demarcated by the arbitrary line that neatly separates public/major and private/minor infrastructure. In its relationship to planning, governance, and regulation, the contemporary 'storage city' of Nairobi thus reminds us of what Schramm and Bize (2023) have called 'planning by exception.' As a dual logic of urban planning in Nairobi, the city's urbanization is driven by 'exceptions from regulation,' especially for large developments, and by 'exceptional regulations' as a form of urban planning performed by (lower-level) authorities outside of the actual planning offices, which particularly affect and regulate, sometimes through deliberate omission, the many 'grey,' marginalized, informalized, and liminal spaces and activities of Nairobi (ibid.; cf. Kimari 2024; Yiftachel 2009). With such an understanding of how the urban is currently planned and produced in Nairobi, the 'storage city' can be read, on the one hand, as the result of sheer ignorance and omission on the part of planning and infrastructure authorities. On the other hand, the 'storage city' is shaped by the 'exceptional regulations' of non-planning agencies and actors, their guidelines, policies, and activities. These actors are not concerned with the urban and its infrastructure *per se*, and – I argue – in the case of the 'storage city' we need to expand this actor landscape even further to include a variety of private and non-state actors who, in synergy with urban residents, significantly shape the technologies and articulations of minor infrastructures in Nairobi. Examples include state agencies such as EPRA, KNBS, and the MoE with their battery standards and import incentives (‣ Chapter 6), but even cooking oil companies, whose product containers eventually become part of Nairobi's water infrastructure (‣ Chapter 5). While such a broad ontology – from the ignorance of planning offices to urban infrastructuring through cooking oil canisters – may stretch the notion of urban planning extremely thin and wide, it yet opens up a large propositional space for discussing storage not only as an analytic, but also as a way and entry point for interventions into the infrastructural space of Nairobi and elsewhere.

Using storage as a propositional space

Since (domestic) storage is infrastructure (‣ Chapter 4), and since any infrastructure is an inherently propositional space with the potential to improve the lives of urban residents (‣ Chapter 2.3), storage deserves attention from all kinds of spatial/urban disciplines and practices. Not only from urban planning and governance, but also from various design disciplines, trade policy, community action, architecture, and more, due to the highly relational, sociotechnical, and socioecological nature of storage and the large liminal space that is the 'storage city.' At every scale, for every configuration and dispositif, there is an opportunity to discuss and advance storage as a space of possibilities and propositions (cf. Baptista and Cirolia 2022; Schramm and Ibrahim 2021). Recognizing the potential and importance of energy storage at different scales, Marsden and colleagues (2024) argue that it is possible and necessary to think about storage

> 'not as a technical solution to a technical problem, but as a necessary part of a more fundamental debate about energy demand and the future of consumption. … Rather than thinking about the types of storage needed to preserve the status quo, the challenge is to imagine the temporal, spatial and organisational qualities of energy systems, including systems of storage, that might be compatible with much lower carbon ways of life, and with very different patterns and levels of demand.'

I fully agree with their sentiments, but would add that a) the storage of other resources, such as water, deserves the same attention, and b) a lower carbon way of life should not be the only goal when reimagining storage to challenge the status quo of infrastructural landscapes. Moreover, given the potential or even tendency of domestic storage to exacerbate infrastructural inequalities (‣ Chapter 8.1), we need to be aware of the 'social life of storage' (Bize 2017) so that we do not advance ideas that address pressing issues such as climate change only in technological and/or economic terms. Especially for urban-infrastructural settings that are heterogeneous and historically charged with inequalities, as is the case in Nairobi (‣ Chapter 2.1), thinking through and with storage for new infrastructural propositions of major or minor articulation must have the goal of ensuring that all city residents benefit as equally as possible from the ambiguous 'tool power' of storage, regardless of their socioeconomic situation, geographic location, or pre-existing sociotechnical dispositif (‣ Chapters 6 & 8.1). This echoes Jon Silver's (2023: 253) call for new propositions for the 'Infrastructural South,' rooted in 'commitments to democratize and socialize power and ownership over urban networks, its primary task being to address techno-environmental injustices.' A more shared and democratized ownership of storage – rather than the largely micro-fragmented and individualized way in which the 'storage city' is currently organized – must critically embrace and work with the place-specific heterogeneity and hybridity of particular infrastructure configurations. By actively rejecting a premature problematization and/or promotion of particular types and scales of storage (‣ Chapter 8.1), planners, policy makers, regulators, private companies, and communities are challenged to work with both storage and infrastructural heterogeneity to design and deploy 'new forms of decentralized, autonomous, and localized systems … beyond the logics of centrally planned large-scale technical networks but deliver the same standards of urban services' (Silver J 2023: 257). I thus argue again for a ‚pragmatic turn' to storage (cf. Jaglin 2016; ▸Chapter 7) as a propositional space and inherent part of (heterogeneous) urban infrastructures that deserves more attention from a wide range of disciplines and perspectives.

Obviously, water and electricity storage have significant specificities, internal differentiations, and situated articulations in terms of technologies, costs, spatial needs, and actor landscapes, as does the storage of any other resource in any other city or geography. And yet, since storage itself is an infrastructural logic and topology that has similarities across resources, I present on the following pages my five key proposals (I, II, III, IV, V) for working consciously with storage as infrastructure in Nairobi, recognizing but not focusing only on any one resource or type and scale of storage.

Figure 44: Drums full of used batteries; photo provided by EWIK.

I

Planning and governing the collective 'storage city'

Recognizing that domestic/minor storage is a vital part of urban infrastructures, urban and sectoral planning should integrate a multi-scalar and holistic view of storage and its variegated and decentralized topology. Since the infrastructural conditions in Nairobi are unlikely to change soon to fully centralized, universal and reliable supply systems, but rather are characterized by continued decentralization through off-grid modes such as SHS and boreholes, future plans for urban development in Nairobi should incorporate storage solutions in all residential settings, informalized and otherwise, and address and balance the needs of all urban residents. This includes promoting, planning, and developing guidelines for more neighborhood-scale community storage arrangements that are a) collectively and transparently organized, and b) allow for the storage of water, electricity, or other resources from a variety of sources, networked or not. Similarly, urban planning documents should clearly include policies that require, or at least encourage, the inclusion of adequate storage solutions in new buildings and housing complexes, especially in multistorey apartment buildings where, for example, communal water storage is often inadequate. The *National Building Code* should thus be reviewed to ensure that a) current water storage guidelines are updated and adapted to different housing typologies, and b) energy/electricity storage is also included. All policies should define not only a required minimum storage capacity per household/capita to ensure that all residents have equitable access to essential resources, but also maximum capacities to combat overextraction from the grid or other sources. Taken together, this approach emphasizes the democratization of resources, ensuring equitable storage and thus access to basic resources for all urban residents and promoting the goal of shared power and ownership. While formal government regulations may not be strictly enforced, urban planning and governance can still prioritize or incentivize adequate storage, including integrating storage solutions into public buildings and spaces. Successful implementation of democratized and multi-scalar storage solutions as part of official infrastructural imaginaries requires collaboration between the state, non-state actors, and local communities. Policymakers should encourage the use of existing collaborative and local governance structures through which communities take an active role in decision-making and management of storage infrastructure. NGOs, CBOs and local community groups should be involved in co-designing storage solutions that meet both individual and collective needs. This collaborative approach ensures that storage arrangements address the unique needs of different neighborhoods or even buildings while promoting broader social equity. Ultimately, the NCC, along with its respective departments and neighboring counties, must lead and coordinate a strategy and effort to integrate storage as a key component of sector-specific plans and regional visions that aim for a just and equitable distribution of the burdens and benefits of storage.

II

‘Exceptional’ regulations and policies for the ‘storage city’

All actors involved or invested in Nairobi‘s infrastructure space, especially for water and electricity, need to recognize that the infrastructuring of the city takes place beyond targeted and/or sector-specific plans and traditional planning efforts and regulations by actors who may or may not have an infrastructural mandate. Recognizing the planning and making of urban infrastructure through ‘exceptional regulations’ means identifying new sites and vectors for spatial, material, and organizational reorganization through, in this case, storage. Thus, to support equitable access to essential resources and promote a sustainable and just ‘storage city,’ policymakers at the county and national levels should integrate the infrastructural importance of supported and regulated storage solutions into a variety of policies and regulations. Trade and manufacturing policies should promote local value chains for the production of storage containers, such as batteries for SHS and lighting, and water tanks. Policies, import tax rebates, and capacity programs that promote equitable and sustainable production with localized design and recycling practices are essential. In addition, clear technical standards and guidelines for household water and electricity storage arrangements and their single technical parts should be established or adapted to ensure that they meet safety, environmental, and functional requirements. This will require regulators and utilities such as EPRA, NWHSA, KPLC, and NCWSC to a) recognize the importance of domestic storage, b) expand their mandates accordingly, and c) work with communities, architects, and private companies involved in the production of storage containers to ensure that these standards reflect local needs and capacities. In addition, utilities and other water and electricity providers could offer, directly or through third parties, integrated storage solutions that come with each meter point or other source, e.g. small battery systems that can act as an integrated UPS to power essential appliances during an outage. Utilizing an expanded mandate for utilities and regulators ensures compatibility with existing infrastructure while promoting decentralized solutions that can increase security of supply for all urban residents.

Adaptable designs and sustainable manufacturing for the 'storage city'

Designers, manufacturers, and various other actors in both the formal and informal sectors have a critical role to play in addressing the need for accessible, sustainable, and adaptable storage solutions that promote infrastructural justice. Industrial and product designers should prioritize the creation of modular and scalable storage containers, both for water and electricity, that can be tailored to meet the diverse needs of different households, architectures, and communities (cf. Staddon and Brewis 2024). Flexibility and adaptability need to ensure that users can change storage arrangements as their needs evolve, to accommodate a wide range of socioeconomic and spatio-architectural situations. However, standards and norms across manufacturers can help maintain functional efficiency and compatibility. Design should also prioritize ease of maintenance, for example by using durable materials that prevent long-term contamination and reduce repair or replacement costs. Specifically, water tanks and super drums should be designed with regular interior cleaning in mind, and manufacturers should provide maintenance and cleaning guidelines; jerry cans – including and especially those initially used as cooking oil canisters – should not only be sturdily stackable to minimize their spatial footprint, but should also be easy to carry and have a sufficiently wide but secure opening and lid to allow interior cleaning and protection from contamination; and battery solutions for domestic use should have easily replaceable parts, such as individual LIB cells that can be swapped. Actual design processes should include user experience and testing with communities and households from different geographical and architectural settings in Nairobi to ensure a) adaptability and potential customization in different settings, and b) that the storage solutions are culturally relevant, affordable, and practical for the intended users. Ultimately, user- and community-driven design processes – which must also include the expertise and needs of key peripheral actors, such as cooking oil companies and EV companies, who could provide great synergy – should inform and should be informed by technical standards and regulatory guidelines (see above) that must be met in final production designs. All storage containers should then be manufactured using sustainable components and materials, especially locally sourced or recyclable options where possible. This not only reduces environmental impact, but also supports local economies, makes storage solutions more affordable, and reflects the policy recommendations above. Local businesses, including small cooperatives and recycling initiatives, can play a central role in value chains and production process, reducing reliance on imported goods while promoting community-driven circular economy practices. Existing recycling networks can transform waste materials into resources for usable storage containers, e.g. polyethylene for water containers, while larger and more technologically sophisticated processing of battery waste should be established at the national level. Overall, sector-specific strategies for the design and production of storage containers as part of larger infrastructure configurations and value chains, in coordination with national and district governments as well as private companies and informal actors, should provide guidance and incentives to design and produce locally for local needs.

Figure 45: Poster with the product portfolio of Kentainers; photo by author (2023).

IV

Constructing (for) the 'storage city'

Architects, along with real estate developers, building engineers, and property owners, have a key role to play in addressing urban storage needs through spatial and architectural solutions that cater for both individual households and communities, especially in Nairobi's many multistorey apartment buildings. For residential developments, it is essential to integrate flexible, adaptable storage spaces within buildings that meet minimum and maximum storage capacity standards (see *Point I*). These spaces should be designed to accommodate a variety of storage needs, from water tanks to battery backup systems and more, and should be easily adaptable as residents' needs change. By prioritizing multi-use and modular storage areas of varying sizes and accessibilities, architects and developers can ensure that storage arrangements are a) space efficient, b) communally organized, and c) provide the opportunity, but not the need, for individual solutions. For communal storage, the focus should be on designing shared spaces and arrangements that serve multiple households with direct and easy access, especially in high-density or informalized settlements. These spaces could include communal water tanks or SHS with battery systems that ensure access to essential resources at all times, while promoting a sense of community ownership and shared responsibility. In addition, individual and lockable spaces or small structures should be added or incentivized in front of individual homes to allow for safe storage by individual households. By designing all these solutions with flexibility in mind, they can be scaled up or down, making them suitable for both temporary and long-term needs dependent on the larger infrastructural configuration. By creating spaces that support both communal and individual storage needs, developers and property owners can ensure that their properties are able to accommodate different and evolving forms of infrastructural supply, whether networked or not, and provide added benefit and value to their tenants, while encouraging and relying on tenant communities to manage their resources effectively and independently.

Ownership, care, and redistribution in the 'storage city'

Since household storage is currently a dominant but largely individualized response to the heterogeneity and intermittency of Nairobi's infrastructure space, individual households are key actors in the present and future of the 'storage city.' Supporting individual households to manage their own water and energy storage is critical, as is encouraging shared and communal forms of storage. Economic incentives and policies that support low-cost storage solutions, especially for marginalized households, are one piece of the puzzle, as are adapted designs and architectural solutions that support the uptake of appropriate storage technologies and promote easy care and maintenance practices. At the same time, community-based initiatives, from informal groups of immediate neighbors to established CBOs, can democratize access to resources through shared battery systems – mobile or static – and communal and self-managed water storage in common areas or public spaces. These solutions are designed to promote collective responsibility and solidarity, ensuring that the costs and responsibilities of storage are more equitably distributed within communities. In addition, such storage solutions for particularly marginalized communities and areas should be financially supported through redistribution schemes that tax or charge those with extensive storage capacities, regardless of the source of their supply. To further sustain community initiatives with shared ownership of decentralized storage, the establishment of local repair and maintenance networks, as well as educational programs, is essential. Partnerships with vocational schools or local NGOs can help residents develop the skills necessary to maintain their individual and/or communal storage arrangements ensuring long-term reliability. In addition, community monitoring programs facilitated by NGOs and CBOs can provide data to advocate for better policies and technical improvements. Again, these capacity and education efforts should be supported through financial redistribution and additional charges to those properties or households in Nairobi that store the respective resources extensively. While additional fees and their enforcement based on storage capacity may be difficult to fully implement, additional incentives or modes of distributing the burdens and benefits of the 'storage city' equally across Nairobi must be at the core of any effort to use storage as a propositional space.

9. Concluding

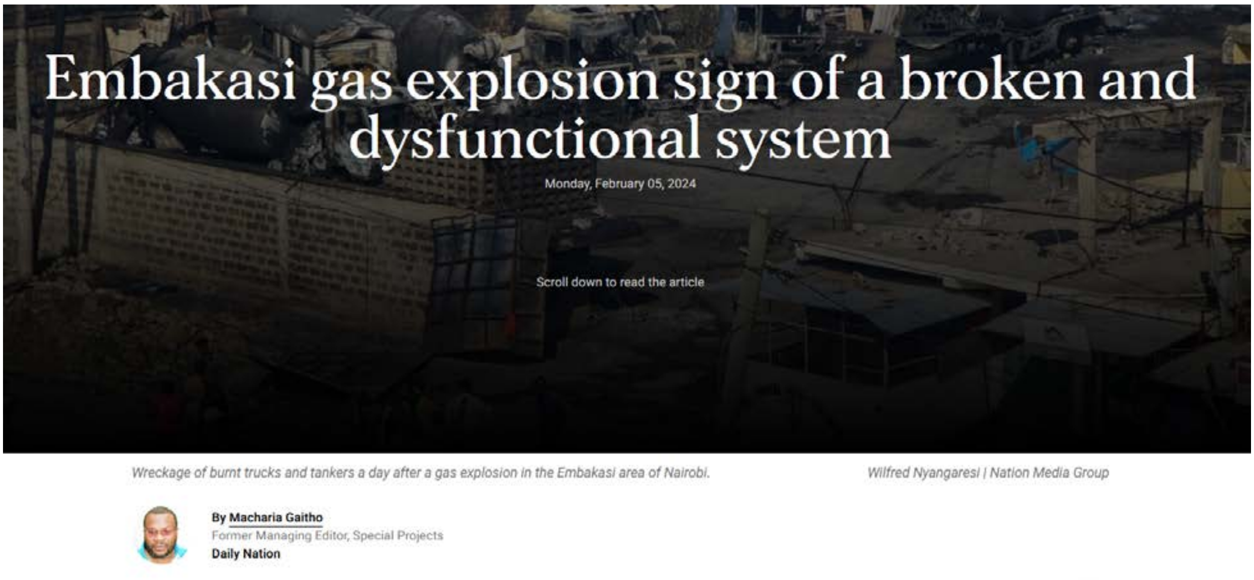
A research agenda

Figure 46: Street scene with a water bowser and power lines in Westlands; photo by author (2023).

Just before midnight on February 1, 2024, a massive shockwave shakes the southern parts of Nyayo Estate in densely populated Embakasi, just a few kilometers north of Nairobi's international airport. The violent explosion occurred at an 'illegal gas depot,' packed with several trucks and used for distribution, storage, and refilling of LPG into smaller cylinders, e.g. for domestic use (‣ Figure 7). Approximately 300 people were injured, with ten deaths ultimately counted, and numerous properties, apartments, and vehicles in the area were severely damaged. The event made international headlines, and local politicians and police were quick to blame the site's owner and the National Environment Management Agency (NEMA), which had wrongly issued a license for the site that should not have been located so close to residential areas (Al Jazeera 2024; Munguti 2024). However, for many Nairobians, as well as for the media, the tragedy of an exploding LPG storage site was a 'sign of a broken and dysfunctional system' (‣ Figure 47), in which urban residents are affected, sometimes brutally, by the inadequacies, irregularities, and inequitable distribution of basic resources such as gaseous energy, and by the lack of effectively enforced urban planning regulations.

For me, who had just left Nairobi two weeks before the explosion, these sentiments rang true, but the event also exemplified how the 'storage city' can be a dangerous, even deadly space, and how some forms of 'planning by exception' can have violent consequences. In this case, it was not water or electricity that was being stored, nor was the gas being stored in residential spaces. But the 'storage city' is multi-scalar, not tied to specific sites, but with multiple locations and resources stored at different points in supply chains, outside and inside single cities, until the resources reach households or other consumers, who – amid infrastructural heterogeneity and intermittency – store all kinds of 'stuff': water, data, cash, waste, electricity, various other forms of energy such as charcoal, diesel, or LPG. It was beyond the scope of this study to explore the storage of other resources as well, but I am confident that – with an infrastructural lens and the use of *storage as an analytic* (‣ Chapter 8.1) – the variegated roles, citywide and systemic significance, and multi-scalar relations of storage arrangements would also come to the fore in resource-specific articulations if we shift our gaze to the storage of various other 'stuff.' With this in mind, I firmly believe that there is a huge untapped potential in using *storage as a propositional space* (‣ Chapter 8.2), and thus reimagining and ultimately implementing infrastructural solutions that serve the goal of equitably distributing the benefits and burdens of urban infrastructures.

Combining a critical sensibility with a non-normative reading of storage and 'joyful explorations of the urban mundane' (‣ Chapter 5) has proven to be a highly productive for this dissertation



Embakasi gas explosion sign of a broken and dysfunctional system

Monday, February 05, 2024

Scroll down to read the article

Wreckage of burnt trucks and tankers a day after a gas explosion in the Embakasi area of Nairobi. Wilfred Nyangaresi | Nation Media Group

By Macharia Gaitho
Former Managing Editor, Special Projects
Daily Nation

Figure 47: Newpaper article in the Nation *about the Embakasi gas explosion; source: Gaitho 2024.*

project. By rooting research in mundane yet crucial storage containers such as water tanks, jerry cans, and batteries – but potentially also LPG cylinders, septic tanks, flash drives, and cell phones – we are able to identify and discuss the indispensable role of decentralized storage within broader infrastructural configurations, heterogeneous or otherwise. Such research challenges orthodox views of modern infrastructures that emphasize centralized and continuous flows. Classical notions of distributive, networked or non-networked infrastructures are not to be dismissed, but rather enriched by a greater integration of storage as an active and enabling force in urban infrastructures, rather than a passive element and an afterthought. Whether it is water containers that provide constant access to water or batteries that maintain 'modernity's illusive promise of continuous, uninterrupted supply' (Cross, in: de Seta et al. 2017), storage arrangements and individual household dispositifs serve as critical stabilizers of infrastructure configurations characterized by heterogeneous, intermittent, and unreliable supply modes. Moreover, they also perpetuate the very fragmentation and inequality they help to mitigate, creating a complex feedback loop that also perpetuates infrastructural heterogeneity.

Looking ahead, I intend for this study to provide a valuable framework and points of reference for rethinking infrastructure in different cities and geographies, southern or otherwise. As states, cities, communities, and individual households grapple with all kinds of transformations, disruptions, and 'infrastructural events' (Carse 2017; cf. Kasper et al. *forthcoming*), recognizing the agency and ambiguous 'tool power' (Meehan 2014) of storage at various scales provides insights for just and sustainable planning, design, and governance of infrastructure in cities and elsewhere. I therefore argue strongly for further explorations of storage, especially but not only in its minor, mundane, and often domestic articulations, as starting points. Such efforts also have the task of critically assessing and advancing our conceptual understandings of 'storage,' which I have defined for the purposes of this thesis as 'a sociotechnical and socioecological assemblage of *storing* practices, *storage* containers, and *stored* 'stuff' that temporarily suspends the circulation of said 'stuff' for the purpose of its later use at some undefined point in the future' (‣ Chapter 2.4). But how does this definition stand up to other empirical, analytical, and theoretical scrutiny? How useful is this definition conceptually, theoretically, and practically for the fields of urban studies, infrastructure studies, planning, and related disciplines? After all, over the course of this project, I have been confronted – in texts, during fieldwork, in conversations and debates – with multiple conceptions or nuances of storage, as well as neighboring concepts such as backup, containment, stockpiling, and so on.[27] While each is potentially useful in framing a research project on urban infrastructures, their particularities and connotations led me to keep returning to my own framing and use of the term 'storage.' And yet, is it really always 'storage' that we are talking about? How do urban residents in different geographies, as well as various other actors, frame, understand, and discuss the phenomena described in this thesis? Ultimately, as we asked as the F/O/S Research Collective (2024a) in our review of Jon Silver's 'Infrastructural South': 'What other vocabularies might exist—as ethnographic facts and not just as categories of analysis—alongside the grammar' that I have utilized?

To answer these and many other questions, I propose a broad research agenda that takes serious storage as an analytic for the urban, its infrastructures, and many other arenas. Also in light of

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[27]For example, *capture* has gained prominence due to energy transitions and climate change mitigation, e.g. in the form of carbon capture (Alexander and Stanley 2022), but – although whatever is captured is usually stored afterwards – the notion of *capture*, with its 'historical and conceptual roots in the capitalist world-economy,' has a rather extractive, less preservative connotation (Degani et al. 2020: 3). *Containment* and *container* are important points of reference for storage – since storage usually means containing something in some container for some time – but the notion of *containment* is applied in variegated ways and situations, e.g. to refer to the restriction of human migration (Jenss 2023; Landau 2019); and the *container* – although it has received much academic interest, especially from anthropology – is 'only' the technology or artefact of storage, but does not automatically lead to the practice of *storing*. To the point, with the standardized shipping container as a prominent example, containers are not only used for storage, but often for transportation (Levinson 2016; Shryock and Smail 2018; Widmer 2020). Similarly, the notion of *confinement* – framed as an infrastructural category by Furlong (2022) – is associated with distributive, transporting infrastructure, such as pipes and canals that confine water; and then there are various notions that are more nuances of storage rather than independent categories: *Stockpile* or *stockpiling* as a highly strategic, securitizing form of storage that usually removes 'stuff' from circulation (Folkers 2019; Keck 2017); similarly, the *backup* as redundancy or emergency storage that may never actually be used (Burt and Ray 2014; Ratick et al. 2008); but also storage as deliberate *concealment* (Newell 2018), and many others.

the limitations of this thesis (‣ Chapter 3.3), and the experiences and insights gained in Nairobi's infrastructure space, I recommend in particular the following list of directions that warrant further attention, research, and elaboration:

- Growing the 'storage city': Expand the concept of (domestic) storage as infrastructure beyond water and electricity to include other vital urban resources such as data, cash, waste, and various forms of energy such as charcoal, diesel or LPG. Examining storage arrangements for such resources at different scales – from household and community to regional and national – can further reveal how situated infrastructure configurations use and distribute storage as part of larger systems, and how storage affects place-specific urban-infrastructural conditions.

- Including storage-as-disposal: Expand the notion of storage as infrastructure, as presented in this thesis, from 'stuff' that flows into households (or other sites of consumption) to include the storage of 'stuff' that is supposed to leave these spaces; for example, by studying septic tanks or solid waste storage. Such research could add to a socioecological, metabolic reading of storage and its role in networks of material circulation, ultimately discussing how storage and disposal are interconnected in urban infrastructure.

- Quantifying and mapping the 'storage city': Conduct quantitative and/or mixed-methods studies that examine how different socioeconomic groups in cities deploy water and electricity storage. By quantifying individual storage, statistically analyzing it by other household variables (such as income, tenant status, and floor level), and mapping responses, variations in storage dispositifs and, thus, access to basic resources are likely to reveal spatial and socioeconomic patterns that warrant further detail and discussion.

- Gendering storage: Examine the gendered aspects of household storage, particularly how women and men are involved in different ways and capacities in the storage of different resources. This could include qualitative interviews and ethnographic research to understand how these practices relate to household labor, decision-making, and power dynamics, with a focus on the bodily scale and corporeal experiences of storage.

- Storing as affective practice: Explore affective, emotional and socio-cultural dimensions by examining (politicized) anxieties, and narratives such as 'preparedness,' as motivators for storage practices, focusing on how households anticipate and respond to (perceived) resource scarcity. Integrating emotional and psychological issues with infrastructural and techno-political dimensions, such research could explore how 'preparedness' is shaped by past experiences, expectations, and future concerns, and how this interacts with the respective supply systems and infrastructures.

- Politicizing storage: Investigate how political forces, from the quotidian techno-politics to geo-politics, shape the sociotechnical, infrastructural landscape of storage in its situated articulations. This research could explore how state policies, regulatory frameworks, and political imaginaries around urban infrastructure inform the development and use of storage technologies at various scales, from the household to national levels.

- Materializing the 'storage city' and following its flows: Focus on the socioecological dimension of storage, particularly the materials stored and the materiality of the containers used. Research could further explore the lifecycle of storage containers, investigating how their multiple materialities are shaped by and shape the 'stuff' stored, and how this relates to broader conditions and relations such as local climate, value chains, and policy landscapes. Ultimately, the ecological impacts and power relations between the various actors involved should be analyzed, as well as how their design shapes user practices and perceptions.

- Circulating and accumulating storage and its capital: Critically examine the economic dimension of storage, focusing on how capital flows into, within, and out of the storage infrastructure market, individual storage dispositifs, and specific storage artefacts. Research could track minor investments in water tanks, batteries, and other storage technologies by households, as well as larger circuits of capital to and from urban infrastructures and major storage facilities. This includes analyzing the role of private capital in promoting or hindering access to storage solutions, and exploring how the circulation and accumulation of capital, stored commodities, and storage artefacts contributes to socioeconomic stratification and urban development.

- **Historizing (mundane) storage artefacts:** Undertake a historical analysis of mundane storage technologies, like the jerry can, to explore how these objects have evolved as infrastructural expressions 'from below.' This could involve tracing the development of storage containers, examining their material culture, and assessing how these technologies have adapted to meet the demands of different historical, cultural, and geographical contexts.

- **Futuring and timing the 'storage city':** Explore how storage is intertwined with temporal concepts such as future-making, infrastructural rhythmicity, and anticipation/ waiting. Research could focus on how storage functions as temporal practices/ arrangements to 'prepare' for future uncertainties, how urban rhythms influence (domestic) storage and *vice versa*, and how all of this shapes residents' sense of time and agency in urban-infrastructural environments.

In conclusion, I am certain that by further exploring the practices, artefacts, materialities, technologies, emotions, and politics of storage, we can continue to contribute to a deeper understanding of situated infrastructural realities, while also providing a critical lens through which to view the evolving dynamics of urbanization in the global south and elsewhere. The many flows and circulations of our interconnected world are undoubtedly fascinating, as are the many major to medium infrastructures that keep our cities running. And yet, as I hope to have shown in this dissertation, it is worthwhile from time to time to shift our gaze to the seemingly minor and less important moments, spaces, and technologies of slowed down or completely stopped circulation of the everyday urban. After all – to end with a quote from Shove and Chappells (2001: 57) that stands in for my fascination with, and view of, water tanks, jerry cans, power banks, batteries and all other kinds of storage arrangements – all these storage arrangements are …

'Mundane and inconspicuous, maybe. Boring, certainly not.'

Figure 48: Water taps and bucket in a garden in Ongata Rongai; photo by author (2023).

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