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Mapping operation and maintenance: an everyday urbanism analysis of inequalities within piped water supply in Lilongwe, Malawi

In this article, we analyze the production of inequalities within the centralized water supply network of Lilongwe. We use a process based analysis to understand how urban infrastructure is made to work and explain the disparity in levels of service by tracing the everyday practices of those who operate the infrastructure. This extends existing analyses of everyday practices in relation to urban water inequalities in African cities by focusing on formal operators, rather than water users, and looking within the networked system, rather than outside it. Our findings show that these practices work to exacerbate existing water stress in poor areas of the city. We conclude with a reflection on how understanding these practices as the product of the perceptions, rationalizations, interpretations of utility staff who seek to manage the city's (limited) water as best they can, offers insight into what is required for a more progressive urban water politics.

Keywords: urban water supply, infrastructure, everyday practices, decentering urbanism, Lilongwe

Introduction

More than a quarter of the 100 fastest growing cities in the world are now in Africa, and the continent's number of urban residents will double over the next 30 years (UN-Habitat, 2014)[1]. These are well known figures, as is the fact that the rate of urban transition, particularly in Sub-Saharan Africa (SSA), significantly outpaces investment in infrastructure and services (Pieterse and Hyman, 2014). For urban water supply infrastructure, levels of coverage for piped water services have declined over the last 15 years while urban population has increased (JMP, 2015). Currently, many cities in SSA provide a smaller percentage of their residents with piped water than they did in 1990 at the start of the Millennium Development Goals.[2]

Where urban water supply infrastructure does exist and 'improved' access has been counted towards MDG targets, we still do not know if piped water supply is safe, or sustainable, or equitable (Nganyanyuka et al. 2014; Obeng-Odoom 2012; Onda, LoBuglio, and Bartram 2012). As David Sattherwaite (2016) argues for the South more broadly, the categorization of access to water under the MDGs as either 'improved' or 'unimproved' conceals the reality that in the majority of cities access to an "improved source" of piped water does not provide quality safe for drinking, and may only be provided for a few hours a day, or a few hours a week. This echoes what Sylvy Jaglin noted: counting an 'improved source' of water via a 'connection' masks the diverse realities of what connection means in the majority of African cities (Jaglin, 2008). As she and others have shown, taking the centralized infrastructure network as the basis for any analysis of inequalities in urban water tells us little about different water qualities, quantities, and continuities inside piped network system (Boakye-Ansah et al., 2016; Graham et al. 2015; Jaglin 2008; 2014). Moreover, as noted by Mary Lawhon and colleagues, it tells us even less about the majority of urban space left ‘’blank’’ outside the network coverage area (Lawhon et al., 2014).

The "blankness" of some urban spaces either conceals the relations between water and urban politics or represents those relations inaccurately. Such flawed accounts emphasize the need to explain the role of infrastructure within the production of uneven urban landscapes in a way that reflects a more diverse set of realities (Parnell, 2014; Silver, 2014). Building on the recent calls for a production of urban theory which can more accurately and meaningfully capture Southern, African – or even global - urban contexts (Myers, 2014; Parnell & Oldfield, 2014; Roy, 2009; Sheppard et al., 2013), research in cities of both North and South has begun to develop explanatory frameworks for the relations between water and urban inequalities on the basis of more diverse set of experiences. For example, Acevedo et al. (2016) with their historical analysis of water supply interventions in Colombia challenge water sector assumptions around trends as decentralization or corporatization. Ranganathan and Balazs (2015) show the usefulness of North-South comparisson in the understanding of periurban water inequalities. Stoler et al. (2012) analyze in metropolitan Accra the persistence of packaged drinking water as one of the main sources of water even in areas ‘served’ by piped system. These are but a few examples of how urban water scholarship is unsettling assumptions of what urban water infrastructure is, how it is made to work, and the complex politics of water it reflects and reproduces, for the majority of the world.

One approach to providing a more accurate picture of how water flows through SSA cities, and why, and what this means for urban inequalities, has been the use of a process based analysis: building explanations from empirical observations of what users actually do, the practices they perform. Thus, instead of interpreting local contexts through a global explanatory framework, or seeing the differences in particular contexts as spaces of "exception'' (Roy & Ong, 2011), this research uses the very particularities of cities previously located in the margins as exceptions in global frameworks. This approach aligns with the recent move within Science and Technology Studies (STS) to decenter analyses of socio-technical systems from the role of artefact itself (the piped network), to understand how it is made to work through the engagement of both human and non-human actors.

In this paper we document the everyday practices that make centralized piped water infrastructure system work in the city of Lilongwe, Malawi. We understand practices as activities of everyday life which are situated in a specific context, consist of embodied performance, knowledges, and objects, and may result in forms of change, resistace, or contunity (Pink, 2012; Reckwitz, 2002; Schatzki, 2001). We use this empirical detail for a process based analysis of inequalities in urban water supply in a city where the uneven flow of water through the centralized piped network system reflects and reproduces other inequalities within the city. Population densities, living conditions, access to services vary dramatically between low-income areas (LIAs) and informal settlements (served through a system of kiosks), and the commercial/high end residential areas in the urban core (with in-house connections). Although both are included in access to the city's centralized water supply network which serves 78% of one million residents (NSO, 2008), LIAs have a much higher rate of supply infrequency. To understand why this is so, and what it can tell about politics of water in the city, we follow the everyday practices of the engineers and water utility staff as they do daily maintenance and operational work. Our analysis of how inequalities in water quantity and continuity are produced within the network reveals the political processes at play in technical processes usually 'black-boxed' and kept from scrutiny.

The research for this paper was conducted over a period of four months in 2014. Data was collected using qualitative methods that included literature reviews, in-depth interviews, participatory mapping, and a focus group discussion. A total of 38 semi-structured interviews were conducted with Lilongwe Water Board (LWB) employees from operators to managers. In addition, a large amount of data was collected through participant observation: following employees in their daily activities and conducting several visits to points along the centralized networked system.

Everyday Practices and urban water inequalities: A review for African cities

The last decade has seen the emergence and consolidation of decentered perspectives that seek to destabilize the application of northern norms across urban theory in order to better explain the dynamics of cities across a variety of contexts (McCann et al., 2013; Sheppard et al., 2013). One approach advocated as a way to decenter from northern based explanatory frameworks is that of an everyday urbanism. This approach uses a process based analysis to understand how cities work and what drives their transformation by taking the richness of the everyday activities of urban dwellers as the basis for urban theory. Parnell and Robinson (2012) identify this approach as a way to recognize and understand the intersection between global processes and local specificities. Ekers and Loftus (2008, 709) see it as a way to turn the attention from more explicit manifestations of power, such large scale infrastructures, to what they define as "the more subtle way in which power works through everyday hydraulic practices […]".

The empirically detailed, process based, ethnographic research identified as one way through which to decenter the production of urban theory has already led to richly diverse accounts of water access in Southern cities. Not all of this work is explicitly identified as an everyday urbanism, or aligned with this project of decentering. However, the empirical detail of these studies does provide a more accurate documentation of how water is distributed across cities and of what urban water inequalities are, and how they are produced. However, as we review through the literature, current analyses of everyday practices in relation to water in African cities tell us little about how different qualities or quantities of water in the infrastructure network are produced. Perhaps because the absence of large scale infrastructure networks is the norm, process based analyses of water flows dealing with inequalities have placed a central focus on the everyday practices of water users and the co-production of a multiplicity of water provision systems which run outside, or alongside of the centralized network (for example, Allen et al. 2016). Where inequalities of water distribution within the piped system are documented (Andreasen & Møller-Jensen, 2016; Nganyanyuka, Martinez, Wesselink, Lungo, & Georgiadou, 2014; Obeng-Odoom, 2012), they are less scrutinized, and less theorized, within the canon of everyday urbanism. This stands in comparison to the work which has been done on South Asian cities (Anand, 2011, 2014; Hossain, 2011; Misra, 2014; Ranganathan, 2014).

In recent years the analysis of drinking water inequalities in African cities has, more or less explicitly, been influenced by everyday urbanism canon. Boakye-Ansah et al. (2016) analyse the role of everyday practices of monitoring, repairing and operating the water supply network in the production of uneven microbiological water contamination. Both Peloso and Morinville (2014), who document practices of water rationing, and Loftus and Lumsden, (2007), who examine the routine act of collecting water from kiosks and other vendors, analyze the role of these practices in producing, consolidating, or contesting condition of access to urban water supply. For the city of Dar es Salaam, Smiley (2013) documents practices of residents in combining water from the utility with other different sources to identify inequalities in terms of reliability, quality, quantity, and cost. Nganyanyuka et al. (2014) go further, to show how the everyday practices required to secure domestic water supply in Dar es Salaam are shaped by socio-economic class: longer term strategies that involve more complex transactions with higher monetary and non-monetary costs, while low-income residents rely on a number of parallel, shorter term solutions.

The analyses of these everyday practices to identify, or explain, inequalities in urban water supply most often start from the water user, with the work of Boakye-Ansah et al. (2016) as an exception. The majority of analyses of everyday water supply practices focus on areas of the city not covered by centralized infrastructure, or on the small-scale water service providers who augment inadequate supply through the network (Allen et al., 2016; Andreasen & Møller-Jensen, 2016). Moreover, while water supply infrastructure at the end of the pipe is seen as incremental, co-produced and flexible – the centralized system itself tends to be represented as fixed once it is in place, despite what is known about daily work required to make water flow and the normality of repair and disruption (Graham & Thrift, 2007). For example, although many studies acknowledge the uncertainties within formally served areas, the (everyday) processes and the relations which produce these differences in supply in the first place are overlooked (Allen et al., 2016; Amankwaa et al., 2014). Analyses of the differences in water flows within the network revert to an identification of purely technical factors (topography influencing pumping capabilities and gravity fed systems). Thus, centralized infrastructure is, in these studies, still primarily seen as a fixed socio-technical system: once it is in place, relations of power shaping water inequalities are tied to its presence or absence, not its operation.

This overlooks the relations of power shaping network operation or maintenance and, thus, *how* and *to whom* water flows where infrastructure is present.

In contrast to the absence of analyses of everyday practices of water providers to make piped infrastructure work in SSA, there have been numerous STS informed analyses of ethnographies of water infrastructure in South Asian cities. Research by both Anand (2011, 2012) and Björkman (2014), document the everyday practices of both water users and providers to show how power works through the everyday practices of putting the infrastructure at work, and what this means for inequalities in water flow within the piped system. Rather than focusing on the piped network itself, the centre of attention is placed on the engagements with the artifacts. This decentered analysis of water infrastructure is echoed by Furlong (2011) and Harman's (2009) work on water from within STS, as they reveal how relations and processes work to alter the utility, reliability, security of the infrastructure itself. They call us to rethink the role of infrastructure itself versus the role of human engagements with the infrastructure to explain the creation and constant maintenance of these divisions between spaces and service areas in the city.

While building new explanatory frameworks for water and inequality in South Asian cities, research using this process oriented approach has shown how material inequalities within centralized piped networks are produced through the everyday operation of the infrastructure. Tracing how prejudices towards particular urban groups based in class, religion, race, etc. are infused in the everyday operation of the network, they document how certain urban settlements are either left with no water, or with a more precarious service (Anand 2011, Hackenbroch & Hossain 2012). Statements as to the "impossibility" of water provision in certain areas, rationalized by engineers and water operators through technical criteria such as end of pipe location, undesirable topographic conditions, or lack of financial resources (Anand, 2011; Cohelo, 2004) are shown instead to be political choices. Analyses of everyday practices of operators shows how utility workers materialize the labels and preconceptions over particular water users making more difficult or easy for them the access to water (Anand, 2011, 2012; Cohelo, 2004; Karpouzoglou & Zimmer, 2016). This highlights how the interests, beliefs, expectations, and integrity shape to whom and when water is made available (Anand, 2011, 2012; Hossain, 2011).

These examples of process oriented analyses of water infrastructure in South Asian cities, together with the rich history of process oriented research in African cities, suggest the possibility – and need – to pay more empirical attention to how urban inequalities are maintained not only through the construction of infrastructure, but through its daily operation and maintenance. Attending to the engagements with infrastructure across both small and large scale (decentralized and centralized) systems, and by water users and water operators, can do more to reveal how inequalities are reproduced, or challenged. We now turn to do this for the city of Lilongwe.

Re-directing flows through everyday operations of the water supply network in Lilongwe

Mapping inequalities in the centralized water supply network

As process based studies of water supply note for other African cities, drinking water supply in Lilongwe is characterized by inequalities in access, reliability, and affordability. The Lilongwe Water Board, a corporatized public utility, serves 78% of the urban population through its centralized water supply network (NSO, 2008). The remaining residents rely on combinations of self-supply via community stand pipes, private wells, boreholes, springs and streams (NSO, 2008). While we acknowledge the distinction between served and unserved population and its relevance, in this paper we center our attention in the uneven supply concealed within the official figures of the served population. With the intention to bridge the existing gap in process based analysis of water flows in African cities, we focus in processes within the networked system, rather than outside it. Although coverage averages may suggest uniform services, in Lilongwe they hide uneven service levels. First, coverage is ensured through two different service modalities, encompassing different technologies and management models. Of the total population served by the water utility 44%, receive water via in-house connections and 56% through water kiosks. Secondly, service levels including continuity of water supply differ from area to area.

According to the projections of Lilongwe city Master Plan, the demand for water outstripped the supply capacity of LWB's infrastructure in 2011, affecting the provision of its service. Water resources are drawn from the Lilongwe River, and treated and distributed to customers through a centralized network. Although there is enough water at the dams, the limited treatment capacity restricts daily production, which is insufficient to meet demand. This gap is of approximately 14.000,00 m^3/day, 11% of the total production (Hadzovic Pihljak, 2014). As a consequence, provision of water is not continuous across the city. LWB reports an average of 18 hours supply a day (LWB, 2012). However, this average of 18 hours is not evenly distributed across the city: while some consumers receive water round- the-clock, others suffer intermittent supply or even lack of water for up to 4-5 days. As Figure 1 shows, the gap is much larger in the southern zone (Figure 1).

[Insert Figure 1 here]

When asked to describe the irregularities in water supply LWB employees reported different qualities of service across of the city. The information of what areas in the city receive what amount of water, on what days and times is not formalized within a water rationing schedule, nor is it included by the utility in maps of service delivery. It is rather embedded within the employees' knowledge of the system. Working together with the LWB staff we mapped service levels to identify the areas where they consider the supply to be good (i.e. close to twenty-four hours a day and reasonable levels of pressure) versus the more critical areas of the city (Figure 2). Overall, this map shows that the southern sector of the city is the one with the largest concentration of problematic areas. In fact, according to a LWB Mid-level manager, only four out of fifteen areas served by the water utility in that part of the city (those located closest to the commercial center of the city) receive an average of 18 hours a day during the entire year, while the rest of the areas get an average of 6 hours a day (most of them are LIAs). Further, other forms of differentiation are constituted by the time of the day in which access to water is granted. For example, during a visit to Area 36, one of the LIAs located in the South-East of the city, reported to have received water only at night for the past eight months, a situation experienced also by other LIAs of the city.

Figure 2 shows a marked socio-spatial distribution of water discontinuity: most of the areas with major problems are classified as LIAs by the land use map of Lilongwe City (MoLGRD, LCC, & JICA, 2010).

[Insert Figure 2]

LIAs of Lilongwe include two categories of residential land: Traditional Housing High Density areas (THAs) and unplanned/informal settlements. THAs emerged as a part of a governmental strategy to develop low-income housing areas (Englund, 2002). They were initially formally planned and plotted by the government in the late 1980s. However, since the early 1990s the plots have been subdivided by owners and subsequently rented and sublet (Englund, 2002; Potts, 1985). Informal settlements started to develop in the 1990s as a result of the congestion in THAs and lack of regulation of informal land (Englund, 2002). LIAs account for more than 50% of the residential land in the city (MoLGRD, LCC, & JICA, 2010) and host 76% of the population (UN-Habitat, 2011). They have grown very rapidly in the past decades and are still growing. Housing conditions are very precarious and access to basic services is extremely poor in those areas.

Explaining the unevenness within the network

The uneven distribution of discontinuity, clearly illustrated by Figure 1 and 2, is very often presented as the result of technical constraints. LWB employees, however, mobilize technical arguments to justify this unevenness. According to them, it is due to differences in the volumes and quality of infrastructure distributed across the city. In this way, they present the different quantities of water availability within the piped water supply system as something static - dependent what number of reservoirs and pumps exist in each area of the city- rather than fluctuating based on their actions and decisions. To explain the differentiated level of services they refer to decisions made by city planners, who determined a larger development of infrastructure in the central and northern sectors of Lilongwe or to the differences in the quality of infrastructures and the construction procedures adopted. According to them, in LIAs pipes are smaller and cannot carry the required flow of water. Service connections are described as exposed and too long (up to 100m or more), because houses are located far from the distribution line. Long and exposed distribution lines are more likely to break as “they have to cross roads and they are also broken by vehicles” (LWB operator) and “are prone to vandalism and damages” (LWB operator). While more breakages are acknowledged in LIAs, “the problem in those areas is that the pipes are exposed. People want water but they don't have enough money to pay the connections so they break the pipes to get water” (LWB operator). According to operators, even if pipes break accidentally residents do not report them so they can benefit from the leakage that slows down the reaction capacity of the utility in LIAs. Further, while in planned areas pipes are laid in an orderly fashion following plot planning, in some LIAs “reticulation has been done without any planning because of rapid urban growth, the hydraulic design is not good” (LWB engineer). In sum, infrastructure is described as a fixed asset, which constrains and limits the options and decisions of engineers and plumbers.

While these are valid reasons as to why continuity of water supply is so different between areas, we argue that they do not completely explain discontinuity configuration in Lilongwe. In following the day to day practices of LWB engineers, managers, we extend existing analyses of water inequalities in SSA that focuses on engagements of users and infrastructure and presents centralized infrastructure as fixed and inequalities result of its design and construction. In particular, we have found that the original inequalities created by infrastructure development are reinforced by its day-to-day operation and maintenance routines. In a context characterized by technical uncertainty and constant malfunctioning the pumps, tanks, valves, and pipes are subjected to daily maintenance by operators whose decisions re-direct water flows. Consequently, this ensures that specific users evade supply problems. It is these day to day practices which build on the original inequalities that were embedded within the water supply system, as political decisions within and outside the water utility shaped the configuration of the system to disadvantage lower income areas of the city (Tiwale, 2015). In the following sections, we turn to describe these everyday practices of infrastructure manipulation and the principles used for deciding where the water flows and which repairs happen first or more frequently.

Re-directing flows (through the "back-up" line)

The first strategy of re-directing flows is embedded in the system itself, which provides the technical means to divert water produced for the southern section to the central and northern ones. In principle, the water network is divided in two subsystems with two separate treatment plants and production points, namely Treatment Works I (TWI) and Treatment Works II (TWII). TWI with a capacity of 35000m^3/day produces water for the southern zone of the city, where most of the LIAs are located, while TW II with a capacity of 60000m^3/day produces water for the central and northern areas of the city. However, the operation of a backup line and valve allows redirecting water from TWI (for the southern zone) to the central and northern areas of the city.

> In a water supply system […] you need to have a backup. […] For that reason, LWB maintained the line between TWI and Mtunthama [i.e. the reservoir that provides water to the commercial center of the city and some high-end residential areas located close to it among others] to supply critical areas in case of emergency (LWB engineer).

However, as one of LWB engineers explained, the interconnection that would allow the opposite: water being directed from TWII to the southern zone in case of emergency, "has never been used", showing a rather unilateral water flow between southern and central/northern zones.

Installed for so-called emergencies, this valve is actually operated regularly. The everyday operation of this valve is a contested and negotiated process between different employees and departments. According to a mid-level manager in working in the southern zone of the City, the decision to divert the water from TWI is usually taken in agreement with the Operations Engineer:

> when we have a problem in the southern zone, pipe bursts, lack of electricity, or the reservoirs are full we let the headquarters know so they can send more water to Mtunthama [i.e. the reservoir that provides water to the commercial center of the city and some high-end residential areas located close to it among others] instead of letting the water stay in our reservoirs (LWB mid-level manager).

However, most of the time, decisions about the valve are taken unilaterally. As one of LWB engineers explains, "there are no written rules about how this should be done. It is decided by the Operations Engineer case by case, to solve emergencies." For example, "sometimes they decide to open when they need to increase the supply in the [rest of the] city" (LWB mid-level manager). While there are technical explanations for the use of this line, the diversion of the flow also responds to the prioritization of some areas: "priority areas are not in these areas of the city [i.e. southern zone]" (LWB engineer). Decisions on where to direct the water are made "in terms of who is the critical customer. Unluckily for users in the South, these critical users are not located there" (LWB engineer).

LWB management ensures that the operation of this line does not impact discontinuity levels in the South of the city: "the line is not interfering with the availability of water in the southern zone. When there is shortage of water there, we close that valve and when there is enough water we open it again" (LWB Engineer). However, according to a LWB operator

> When they open this line, we suffer a lot. We are not always informed when this is going to happen. Sometimes my supervisor sends me to investigate what is happening when we see the levels in the reservoirs going down (LWB operator).

Producing differentiated water pressure in the network

The use of connections to high-pressure pipes represents a second example through which the flows of water in the city can be altered. The water supply network in Lilongwe is a combined gravity and pumping system. Water is pumped to the reservoirs located in different parts of the city using pipes at high pressure. From the reservoirs, it is distributed to costumers by gravity. However, on some occasions the gravity system is unable to ensure sufficient pressure for all users. In those circumstances the LWB staff can decide to bypass the reservoirs and connect customers directly to pipes at high pressure. This procedure can be implemented at what LWB staff calls take-off points[3]. This procedure solves the problem for some users. However, providing them with the pressure they are unable to get from the gravity system, negatively impacts other customers who see their share of water reduced (i.e. those not connected to high pressure pipes) and affects the system in overall (i.e. reservoirs are not balanced, pressure produces stress in pipes and ultimately breaks them, higher energy consumption).

LWB staff are aware of the negative implications that the use of connections has for the functioning of the network but at the same time they accept the political reasons behind them.

> Instead of filling the reservoirs most of the water is taken along the way, and these things happen behind the operations, our friends in the zone offices are responsible for distribution, if someone somewhere makes a lot of noise they opt to tap them water from the pumping main which is not recommended. […] They have to deal with the customers, they are the ones exposed and they cannot deny them water (LWB engineer).

This ad-hoc procedure re-directs flows towards consumers that are more capable to negotiate better conditions of access. This was the case during the construction of a new embassy location, as explained by one of the LWB managers.

> They came into my office and I said no, I am not going to connect you from that line [i.e. Pressurized line] I cannot. […] They were not happy; they went and met the GM. The GM took some time to make the decision but we have done it (LWB mid-level manager).

Similar prioritizations also occurred in favor of users located in Kanengo Industrial Pole (North of the city) and the presidential houses (the State House, situated in Area 44 and the State Lodge, situated in Area 3) are served through pressurized connections.

Improvising the operation of distribution valves

The operation of distribution valves provides another opportunity to re-direct water flows in the city. Valves are used to control the direction of the flow and, thus, to determine which areas and in which order they will be served. LWB has not developed standard operating protocols for the valves and staff are not required to keep track of their operation. The valves are, thus, operated on an ad hoc basis: "they [i.e. operators] cut off on some areas. When people complain, they open some valves here and close there, but after a while they do not remember which valves they have opened or closed" (International expert). According to some LWB operators, the issue has a very easy solution: if valves were locked and a record of their manipulation was maintained, it would be less likely that anyone could alter the proper functioning of the system. However, according to a LWB operator, staff in charge of the valves "do not accept it because they want to be able to operate them following their interests," as they respond to a department that is more exposed to customers and therefore to external pressures. This, once more, results in prioritizing solutions that are more effective for those people who are able to negotiate their access or those who have personal connections with LWB employees. As a LWB operator bluntly explains, if there is no water in an area where "my colleagues or my relatives stay, you tend to switch water to this area". Similarly, during maintenance and repair, valves are operated to redirect the flow and benefit specific critical customers like, for example, big hotels (LWB mid-level manager).

Everyday operation of the valves also encompasses manipulation by customers or informal plumbers, who tamper with valves to get a better supply for themselves or for specific areas. At times, this operation might involuntarily result in further exclusion from supply:

> When there are problems with supply they might think that has been LWB staff that has closed the line, they [i.e. users] touch the valves and it turns out that there is no water because there is a lack of water in the reservoirs so they are actually closing their own supply (LWB operator)

Differentiated maintenance and response to breakages

Everyday maintenance decisions configure the way water flows through the city. Those decisions suggest negligence by LWB operators in relation to the needs of LIAs. In terms of reparations, Boakye-Ansah et al. (2016) show that while maintenance in LIAs can take up to three months; in higher-income areas response takes a maximum of three days. The same author also highlights that more maintenance activities take place in higher-income areas, even though more breakages are recorded in LIAs. An employee of the LWB unit explains that some of the main pipes carrying the water to the southern zone of the City were washed away during a flood. Although these elements of the network could have been easily repaired or substituted, LWB was unable or unwilling to repair them.

> I think we could pump more water to Mwenda, Nwenya [i.e. Tanks located in the southern zone that provide water to LIAs]. Maybe the reason was the money, the designs were done, we presented them, but they preferred to invest the money in other parts of the network (LWB operator, 2014).

Similarly, water shortages in high and lower income areas are treated differently, with obvious impact on continuity of the service. As one of the LWB mid-level managers puts it, “when there is a problem in the high-income areas we rush or we give alternative supply, like water bowsers[4], but when the same problem happens in those areas you don't send the water bowser”. The differentiated response to emergencies further enhances disparities between areas. In some, the service is continued with bowsers; in others, service is interrupted, with the justification that in LIAs “many people there don't have connections, so they have alternative sources of water anyway” (LWB mid-level manager)

Rationalizing re-direction of flows in the city of Lilongwe

Redirection of flows in the city are not always a product of direct orders from above, nor of formal standard operating procedure, or a coordinated strategy within LWG, but rather a result of everyday improvisation and ad hoc decisions of individuals. Uncovering these processes requires understanding the dynamics of everyday practices of operating and maintaining the water supply network. Understanding these dynamics also requires an explanation of these practices. In our discussions with the LWB employees, we found that the everyday interaction of LWB employees with infrastructure to prioritize or neglect specific users and locations, is shaped by the water utility employee’s understandings of the city and their (personal and internalized) sense of who is more entitled to receive (better) services. The perceptions of entitlement are not formalized as the everyday interactions of the engineers with the piped network are not codified in any operating procedure. Rather, the priority of water supply for certain areas of the city, and certain kinds of consumers, is implicitly shaped by indicators of social status, political priorities, and economic necessity of the LWB employees.

While we acknowledge that the category of LWB employees is not uniform and power, knowledge, and interests differ among individuals, the perceptions of LWB employees suggest in general the internalization of obvious socio-spatial differentiation built into the city since its origins (Potts, 1985; Myers, 2003). In the promotion of the "garden city" imaginary, city planners have continually strived to separate LIAs, perceived as an undesirable view, from the city center and its services and infrastructures (Potts, 1985). These socio-spatial separations between areas in the city remain. Therefore, practices of particular individuals working at LWB are reinforcing the marginalization of low-income residents that are already disadvantaged in access to other forms of public infrastructure. This spatial and social engineering influences prioritization of water supply to certain areas, which, in turn, reinforces these stark visual reminders of the differences between areas of the city and relative importance of the different residents.

Explicitly, when discussing the rationale for flow redirections with LWB employees, the manipulation of the system and re-direction of flows is based on two assumptions that reflect the implicit sense of who - or what - is important. The first assumption of the LWB employees is that specific areas of the city are more entitled to receive a good service, given the importance of the customers. As a plant operator summarizes, “there are important people there, they can leave the country, they can call the president directly if they do not get water”. This reflects the social status - and political connections - of those who ‘deserve’ better water supply. In stark contrast with this image, customers in LIAs are often unable to negotiate improved access: “high density areas and poor areas are not so influential. […] Their complaints are not taken as seriously as in other areas" (MoIWD representative). This differentiated treatment is also justified on the ground that "they are used to not getting water at home" (LWB operator) or "have many other problems besides water" (LWB mid-level manager) or, more pragmatically, "do not even have a phone to call and complain" (LWB operator).

The second assumption used to rationalize water flows is that low-income dwellers have *different* water needs and they are better able to cope with discontinuous supply. According to an operator working in the South of the city, for most customers in his area six to twelve hours of water supply is enough. He makes this statement based on the fact that there most of the customers receive water from kiosks: residents collect the amount of water needed for daily household activities each morning, and store it in the home. The amount of water collected and stored by each household is determined by what can be physically collected, the volume that can be stored, what can be afforded, and what is available. Thus, households adapt their water needs to what they can access. To supplement this, households in LIAs have alternative sources of water that they can use in case of necessity like private wells or streams. In this way, the inequalities in infrastructure development - specifically, the neglect to invest in public services for poorer areas of the city - come to provide a justification for the inequalities in continuity of the service. Areas of the city served by water kiosks - with few or no household connections - have less water provided to the limited infrastructure that does exist. Based on the number of consumers who rely on a kiosk versus a house connection, supplying water to the kiosks would seem to be more of a priority when thinking about total coverage. However - as we showed, the LWB staff seem instead to base their decisions on calculations, which prioritize giving the most water to a small fraction of the total number of consumers. Similarly, the explanation that low-income households need less water from the utility since they can, if there is no other alternative, rely on other sources, also ignores the fact that alternative sources are often highly contaminated.

Conclusion: Transforming the unevenness of water in Lilongwe

In this paper, we have traced the routines of water supply staff as to identify the systematic disadvantaging of Lilongwe's sub-urban areas through the operations and maintenance of the infrastructure systems. We have shown how their everyday decisions and practices contribute to produce highly differentiated water supply in the LWB network.

This analysis fills a gap within current research on water and urban inequalities in African cities, where we know little about the socio-technical processes and social relations producing different quality or quantity of water in the infrastructure network. First, by looking at everyday practices and the infrastructure 'at work' we have shown that it is not only the technology or infrastructure itself that provides the means for differentiation, but also the human engagements with the infrastructure. Further, through the process based analysis we have identified the social relations underlying unequal water distribution patterns in Lilongwe. 'Manipulations' of the infrastructure are shaped by worldviews and assumptions about particular groups that contribute to their exclusion. In this, our work contrasts with findings by Anand (2011, 2012) and Björkman (2014) who find that engineers do accommodate slum needs despite the 'world classing' going on in Indian cities. In Lilongwe, the differentiated access within the LWB network seems to be implicitly accepted by LWB staff, who see lower income residents as needing less water and being better able to cope with discontinuity. What is most striking is that the majority of water operator staff lives in the same urban areas that they disadvantage.

Although inequalities of water distribution within the piped system are often documented for cities across the continent, they are less scrutinized, and less theorized, within the canon of everyday urbanism. This is problematic in an era when major development investment is being mobilized to increase coverage of large scale networked water infrastructure in the rapidly growing urban centres of Africa (AfDB, 2015). We believe that understanding how the network is really made to work, by whom, for whom, also reveals "more accurately who runs the cities of the South, how that power is gained and used, and how it might be transformed to be more progressive" (Parnell & Robinson, 2012, p. 601).

For Lilongwe, this requires us to understand the everyday practices of water utility staff as the product of the perceptions, rationalizations, interpretations of utility staff who seek to manage the city's (limited) water as best they can. This means that, like in other cities, access to infrastructure is important for reducing inequalities, but not sufficient. Investment into water supply infrastructure is needed across the continent (AfDB, 2015), but to assume that they will deliver an urban infrastructure ideal is naïve. The majority world will continue with the normality of disruptions in urban infrastructure, and this means that the worldviews and attitudes of those who operate the infrastructure systems will continue to shape distribution. Changing these attitudes is the work for new knowledge engagement strategies between academics, utility managers, and urban actors.

Notes

1. By 2050 more than half of the continent's residents will be living in cities: an estimated 2.2 billion people; go from 40-60% urbanized (Cillier s et al. 2011)

2. According to WHO/UNICEF definition, improved sources of water include piped water into dwelling/yard/plot, public tap or standpipe, tube well or borehole, protected dug well, protected spring, rainwater
3. Take-offs are points of connection between the high-pressure pipes and the distribution system closed by a valve. They originally exist to be used for the maintenance of the system or in case of emergencies.
4. Water trucks

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References

Acevedo, Tatiana, Furlong, Kathryn, & Arias, Jeimy. (2016). "Complicating Neoliberalization and Decentralization: The Non-Linear Experience of Colombian Water Supply, 1909–2012." *International Journal of Water Resources Development* 32 (2). Routledge: 172–88

AfDB. (2015). "Water Supply and Sanitation in Africa: Findings, Lessons and Good Practices to Improve Delivery."

Allen, Adriana, Pascale Hofmann, Jenia Mukherjee, & Walnycki, Anna. (2016). "Water Trajectories through Non-Networked Infrastructure: Insights from Peri-Urban Dar Es Salaam, Cochabamba and Kolkata." *Urban Research & Practice* 5069 (July): 1–21.

Amankwaa, Ebenezer Forkuo, Owusu, Alex Barima, Owusu, George, & Eshun, Fatima. (2014). "Accra ' S Poverty Trap: Analysing Water Provision in Urban Ghana." *Journal of Social Science for Policy Implications* 2 (2): 69–89.

Anand, Nikhil. (2011). "PRESSURE: The PoliTechnics of Water Supply in Mumbai." *Cultural Anthropology* 26 (4): 542–64.

Anand, Nikhil. (2012). "Municipal Disconnect: On Abject Water and Its Urban

Infrastructures." *Ethnography* 13 (4): 487–509.

Anand, Nikhil. (2014). "Consuming Citizenship : Prepaid Meters and the Politics of Technology in Mumbai."

Andreasen, Manja Hoppe, & Møller-Jensen, Lasse. (2016). "Beyond the Networks: Self-Help Services and Post-Settlement Network Extensions in the Periphery of Dar Es Salaam." *Habitat International* 53. Elsevier Ltd: 39–47.

Björkman, Lisa. 2014. "Un/known Waters: Navigating Everyday Risks of Infrastructural Breakdown in Mumbai." *Comparative Studies of South Asia, Africa and the Middle East* 34: 497–517.

Boakye-Ansah, Akosua Sarpong, Ferrero, Giuliana, Rusca, Maria, & van der Zaag, Pieter. (2016). "Inequalities in Microbial Contamination of Drinking Water Supplies in Urban Areas: The Case of Lilongwe, Malawi." *Journal of Water and Health*.

Cohelo, Karen. (2004). "Of Engineers, Rationalities, and Rule: An Ethnography of Neoliberal Reform in an Urban Water Utility in South India." University of Arizona.

Ekers, M., & Loftus, A. (2008). "The Power of Water: Developing Dialogues between Foucault and Gramsci." *Environment and Planning D: Society and Space* 26 (4). SAGE Publications: 698–718.

Englund, Harri. (2002). "The Village in the City, the City in the Village: Migrants in Lilongwe." *Journal of Southern African Studies* 28 (April 2015): 137–54.

Furlong, Kathryn. (2011). "Small Technologies, Big Change: Rethinking Infrastructure through STS and Geography." *Progress in Human Geography* 35 (4): 460–82.

Graham, Stephen., Desai, Renu, & McFarlane, Colin. (2015). "De-Networking the Poor. Revanchist Urbanism and Hydrological Apartheid in Mumbai." In *Beyond the Networked City: Infrastructure Reconfigurations and Urban Change in the North and South*, edited by Olivier Coutard and Jonathan Rutherford. Routledge Studies in Urbanism.

Graham, Stephen, & Thrift, Nigel. (2007). "Out of Order: Understanding Repair and Maintenance." *Theory, Culture & Society* 24 (3): 1–25.

Hackenbroch, Kirsten, & Hossain, Shahadat. (2012). "'The Organised Encroachment of the powerful'—Everyday Practices of Public Space and Water Supply in Dhaka, Bangladesh." *Planning Theory & Practice* 13 (3): 397–420.

Hadzovic-Pihljak, Lejla. (2014). "Water Pricing Regimes and Production of Urban Waterscape. MSc Thesis." UNESCO-IHE.

Harman, Graham. (2009). *Prince of Networks: Bruno Latour and Metaphysics*. Melbourne: Re.press.

Hossain, Shahadat. (2011). "Informal Dynamics of a Public Utility: Rationality of the Scene behind a Screen." *Habitat International* 35 (2). Elsevier Ltd: 275–85.

Jaglin, Sylvy. (2008). "Differentiating Networked Services in Cape Town: Echoes of Splintering Urbanism?" *Geoforum* 39 (6). Elsevier Ltd: 1897–1906.

Jaglin, Sylvy. (2014). "Rethinking Urban Heterogeneity." In *The Routledge Handbook of Cities of the Global South*, edited by Parnell Susan and Oldfield Sophie. Routledge.

JMP. (2015). "Progress on Sanitation and Drinking Water – 2015 Update and MDG Assessment." *World Health Organization*.

Karpouzoglou, Timothy, & Zimmer, Anna. (2016). "Ways of Knowing the Wastewaterscape: Urban Political Ecology and the Politics of Wastewater in Delhi, India." *Habitat International* 54: 150–60.

Lawhon, Mary, Ernstson, Henrik, & Silver, Jonathan. (2014). "Provincializing Urban Political Ecology: Towards a Situated UPE Through African Urbanism." *Antipode* 46 (2): 497–516.

Loftus, Alex, & Lumsden, Fiona. (2008). "Reworking Hegemony in the Urban Waterscape." *Transactions of the Institute of British Geographers* 33 (1). Blackwell Publishing Ltd: 109–26.

LWB. (2012). "Lilongwe Water Board Annual Report 2011/2012."

McCann, Eugene, Roy, Ananya, & Ward, Kevin. (2013). "Assembling/Worlding Cities." *Urban Geography*, no. February 2014: 37–41.

McFarlane, Colin, Desai, Renu, & Graham, Stephen. (2014). "Informal Urban Sanitation: Everyday Life, Poverty, and Comparison." *Annals of the Association of American Geographers* 104 (5). Routledge: 989–1011.

Misra, Kajri. (2014). "From Formal-Informal to Emergent Formalisation: Fluidities in the Production of Urban Waterscapes." *Water Alternatives* 7 (1): 15–34.

MoLGRD, LCC, and JICA. (2010). "The Study on Urban Development Master Plan for Lilongwe in the Republic of Malawi. Final Report."

Myers, Garth. (2003). *Verandahs of Power : Colonialism and Space in Urban Africa*. Syracuse University Press.

Myers, Garth. (2014). "From Expected to Unexpected Comparisons: Changing the Flows of Ideas about Cities in a Postcolonial Urban World." *Singapore Journal of Tropical Geography* 35 (1): 104–18.

Nganyanyuka, Kapongola, Martinez, Javier, Wesselink, Anna, Lungo, Juma H., & Georgiadou, Yola. (2014). "Accessing Water Services in Dar Es Salaam: Are We Counting What Counts?" *Habitat International* 44 (2014). Elsevier Ltd: 358–66.

NSO. (2008). "2008 Population and Housing Census Main Report." Zomba, Malawi.

Obeng-Odoom, Franklin. (2012). "Beyond Access to Water." *Development in Practice* 22 (8): 1135–46.

Onda, Kyle, LoBuglio, Joe, & Bartram, Jamie. (2012). "Global Access to Safe Water:

Accounting for Water Quality and the Resulting Impact on MDG Progress." *International Journal of Environmental Research and Public Health* 9 (12). Molecular Diversity Preservation International: 880–94.

Parnell, Susan. (2014). "Conceptualizing the Built Environment: Accounting for Southern Urban Complexities." In *The Routledge Handbook of Cities of the Global South*, edited by Sussan Parnell and Shopie Oldfield, 431–33. New York: Routledge.

Parnell, Susan, & Oldfield, Shopie (Eds.) (2014). *The Routledge Handbook of Cities of the Global South*. *The Routledge Handbook of Cities of the Global South*. Routledge.

Parnell, Susan, & Pieterse, Edgar (Eds). (2014). *Africa's Urban Revolution*. Zed Books.

Parnell, Susan, & Robinson, Jennifer. (2012). "(Re)theorizing Cities from the Global South: Looking beyond Neoliberalism." *Urban Geography* 33 (4): 593–617.

Peloso, Megan, & Morinville, Cynthia. (2014). "'Chasing for Water': Everyday Practices of Water Access in Peri-Urban Ashaiman, Ghana." *Water Alternatives* 7 (1): 121–39.

Pieterse, Edgar, & Hyman, Katherine. (2014). "Disjunctures Between Urban Infrastructure, Finance and Affordability." In *The Routledge Handbook on Cities of the Global South*. Routledge.

Pink, Sarah. (2012). Situating Everyday Life: Practices and Places. Los Angeles & London: Sage Publications.

Potts, Deborah. (1985). "Capital Relocation in Africa : The Case of Lilongwe in Malawi." *The Geographical Journal* 151 (2): 182–96.

Ranganathan, Malini. (2014). "'Mafias' in the Waterscape: Urban Informality and Everyday Public Authority in Bangalore." *Water Alternatives* 7 (1): 89–105.

Ranganathan, Malini, & Balazs, Carolina. (2015). "Water Marginalization at the Urban Fringe: Environmental Justice and Urban Political Ecology across the North–South Divide." *Urban Geography* 36 (3): 403–23.

Reckwitz, Andreas. (2002) Toward a Theory of Social Practices. A Development in Culturalist Theorizing, European Journal of Social Theory 5(2): 243–263

Roy, Ananya. (2009). "Why India Cannot Plan Its Cities: Informality, Insurgency and the Idiom of Urbanization." *Planning Theory* 8 (1): 76–87.

Roy, Ananya. (2011). "Urbanisms, Worlding Practices and the Theory of Planning." *Planning Theory* 10 (1): 6–15.

Roy, Ananya, Ong, Aihwa. (Eds.) (2011). *Worlding Cities: Asian Experiments or the Art of Being Global*. Blackwell.

Satterthwaite, David. (2016). "Missing the Millenium Development Goal Targets for Water and Sanitation in Urban Areas." *Environment and Urbanization* 28 (March):

1–20.

Sheppard, Erik, Leitner, Helga, & Maringanti, Anant. (2013). "Provincializing Global Urbanism: A Manifesto." *Urban Geography* 34 (7): 37–41.

Schatzki, Theodore R., (2001). Practice mind-ed orders in Theodore R Schatzki, Karin Knorr-Cetina, & Eike von Savigny (Eds.)The practice turn in contemporary theory:; Routledge, London and New York.

Silver, Jonathan. (2014). "Incremental Infrastructures: Material Improvisation and Social Collaboration across Post-Colonial Accra." *Urban Geography* 35 (6): 788–804.

Smiley, Sarah L. (2013). "Complexities of Water Access in Dar Es Salaam, Tanzania." *Applied Geography* 41. Elsevier Ltd: 132–38.

Stoler, Justin, Weeks, John R., & Fink, Günther. (2012). "Sachet Drinking Water in Ghana's Accra-Tema Metropolitan Area: Past, Present, and Future." *Journal of Water, Sanitation, and Hygiene for Development : A Journal of the International Water Association* 2 (4). NIH Public Access.

Tiwale, Sachin. (2015). "Understanding Lilongwe's Thirst for Water: Linking Infrastructure Development to Differentiated Water Supply. MSc Thesis." UNESCO-IHE.

UN-Habitat. (2011). *Malawi: Lilongwe Urban Profile*.

UN-HABITAT. (2014). "State of African Cities, Re-Imagining Sustainable Urban Transitions."