From fragmentation to integration and back again: The politics of water infrastructure in Accra’s peripheral neighbourhoods

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This paper examines the dynamics of fragmentation and integration in Accra’s water infrastructure. Inspired by figurational sociology, we analyse infrastructure as both reflective and constitutive of interdependencies between different class fractions and parts of the urban region. We draw on historical archives, an in-depth ethnographic study of one suburban neighbourhood, a survey of eight additional neighbourhoods, and statistics from Ghana’s census to investigate the mechanisms and drivers of infrastructural integration as well as fragmentation. Our analysis shows that, following Ghana’s independence, the piped water network gradually expanded to integrate different class fractions and parts of the urban region. But this process has more recently hit its limits on Accra’s peri-urban fringe, where the wealthy are disconnecting from the public piped water network and, by implication, from those who still depend on it. The progressive expansion of the pipe network thus grinds to a halt, giving way to a fragmented constellation of water infrastructures.

KEYWORDS
Accra, fragmentation, infrastructure, integration, networked city, water

1 INTRODUCTION

When Angela and her husband moved from central Accra to the peripheral district of Bulasu in 2013, there were no more than ten houses in the area. Bulasu had no electricity, water, paved roads, drains, or other facilities. Three years later, when enough people had settled in the area, the pioneers formed a Residents Association. They gathered money to pay for a connection to the nearest Ghana Water Company (hereafter GWC) pipeline, 500 m away, but soon found that the pipes often ran dry. Being relatively wealthy, many of Bulasu’s residents could afford a private alternative. Angela and her neighbours turned to a water trucking company to fill their 10,000 litre black poly tanks once a week. Although costly—around 300 cedi ($75) a month—Angela is not complaining. At least they have a steady supply of water and no longer depend on the unreliable pipe network.

In Bulasu, we witness a contradictory dynamic widespread in Accra and other rapidly growing cities in Sub-Saharan Africa. On the one hand, the piped water network is expanding, a process driven less by conscious state planning than by residents’ efforts to arrange their own connections. As the network progressively expands, it connects different class fractions and parts of the city, in effect contributing to the integration of the city. On the other hand, this integration process is hitting its limits on Accra’s periphery (see Bartels et al. 2018). As residents like Angela take recourse to private sources of water, they disconnect from the public pipe network and, by implication, from the residents who continue to depend on it.
As this example illustrates, infrastructures can serve as vehicles of both integration\(^1\) and fragmentation (Graham & Marvin, 2001). In examining the pathways to integration and fragmentation in Accra’s water infrastructure, this paper brings figurational sociology into conversation with critical approaches in geography, specifically urban political ecology and critical infrastructure studies (cf. Castro, 2005, 2013). Figurational sociology and critical approaches share certain ontological and epistemological assumptions. Both have an ontology of change; approach the formal/informal, private/public, and licit/illicit as conjoined rather than separate realms; and attend to how technology and materiality mediate power relations. But they also differ in their respective emphases. Whereas figurational sociology as pioneered by Norbert Elias is mainly concerned with pathways to integration, critical approaches mostly focus on fragmentation. By bringing together both literatures, we seek to understand how processes of integration and fragmentation play out and intersect. Using historical archives, the in-depth ethnographic study of one suburban neighbourhood, a survey of eight additional neighbourhoods, statistics from Ghana’s census as well as other sources, we explain why, where, and how tendencies towards integration or fragmentation prevail. We argue that the broad historical trend towards integration is being reversed as Accra’s higher strata—whose members can increasingly access alternative sources of water on the private market—loses its interest in improving and expanding the public network.

In what follows, we first outline our theoretical focus on infrastructures and interdependencies. We then describe our methods. The first empirical section examines the development of Accra’s piped water network since independence: despite chronic shortages and daunting logistical challenges, the piped water network expanded rapidly in the post-colonial period, integrating different class fractions and parts of the urban region. But as the subsequent section shows, this expansion has been uneven and erratic. The third empirical section then details an incipient process of fragmentation resulting from groups of especially wealthy residents disconnecting from the piped water network. Our conclusion explores the broader relevance of bringing together systemic and situated analyses of infrastructures in understanding processes of integration and fragmentation.

2 | INFRASTRUCTURES AND INTERDEPENDENCIES

Although we build on different literatures, we are especially indebted to figurational sociology as developed by Elias (1978). Figurational sociology, we argue, has much to offer the geographical analysis of infrastructures as it identifies specific drivers and mechanisms that bind together or pull apart different class fractions and urban areas (De Swaan, 1988). Figurational sociology can also complement the critical approaches—particularly urban political ecology (cf. Kaika, 2005; Swyngedouw, 2004) and critical infrastructure studies (cf. Graham & Marvin, 2001)—that geographers often call on to study water politics and infrastructural development. Given our aim of understanding the dynamics of integration and fragmentation, the literatures’ complementarity results from their markedly different emphases, with figurational sociology studying the decline of violence and the growth of (welfare) state functions (Elias & Scotson, 1994; De Swaan, 1988; Pinker, 2011) and the critical approaches emphasising the violence inherent in the making of uneven waterscapes (Kaika, 2005; Swyngedouw, 2004). Simply put, figurational sociology alerts us to tendencies towards integration and equality while critical approaches alert us to tendencies in the opposite direction. Below, we use figurational sociology to bring out what has been ignored or downplayed in critical approaches in geography: that progressively more people are acquiring access to progressively better water. Dispossession, enclosure, and commodification notwithstanding, a growing proportion of the population, in Accra and worldwide, are securing access to water (cf. Our World in Data 2019)—a hopeful development that needs explanation. Although our local case study cannot account for this global development, figurational sociology allows us to identify the pathways at work in Accra, which may also be present elsewhere. We also draw on urban political ecology and critical infrastructure studies to bring out what is often ignored in figurational sociology: the formidable forces working against equitable access.

2.1 | Pathways to integration

Figurational sociology as pioneered by Elias (1978, 1996) focuses on the interrelationship between changes in the structure of social relations and changes in individual perceptions, sensitivities, and habits. In his classic text, _The civilizing process_ (1996), Elias traces how the minutest of practices (such as spitting or blowing one’s nose) develop in tandem with the broadest of social structures (such as states). Figurational sociologists have examined how technological developments—for instance, in fire control (Goudsblom, 1992), transport (Elias, 1995), and water and sewer infrastructures (De Swaan, 1988)—emanate from and in turn shape ties between people occupying different social and spatial positions.\(^2\) A key theme is how infrastructures and institutions that bind people together trace their origins to local developments. In his extension and
elaboration of Elias’ analysis of the civilising process, Abram de Swaan (1988) identifies three pathways that help us understand how infrastructural integration comes about: community action, cascades, and state imposition.

In the first pathway—that of community action—infrastructural integration comes about as community provisions are integrated within state structures. De Swaan gives the example of schools and hospitals, first created as community provisions before being incorporated into the state. Local community action is especially relevant in places where citizens do not expect the state to take the lead in the creation of public goods. In rapidly growing cities in the Global South, urbanisation often precedes the extension of infrastructure and the development of state institutions, meaning communities must establish or procure services on their own. Such situated community action often takes place in “grey zones” and may involve informal entrepreneurs, political brokers, or “water mafias” who extend water supply infrastructures and mediate access to communities and residents without access to formal state services (Lawhon et al., 2017; Ranganathan, 2014a; Truelove, 2019). While these situated constellations operate beyond the legal realm of the state, they can nevertheless support or prefigure broad, formal, standardised arrangements (De Swaan, 1988; cf. Boudreau, 2016). In this pathway, “the state”—an emergent and heterogeneous constellation rather than a singular actor—capitalises, grows on, and usurps the constellations that emerge outside of it, aligning and connecting them within its overarching structure.

The second pathway of infrastructural integration—that of the cascade—occurs when wealthy residents take private initiative to set up services, thereby lowering costs for others. De Swaan (1988) notes that most urban provisions—from the police to the water supply—were first established through the private initiative of wealthy residents, the only ones with the resources necessary to do so. One usually unintended side-effect is that marginal costs are driven down, allowing less affluent groups to opt in at a lower price (Granovetter, 1978). Access to the service then cascades throughout the population of a neighbourhood or city, from the top to the bottom strata of society. This pathway is particularly relevant in contexts, such as that of Ghana, where the philosophy of “cost recovery” dictates that residents are only connected to a given service if they cover the marginal costs of the connection or extension. When a wealthy household pays to get a connection extended to its home, less affluent households nearby or along the connection’s route see its price drastically reduced. Such cascades occur not only for services provided through the state but through the market. Markets for water purifiers, boreholes, or mineral water, for example, typically serve elites first and then expand to include lower strata.

The third pathway of infrastructural integration is state action. Elites acting through states can aspire to extend infrastructures for a range of reasons. While elites might attempt to insulate themselves by retreating to their own living quarters (Grant, 2009), they often find that they cannot shield themselves from social misery—the diseases, crime, and anger fuelled by the living conditions of less privileged groups. Cholera epidemics, for instance, typically emanate where sanitation is poor but have repercussions far beyond their point of origin and may prompt elites—acting through the state and its partners—to expand and improve the sewer system and water supply (De Swaan, 1988). In other cases, elites have altruistic, paternalistic, or opportunistic reasons to expand infrastructures to poorer areas. The urban poor potentially represent powerful political groups that politicians seek to coax through the promise of services (Paller, 2019). In addition, international charities, donor countries, and institutions such as the World Bank are involved in extending infrastructure into poorer neighbourhoods.

These pathways are of course ideal-types. In reality we find mixtures and variations, hybrid and heterogeneous arrangements (Anand, 2015; Lawhon et al., 2017; Truelove, 2018; Truelove, 2019). Nevertheless, distinguishing between these three pathways allows us to see the different mechanisms and drivers of infrastructural integration. Whereas the recent ethnographic literature emphasises how “the state” is a complex, situated, and emergent entity, figurational sociology invites us to view the emergence of state structures through a long-term lens—how they grow out of, and in turn structure, interdependencies between different strata and locations within city regions. Whereas assemblage urbanism sees it “as a given that the city is made of multiple partially localized assemblages built of heterogeneous networks, spaces and practices” (Farías and Bender, 2012, p. i) and examines “what is” (Lawhon et al., 2017), figurational sociology’s historical perspective invites us to decipher general trends in the evolving complexity of urban infrastructures.

As we draw on theoretical notions developed by Elias and De Swaan to study the development of infrastructures and interdependencies, we need to acknowledge that they sought to explain the trajectories of societies in the affluent West. Although both acknowledged that the formation of comprehensive states is not complete, irreversible, inevitable, or universal, they devoted little attention to contradictions and contingencies; their empirical focus on societies in the affluent West corresponds to the analytical focus on processes of integration—of how interdependencies grow longer and denser over time. But while a patchwork of different water infrastructures ultimately evolved into a coherent and comprehensive system in much of the Western world, this trajectory is not a foregone conclusion. As Graham and Marvin (2001, p. 8) argue, the idea that infrastructures are “integrators of urban space” reflects specific geographies and histories, and obscures the many ways in which infrastructures reflect, buttress, and fortify social and spatial inequalities. Others argue that the ideal of the
networked city itself is rooted in particular Western experiences (cf. Coutard & Rutherford, 2015; Dupuy, 2008; Monstadt & Schramm, 2013, 2017).

2.2 | Pathways to fragmentation

Whereas figurational sociology views the development of infrastructures as a cause and consequence of thickening interdependencies that bind together previously disparate groups (cf. Elias, 1996, p. 368), critical infrastructure studies and urban political ecology emphasise the violence and inequality inherent in their creation (cf. Gandy, 2013; Graham & Marvin, 2001; Graham & McFarlane, 2015; Kaika, 2005; Swyngedouw, 2004). Indeed, De Swaan’s pathways to infrastructural integration have their analogues working in the opposite direction. Whereas community action contributes to infrastructural integration when improvised constellations are incorporated into broader state structures, community action can also work in the opposite direction, for example when wealthy households abandon overburdened public infrastructures to tap into “premium water networks” (Boland, 2007), giving rise to a fragmented infrastructure where the quality of provision reflects resident status. Cascades can likewise lead to fragmentation rather than integration. When rich households withdraw from publicly or communally managed infrastructures, it reduces the quality or funding of services, encouraging others to leave until eventually only those with no other options are left—a process known in the housing literature as residualisation (Malpass & Victory, 2010). Finally, state action can also lead to fragmentation. State action can expand access to water but also take it away, often as part of a broader politics of austerity or revanchism.

Critical scholarship in urban political ecology and infrastructure studies has focused on how processes of infrastructural integration have been halted or reversed, often replaced by “a more diffuse, fragmentary and polarized urban technological landscape” under the impact of neoliberalisation (Gandy, 2004, p. 363; Graham & Marvin, 2001; Sassan, 2014). This trend, however, is specific to the Global North. As Kooy and Bakker (2008) point out, colonial water delivery was designed to mark the division between the white colonial quarters and indigenous areas; water supply networks in colonised societies were “splintered” from the outset. In post-colonial settings such as Ghana, infrastructural inequalities grew out of and reproduced previous racist divisions in the urban waterscape (Truelove, 2018; McFarlane, 2008). Post-colonial trajectories of infrastructure development thus poorly fit the fragmentation-of-previously-integrated-structures narrative (Guerrero et al., 2016), which applies to Ghana as well. As we will see below, the historical development of the piped water network in Accra cannot be described as a shift from integration to fragmentation. But nor do we see the unbroken continuation of colonial-era inequalities. Instead of assuming a singular trend, we start from the premise that both processes of integration and fragmentation are operative and that each results from a multiplicity of pathways. The task, then, is to identify these pathways to explain how particular tendencies towards fragmentation or integration play out and why one or the other prevails. We turn now to our methods to research these processes.

3 | METHODS

In line with the perspective outlined above, the research collected qualitative and quantitative data to chart patterns of interdependence as mediated by the development of water infrastructures through time and across space, and used qualitative methods to identify specific drivers and mechanisms underlying these patterns. Our data sources—a neighbourhood ethnography; a survey of eight additional neighbourhoods; interviews with residents, officials, technicians, and entrepreneurs; readings of government documents; GIS files; and census data—are discussed below.

3.1 | Neighbourhood ethnography

Our primary empirical reference point is Sebrepor, a neighbourhood on the outskirts of Accra. We conducted extensive fieldwork in Sebrepor over ten months between 2015 and 2018. Sebrepor was established in the 1970s as a farming community and grew into a neighbourhood in the 1990s and 2000s as Accra expanded. Sebrepor is unremarkable in terms of its population: neither very poor nor very rich, nor dominated by any one ethnic group. Developing our view of water infrastructure from the neighbourhood level upward had particular advantages. Had we not started in Sebrepor, we may not have grasped the extent and significance of the water infrastructure’s informal and incremental development (cf. Silver, 2014). Starting from the neighbourhood level allows us to see how the network extends incrementally through practices that are formally beyond the state, yet integrated into it.
3.2 | Interviews and observations in eight additional neighbourhoods

While our ethnography in Sebrepor allowed fine-grained observations of the piped water network and its development, we cannot assume that the pathways at work in Sebrepor are found elsewhere. To broaden our view, we undertook systematic observations of water infrastructures and conducted 19 semi-structured interviews in eight additional neighbourhoods (Table 1). In each neighbourhood, we or a research assistant conducted at least two interviews with long-term residents, often early settlers who established resident associations (see Gough, 1999) and played critical roles in bringing water to the neighbourhood. In the interviews, we asked about the origins and development of the water infrastructure. Who took the initiative to connect the area to the pipe network? If the neighbourhood does not get its water from the pipe network, how do residents fulfil their needs?

3.3 | Policy documents and interviews with officials

At the GWC, we interviewed 15 officials and received generous access to the company’s files. We spoke with employees of different ranks, from the headmen of work crews to regional managers and executive staff. These interviews revealed the difficulties of controlling and expanding the network in an environment where demand far outstrips resources. Interviews at the GWC’s regional and national headquarters provided insight into the challenges and strategies of engineering the pipe network at the macro-level. The policy documents—typically written jointly by government departments, donor countries, and non-governmental organisations with the aid of international consultants—outline organisational goals and furnish metrics and maps on the availability of piped water and potable groundwater.

3.4 | Census and GIS files

The Ghanaian government provides free online access to a nationwide 10 percent sample of the most recent census dataset (2010). The census reveals variations in water provision over time and throughout Accra, for instance that the consumption of water sachets is much higher in peripheral than in central areas. GWC provided generous access to its GIS files containing information on its connections and network. These files allow us to trace the system’s backbone infrastructure, i.e., water treatment plants, mainline infrastructure, and booster stations. They also suggest which parts of the system are not systematically mapped and thus can not be comprehensively managed.

3.5 | Interviews with entrepreneurs

We interviewed representatives and managers of three borehole companies to gain insight into the growing market for boreholes. We also interviewed four water management consultants to understand how boreholes affect the water ecology and how the government formulates and enforces (or does not enforce) rules to regulate this growing industry.

| Table 1 | Profiles of surveyed neighbourhoods |
|---------|-------------------------------------|
| **Sebrepor** | **Socio-economic profile** | **Residents Association active** | **Established** | **Water pipe network** |
| Afienya | Lower middle class | Yes | 1998 | Self-built |
| Bulasu | Upper middle class | Yes | 2013 | Self-funded |
| Christian Village | Middle class | Yes | 1995 | Self-built |
| Community 25 | Middle class | Yes | 2010 | Self-built |
| Dawhenya | Lower middle class | No | 1960 | Government-funded, government-built |
| Gbetsile | Poor | No | 1985 | Government-funded, self-built |
| Golf City | Middle class | No | 2000 | Self-built |
| Kpone | Lower middle class | Yes | 1950 | Self-built |
| Sebrepor | Middle class | Yes | 1975 | Self-built |
3.6 Archives

We obtained historical documentation on the colonial and early post-colonial periods from the Public Records and Archives Administration Department (PRAAD). Drawing on this source as well as secondary literature, we document how the colonial regime constructed the network as an exclusive provision to its constituents. GWC officials further supplied us with a number of historical master plans and reports published since the 1960s, providing us with a window on changes to the network’s backbone infrastructure over time.

4 FROM FRAGMENTATION TO INTEGRATION

The first public water supply system in Accra, and in fact all of Ghana, was established just before the First World War (GWC, 2016, p. 11). The network steadily expanded in subsequent years. By the 1920s, there were functioning systems in several cities, including the colonial capital of Cape Coast, Sekondi, the missionary centre of Winneba, and Kumasi, the capital city of the powerful Ashantis. Whereas colonists usually had private, metered connections to the network, the indigenous population mostly relied on water from standpipes or wells (Patterson, 1979; Shaloff, 1972). Water in this period was a highly contentious issue; it took about two decades to introduce a water charge as any such attempt was vehemently opposed by the indigenous population as well as by local leaders and the press. Although popular opposition preempted the introduction of a water charge and safeguarded the availability of water from standpipes, the water supply infrastructure was splintered from the outset, with colonists enjoying premium access to the piped water network (cf. Kooy & Bakker, 2008). The piped water networks were small but reliable; interruptions to the supply of a few hours a day were important enough to be mentioned in a letter from the Gold Coast Governor to the Colonial Office, urgently asking for more materials (PRAAD, 1931). In sum, the system was highly functional and extremely exclusionary.

When Ghana became the first Sub-Saharan country to gain independence in 1957, Nkrumah’s government promised the expansion of facilities such as piped water to areas that had previously been excluded. In the 1960s, the World Health Organization helped the new government draft a Masterplan for its water sector (WHO/UNDP/GoG, 1963), while the World Bank and donor countries provided substantial funds to invest in water infrastructures. While the colonial government had limited its infrastructural efforts to a few colonial centres, developing a total of 35 pipe-borne water supply systems throughout Ghana, Nkrumah’s government and its successors increased this to 194 pipe-borne systems and added 2,500 hand-pumped borehole systems for rural areas (GWC, 2016, p. 33). Although the inequalities written into the water supply network during the colonial era persisted (the area covered by the colonial network still enjoys the best connection), the efforts of postcolonial governments brought considerable change: the network’s coverage expanded dramatically while the extensions did not exclusively benefit elites, marking a shift towards infrastructural integration.

After Nkrumah was ousted in 1966, a succession of military and civilian governments—nearly all with modernist visions of nation-building—sought to expand the pipe network, seen as a vehicle to integrate the nation. Colonel Acheampong’s regime (1972–1978) embarked on extending the water infrastructure beyond the city limits as part of Operation Feed Yourself to support agricultural production. Although the programme was meant to support rural areas, in some instances it served to facilitate Accra’s rapid growth. One of the neighbourhoods in our survey, Dawhenya, developed around a mainline and standpipe created during Operation Feed Yourself, which are still serving residents decades later. This example, too, illustrates how efforts at extending the network effectuated a break with the small, functional, and exclusionary network inherited from the British. But although Ghana’s postcolonial governments explicitly sought to achieve infrastructural integration, their efforts were frustrated by chronic shortages of funding in a context of rapidly growing demand. Between 1980 and 2003, Accra’s population grew by 172 percent, from 1.1 million to nearly 3 million (Ghana Statistical Service, 2013). The city’s physical size grew even faster as population density decreased over this period (Angel et al., 2016). Despite the chronic shortage of government funds, the pipe network grew at breakneck speed, suggesting there were other drivers of expansion.

How did the network expand so rapidly in the absence of sufficient government funding? Findings from our fieldwork suggest that the majority of new network extensions, especially the smaller branches, were initiated and funded by residents rather than the Ghana Water Company. Sebrepor, our main case study area, provides an extreme example of expansion through community action, powered by informal entrepreneurship. Having received its first homesteaders in the 1970s, Sebrepor today is well embedded in the urban fabric north of Tema Harbour. One of the first settlers was a retired army plumber, Jacob Milehu, locally known as “Mr Jacob.” Using his connections in the military and the GWC, he obtained permission to connect the growing hamlet of Sebrepor to the water network of the nearby army base, Michel Camp. The
GWC drew a pipeline under the busy road separating Michel Camp and Sebrepor, and connected a standpipe there on the roadside.

Dissatisfied with a mere standpipe, Mr Jacob enlisted the help of the local chief and a number of neighbours and established the Water Committee, part of the incipient Sebrepor Settler Society. They collected contributions, bought pipes, and put the area’s youths to work digging trenches, extending the pipeline a few hundred metres into the village. From this point on, all those who wanted a personal connection to the pipe network literally had to pay it forward. The price: material for the home connection, Mr Jacob’s labour costs, and four additional lengths of pipe (about 120 m) to expand the distribution network. Although this was very much a community initiative that could not have materialised without the support of the Settler Society and other local organisations, the extension was carried forward primarily by wealthier farmers. Since they were dispersed across Sebrepor and paid for the connections to their plots, this meant the network eventually cascaded to reach every part of the neighbourhood.

Under Mr Jacob’s supervision and shepherding, the network branched out, upgraded to larger pipes, and was even extended to neighbouring villages. The Sebrepor Water Committee was never a legal entity although it did formalise, creating its own stationery, a supervisory board of local notables (“big men”), and several apprentice plumbers. This formalisation and standardisation allowed the state to all but usurp the efforts of the Water Committee, in effect making it an appendage of the state (cf. Peloso & Morinville, 2014). Today, the self-help pipe network of Mr Jacob’s Water Committee includes all of Sebrepor and its surroundings, about three square kilometres of dense urban neighbourhoods. While the pipe network expanded incrementally through voluntary contributions, entrepreneurship, and grassroots organisation, the end result was incorporated into the state: the connections, once established, were regularised and became official (cf. Pilo’, 2017). What emerged informally and incrementally outside of the state was thus folded into it (cf. Tieleman & Uitermark, 2019). Here we see how informal organisation prefigures and supports state structures: while the Ghana Water Company did not initiate or fund the extensions, it allowed and formalised the extensions established by residents (De Swaan, 1988).

Whereas grassroots collective action was crucial for the expansion of the network in Sebrepor, in other areas the cascade pathway played a larger role. Afienya is a case in point. Funded by their own contributions, Afienya’s residents had pipes drawn to the border of their settlement before their organisation ran out of steam and money. The wealthier households subsequently arranged for their own connections from the settlement’s edge. Others built forward from these connections, gradually expanding coverage throughout the area. Here we see the cascade pathway at work at the micro-level, with infrastructure successively expanded to incorporate increasing proportions of the urban population (Granovetter, 1978; De Swaan, 1988).

The third pathway—that of state action—played a crucial role in several poorer neighbourhoods where local and national politicians worked with donor countries and non-governmental organisations to extend the pipeline network. In Gbetsile, the local constituency chairman for the National Democratic Congress (one of Ghana’s two major parties) played a central role, acquiring funding for the materials and pushing and paying local youths to dig the trenches. While the government took a more proactive role by arranging the distribution lines, the costs for connecting homes still had to be covered by the residents due to GWC’s cost recovery policy. While investments in distribution lines—often co-funded by donors—helped to incorporate poor neighbourhoods into the network and reduce connection costs for residents, the costs of a water meter and the required plumbing were still prohibitive for many residents. Although the pipe passes in front of their doors, many Gbetsile residents cannot afford a personal connection.

In sum, although connectivity remains uneven, Accra’s piped water network has expanded dramatically while access is no longer restricted to elites. Looking at the mechanisms underlying this process, the general pattern appears to be as follows: in most neighbourhoods, we observe a combination of pathways that vary in importance. In homogeneously wealthy neighbourhoods (including gated communities), the community action pathway is often successful, with neighbourhood-wide pipe networks collectively financed and built in a single operation. In homogeneously poor neighbourhoods, residents generally cannot gather sufficient funds and must rely on state action. In socio-economically heterogeneous neighbourhoods, where the cascade pathway is most prevalent, wealthier residents become forerunners in the network construction process, lowering the marginal costs of connecting for those around them. Through these various pathways, the pipe network has expanded throughout the Greater Accra Region, integrating the urban region by means of infrastructure. Not unlike a tree growing roots, the network has expanded incrementally in a decentralised process. As the GWC is chronically underfunded in light of its formal aim to provide water to all of Accra’s residents, the mobilisation of local efforts and their incorporation into formal structures is a remarkably effective way of extending the network.
5 THE CONTRADICTIONS AND LIMITATIONS OF INTEGRATION

One might expect such widespread and successful self-help to be celebrated by the state and the utility company, but this is far from the case. One reason is that the GWC is formally responsible for the network. Although it would be manifestly unreasonable to expect the utility to fully meet its responsibilities given the chronic shortages, acknowledging that it does not have full control over the network can be construed as an admission of incompetence. A more substantive reason why the GWC loathes resident-driven incremental expansion has to do with the system weaknesses that this kind of expansion engenders. Staying with the tree analogy, there are important differences with the growth process of roots. Trees naturally develop an efficient system, optimising the width of their branches for the circulation of water and nutrition (e.g., West, 2018). But decentrally built pipe networks like Accra’s lack such optimisation as they develop inefficient twists, large and demanding network sections built onto narrow initial pipe connections, and all sorts of other bottlenecks. Unlike organic tissue, water pipes are not self-sustaining and self-upgrading; they require constant maintenance and frequent upgrading in size and quality. And when the overall capacity of the water supply network remains the same, the network’s incremental and granular growth reduces volume and pressure per connection. Here we examine Accra’s pipe network to discuss how incremental development through local action shapes, and occasionally disfigures, the system’s global architecture.

The main obstacle to further infrastructural integration is the pipeline’s backbone infrastructure, which has been unable to keep pace with the rapid development of the distribution network and its user base. Following independence in 1957, major investments were made in water treatment plants. Capacity in 1939 was some 5,000 m³ per day (Director of Public Works, 1939); by 1981, it had grown to 85,000 m³ per day (Tahal Engineers, 1981). But since the 1970s, there has been little expansion or even maintenance of water treatment plants and major transmission lines. As a 1998 World Bank report noted: “The water supply systems in Ghana deteriorated rapidly during the economic crises of the 1970s and early 1980s when Government’s ability to adequately operate and maintain essential services was severely constrained” (World Bank, 1998, p. 1). Infusions of donor money in 1970, 1981, and 1988 brought some relief, but not much (GWC, 2016, p. 3). A 1997 report found that water production capacity had remained practically unchanged since 1980 (OTUI, 1997, p. 71). A decade later, capacity had only increased by some 20 percent (GWC, 2012, p. 16). The first major overhaul of the backbone system since the 1960s would not occur until the late 2000s and early 2010s, when the capacity of the network was roughly doubled (2012, p. 15).

It is not only the production of clean water that is falling behind demand. The distribution mains and pumping installations are beginning to crack under the strain of delivering ever more water through a network designed for a smaller city with a smaller population. As a GWC evaluation report stated:

From the various scenarios discussed, it was identified that the system suffers from inadequate pumping, bottlenecks within distribution, lack of pressure separation in addition to growing demand. Any attempt to increase production capacity must as a matter of necessity consider solving these hurdles as a foremost attempt. … In the distribution network, a lot of the DN 200 [200 mm diameter] lines and below have become bottlenecks. (GWC, 2012, p. 36).

Despite these efforts, water delivery today is unstable in many parts of Greater Accra, with large numbers of connected residents receiving almost no water at all. Figures 1 and 2 show the scale of the problem in April 2012. In Figure 1, green areas receive water 70–100 percent of the time, yellow/orange areas 30–70 percent of the time, and the red areas have water flow 0–30 percent of the time. Figure 2 depicts the flow rate, showing that some 60 percent of Accra has a flow rate (when water flows at all) of less than 10 m³/hour, a mere dribble from the tap. According to this map, the supply to the south-eastern and northern parts of Accra—the areas containing most of the newly developing neighbourhoods—is woefully inadequate. Our own observations and interviews suggest that the map probably errs on the side of optimism. In addition, there are stark differences within neighbourhoods: households closest to the mainline have higher pressure and more water than those further down.

These problems are projected to get worse. While work is underway to improve the backbone infrastructure, the pace is slow. In 2003, the water supply stood at 320,000 m³/day, against a demand of 450,000 m³/day, meaning that 71 percent of demand was being met (Adank et al., 2011; GWC, 2012, p. 15). In 2012, the available supply had increased to 420,000 m³/day but was outpaced by demand which had risen to 640,000 m³/day, meaning that 66 percent of demand was being met. The demand for water is projected to double within 15 years. If the supply continues to grow at the same rate as it has over the past decade, the supply to demand ratio will further deteriorate, and Accra’s available water supply will be less than 50 percent of what is required.
The contrast with the network’s early days is striking. While a disruption of water supply to some customers of “up to four hours a day” was found important enough to be mentioned in a letter from the Gold Coast Governor to the Colonial Office in 1931 (Slater, 1931), many GWC customers today suffer flow interruptions that continue for days, sometimes even months. The GWC tries to at least make these interruptions predictable through a systematic rationing process, rotating the supply through neighbourhoods on a weekly schedule. But even when water does flow, the pressure is often inadequate and fails to reach sections of the targeted areas. The most recent estimates indicate that slightly more than half of GWC’s customers receive significantly less water than they need (GWC, 2012).

In an effort to get a handle on the flow of water (cf. Anand, 2017), the GWC was mapping its distribution network at the time of our research (2018). But its efforts are limited to pipes with a diameter of over 150 mm, that is, only the larger transmission lines. A normal neighbourhood-level distribution pipeline (not a personal pipeline, but the type one finds running along main community thoroughfares) generally falls in the 100–150 mm range, meaning that almost the entire distribution network will remain invisible to GWC planners. As the GWC GIS engineer explains, even in the future it will not be feasible to map the entire network:

Currently, we have [mapped pipes with diameters of] 150 mm and above. For asset management, we ideally want [to map] everything, but we will probably go for 75 mm and bigger. [...] When you have these small pipes, they may run through the community without any properly planned route. They just move through, and people just connect from them. So we only want to measure the ones we can easily control.
Not knowing where the pipes are means that maintenance is a daunting task. Leaks are often left unattended for weeks. In many neighbourhoods, nobody knows the entire network, making it difficult to engineer structural solutions.

In sum, the GWC operation is running far behind the network that distributes its water and for which it is formally responsible. The strain caused by the unplanned expansion of the GWC user base is visible throughout the system. In this challenging environment, GWC staff must continuously search for solutions to get a grip on the network. In response to theft, bribing, and tinkering, GWC has developed plastic meters that can be read remotely. The network is being mapped and a model of water flows has been developed, facilitating rationing and more precise distribution. The company is also working hard to expand water purification capacity and improve transmission mainlines. But although the company’s efforts result in piecemeal improvements, they do not begin to address the structural discrepancy between the rapid growth of a largely unknown network and chronic budget shortages.6

6 | THE DYNAMICS OF FRAGMENTATION

The previous sections charted the drivers of infrastructural integration and the structural limitations inhibiting the consolidation of a smoothly functioning, universal network. This section analyses how these circumstances have propelled the development of alternative, private water provision systems underpinned by different sets of interdependencies. These alternative sources of water provision allow wealthy households to buy into “premium water networks” (Boland, 2007) and reduce their dependence on the pipe network. The main means through which residents reduce their dependence on the pipe network (and those who continue to depend on it) are water tanker trucks, boreholes, sachets, and poly tanks. We consider each of these alternative sources of water provision in turn to identify mechanisms of infrastructural fragmentation.

We first consider the growing importance of sachets as an index of infrastructural fragmentation. The sachet represents a technological development in water supply that both reflects and reshapes interdependencies among different groups and places in the city. It emerged in the 1970s and 1980s from the roadside practice of selling water by the cup. In the early

**FIGURE 2** Rate of flow in each area. Blue and green areas have sufficient pressure, orange and red areas do not (GWC, 2012). [Colour figure can be viewed at wileyonlinelibrary.com]
1990s, the cups were replaced by small plastic bags, tied up by hand. In the late 1990s, the industry got another technological upgrade when Chinese entrepreneurs brought in heat-sealing machines (Stoler et al., 2012b). Nowadays, sachets typically consist of 500-ml plastic bags, heat-sealed on either end, and sold in batches of 20 for home use or individually on the roadside. The sachet industry has spawned a new line of employment, with women selling refrigerated sachet water directly to car drivers and passengers at traffic lights for 0.20 cedi ($0.05), from plastic bowls carried on their heads. Sachets are cheap to produce, easy to transport, and perfectly suitable for sale in bulk or as individual packages. Colloquially known as “pure water,” sachet water is also perceived to be of higher quality than pipe-borne or borehole water (Stoler et al., 2012a, 2012b). The consumption of water sachets has risen sharply over the past years, with estimates of the percentage of Accra’s population using this as their primary source of drinking water ranging from 26 to 71 percent (Ghana Statistical Service, 2013, 2014).

Another prominent alternative to the piped water network is the water tanker industry. This term refers to a truck with a water tank mounted on it, generally with a capacity of 5,000–20,000 litres. Although the option has been around for as long as motorised transport, the use of tanker water mushroomed in the late 1980s and early 1990s. Tankers first got their water by illegally tapping GWC fire hydrants (Odai & Andam, 2002, p. 33). In 1992, the government pushed tanker operators to organise so that they could be regulated. The tanker owner-operators formed the Private Water Tanker Owners Association and special depots were created to supply these tankers. Especially outside of the city centre, towards the city’s limits, the tanker and vendor industry is making inroads. According to the Ghanaian Census (2014), this industry provided 17 percent of households with their regular water supply in 2010.

Perhaps the most serious challenge to the piped water network is not (yet) visible in the census data: the rapid growth of the private borehole industry. In 2010, only a small proportion of the urban population relied on boreholes. But during our fieldwork, we observed that a large market for private boreholes was emerging, with posters advertising private boreholes gracing the walls of Greater Accra. Whereas the digging of boreholes first depended on relatively rudimentary technologies, first Chinese and later Indian machinery has advanced the borehole industry in Ghana. With technological advances, the price of a simple but professionally built borehole for domestic use has fallen to 8,000–13,500 cedi ($1,650–2,750) (Interview Agbeka, 2018). In comparison, a connection to the GWC pipe network averages around 700 cedi ($175). But the price climbs steeply with one’s distance from the network, with the cost for distances above 100 metres beginning at around 10,000 cedi ($2,500). Especially for residents who live at some distance from the pipe network, boreholes are an affordable and reliable alternative. As a result, the market for boreholes is growing especially rapidly on the city’s periphery. On our visits to newly built neighbourhoods, we often found wealthier residents—an expanding group including local elites and return migrants—using their private boreholes as their main source of water. While sachets and bottles replace piped water as the main source of drinking water, water from boreholes is used for washing, cleaning, flushing, and other such bulk uses.

In all three alternative modes of water provision, we observe two mechanisms of fragmentation working together. First, higher-class groups reduce or eliminate their reliance on the pipe network, abandoning the public infrastructure of the pipe network partially or entirely. Second, cascades are at work. While the initial investments in the development of sachets, poly tankers, and boreholes are high, prices decline as the market grows, setting into motion a cascade where these private sources of water provision become accessible to a greater number of residents (cf. Granovetter, 1978). Meanwhile, the customer base of the pipe network contracts and residualises—another self-reinforcing trend leading progressively more residents to turn away from the network. Until recently, the GWC network was the dominant and indeed universally preferred option for accessing water. In 2005, a survey found the near universal reply to “What is your preferred water source?” to be: GWC (PURC (Public Utilities Regulatory Commission) 2005, p. 13). But the balance is shifting. While the quality of sachet water was generally perceived as inferior to pipe-borne water in 2006 (Sarpong & Abrampah, 2006), this is no longer the case. The question thus arises: how long will the GWC network remain the generally preferred option? For drinking water, many have already switched to other sources. While a large proportion of Accra’s residents still rely on the pipe network for water to wash and clean, a growing proportion of residents, especially on the periphery, are disconnected from the network as they increasingly turn to tankers and boreholes for most of their water needs. Whereas researchers have shown that connecting to the pipe network affirms the citizenship of informal settlement dwellers in Mumbai (Anand, 2017; Ranganathan, 2014b), in Accra the historical link between social standing and a pipe connection is being severed to the point where wealthier residents can signal their status by not relying on piped water. In our research, we encountered areas, such as Bulasu, where almost every single house has its own borehole. Residents in these areas often had connections to the pipe network but felt water provision was simply too unreliable and elected to find other solutions. When elites depended on the pipe network, they pushed the government to maintain its quality. Today, opting out of the pipe network is an affordable and realistic option for many wealthier residents. Since the system encounters its limits first and most
prominently on the city’s periphery, this is where residents and businesses first develop new—and not necessarily progressive—ways of handling the chronic shortage of piped water. Their innovations reveal a dynamic similar to the cascade expansion path of the pipe network.\(^8\) Whereas the wealthy were previously the first to connect, lowering the threshold for others, they are now the first to disconnect. Should it continue, the victims of this process will be poorer and middle-class residents who in the past benefited from elites’ commitment to the piped network.

### 7 | CONCLUSIONS

Although the details of the uneven expansion of Accra’s water infrastructure are intricate and complex, we can identify broad trends: one towards infrastructural integration in the years following Ghana’s independence, followed more recently by a trend towards fragmentation. We first discuss the main pathways towards infrastructural integration. Following independent statehood in 1957, Accra’s piped water network expanded dramatically, with more residents connecting to the network and thus to each other. State investments were a precondition for this expansion. Post-colonial governments expanded the system’s backbone (including water treatment plants and booster stations) and extended mainlines beyond elite and inner-city districts, while the network’s granular extension into neighbourhoods and across different strata was achieved by residents. Notable throughout the data is the dogged incrementalism and the degree to which residents have managed to build parts of the network. They either gathered informally to organise the network’s incremental extension (as in Sebrepor) or individually sought to build onto connections established by others (as in Afienya). Although unplanned, the process is efficient because it mobilises local expertise, labour, and funding. The state subsequently capitalises on this self-organisation by formalising the network connections. The overall effect is one of intensified interdependencies between different strata and neighbourhoods as they are integrated into the pipeline network.

To identify the overall process and its underlying mechanisms, we relied on figurational sociology which, we argued, is particularly suitable for identifying long-term trends in the direction of greater infrastructural integration. This emphasis complements and counterbalances critical work in geography that emphasises trends towards fragmentation, exclusion, and dispossession. More specifically, our findings qualify claims that contemporary infrastructures only perpetuate inequalities inherited from colonialism. Mike Davis, for example, argues that post-colonial elites in Accra merely “recapitulate older forms of imperial control and racial dominance” to “defend their own class privilege and spatial exclusivity” (2006, p. 96). Although it is true that colonialism continues to shape Accra’s urban development, it is crucial to acknowledge what has changed. The pipe network has radically expanded and provided a growing number of residents—and not only elites—with a vital provision. Discounting this risks fuelling nihilism and relativising colonial domination by arguing that nothing—neither the “rhetorics of national liberation and social justice” (Davis, 2006, p. 96) nor “illusions of self-help” (2006, pp. 70–94)—has dented the logic of domination. Our analysis shows that the efforts of post-colonial governments to improve infrastructure and residents’ efforts at self-help have led to much broader coverage. Although “spatial exclusivity” (Davis, 2006, p. 96) is evident in some domains (e.g., Grant, 2009), the pipeline network has grown out of and fostered interdependence between elites and lower strata (cf. De Swaan, 1988).

While expansion and integration continue to this day, we also observe tendencies in the opposite direction. The elite strata of the user base, the first to opt in, are increasingly opting out of the piped water network in favour of private options such as boreholes and tankers that bring water directly into their homes. While affluent residents previously relied on the pipe network and poor residents relied on boreholes, we are now witnessing a reversal with far-reaching consequences: as affluent residents extract their households from the pipe network, they lose interest in maintaining and improving the network, undermining its viability in the long run.

Although there is presently a strong push toward fragmentation, it is not a foregone conclusion that this process will continue or prevail. Our analysis suggests that, historically, forces of integration have been strong. Understanding these forces of integration is important to account for historical developments but also has practical implications for policy. Crucially, our analysis suggests that in addition to technical, legal, political, and economic considerations, the creation of infrastructures involves the structuration of interdependence between groups: the pipe network’s expansion will only find support when different social strata and areas benefit. More specifically, we noted the risk of a cascade in the form of a downward spiral: when the resourceful and powerful users opt out of the pipe network, this results in declining quality, leading more residents to abandon the pipe network, and so forth. This downward spiral can be prevented by state investments in the system’s backbone infrastructure (i.e., water treatment plants, mainline infrastructure, and booster stations) and by (dis)incentivising elites to opt out, for instance, by obliging developers of new estates to connect to the pipe network and regulating boreholes more strictly. Perhaps more discomforting, our analysis points to the critical role of elites in infrastructural integration and fragmentation. There are risks to strategies that maximise access for low-income residents: if
investments are made to increase the number of connections among poor households without concomitant investments in the backbone infrastructure, quality suffers and elite abandonment may ensue, setting in motion a cascade with detrimental effects on the network as a whole.

We suspect that Accra is far from unique in that processes of fragmentation are especially manifest on the city’s outskirts. In the face of rapid urban growth, many governments are hard pressed to extend infrastructure to these new areas; the peripheral areas of cities also often contain sizeable groups of wealthier residents who can afford other options. This is not to say that rapid urbanisation pre-empts the provision of state-managed utilities. But it does raise serious challenges. To better understand these dynamics, we need approaches that bridge the rift in the literature between ethnographic studies that examine situated practices (often drawing on some variant of assemblage urbanism) and studies examining the systemic logics of infrastructures at higher levels (often rooted in political economy; Bartels et al., 2020). Our study contributes to closing this gap by showing how local developments feed into and grow out of broader developments. Moreover, in addition to approaches that interrogate established concepts and critique dominant practices (Furlong & Kooy, 2017; Lawhon et al., 2014; Silver, 2014; Truelove, 2019, 2020), we need approaches that explain tendencies toward and away from equitable infrastructure provision. The perspective developed in this paper provides one way of identifying the mechanisms underlying long-term trends toward infrastructural integration and fragmentation. Deepening our knowledge of these mechanisms is critical both for understanding and shaping equitable infrastructures.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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ENDNOTES

1 Following figurational sociology, we define “integration” as a densification and extension of interdependencies between different groups and territories (cf. De Swaan, 1988; Elias, 1996). Thus understood, integration is the opposite of fragmentation, or what Marvin and Graham (2001) refer to as “splintering”—a process where infrastructures are differentiated and customised according to resources and status. Some policymakers use the term “integration” to refer to something quite different, namely the fusion of different policy fields in the pursuit of more efficient solutions (Williams et al., 2019).
2 Elias was unsuccessful in his attempts to transpose his analysis to Ghana, and to contexts outside of the West more generally (see Goody, 2002, 2003). Rather than following in Elias’ footsteps, we mine his work, and that of scholars inspired by him, for concepts and insights relevant to the case at hand. We further draw on critical literature on the post-networked city to steer away from the premise, present in some of Elias’s work, that countries are destined to follow in the West’s footsteps. A more comprehensive reassessment and reworking of Elias’ ideas in light of post-colonial criticism is called for but beyond the scope of this paper.
3 Although there are no exact data for this period, an indication can be gleaned from the growing number of water usage metres. In the chaotic years of alternating governments leading up to Rawlings’ second coup in 1982, the number of domestic connections grew annually by 8.6 percent (OTUI, 1997, p. 71). The number of registered GWC customers in Greater Accra grew from roughly 80,000 in 1980 (calculation based on Tahal) to more than 250,000 in 2015 (Ghana Water Company, 2015). The expansion shows no signs of abating (GWC customer data files, 2016–2018).
4 The first movers in a newly settled area are often eager to connect to utility networks not only for their own use, but as a way to attract more people. As a result, different types of resident initiative proliferate in Accra’s new neighbourhoods (Gough, 1999).
5 Note that this does not happen everywhere: Dawhenya and Mataheko do not have access to the pipe network. Dawhenya has been serviced by standpipes for the past 40 years, ever since the area became a farming hub under President Acheampong’s Operation Feed Yourself. Grassroots organising has failed to transform these standpipes into a network of household water connections. To date, Mataheko has lacked the grassroots organising or funding to construct a local network.

6 In the early 2000s, the government agreed to privatisation and outsourced the network’s operations to an international consortium, which did not result in structural improvements (Hirvi and Whitfield, 2015). This is hardly surprising: unless overdue maintenance and insufficient capacity are addressed, tinkering with the system and strategically addressing the most pressing problems is the most that can be done.

7 Customers may not immediately notice changes in the relative quality of water. Research on user perceptions of drinking water showed that people mostly assess water quality by looking at its colour (80 percent), smelling for chlorine (10 percent), or simply by tasting it (10 percent) (Sarpong and Abrampah, 2006, p. 44). Water sachets began as a relative luxury. But as sachets became mainstream, bottled water emerged as the deluxe alternative, now routinely sold by street-side hawkers. The next step appears to be brand-specificity, where only specific brands of bottled water are considered acceptable by wealthier segments of the population. Whether this continuous upgrading and cascading process leads to quality deterioration in technologies lower down on the luxury ladder (such as sachets that have lower socio-economic status and perhaps a higher degree of price competition) remains to be seen.

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