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Co-producing maintenance and repair: hybrid labor relations in water supply in Accra, Ghana

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ABSTRACT

Access to water supply is still a problem in African cities. This has sparked discussions about how small-scale private actors could collaborate with the state to improve water supply. However, scholarly discussions on water supply have hardly examined the role of such actors in maintenance and repair. This paper shows how water infrastructures are maintained and repaired through hybrid labor relations between private and public actors where formal and informal practices are combined. These findings allow us to shift conceptualization in maintenance and repair beyond the state and explain how private actors enact and challenge the state's power through maintenance and repair practices.

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informality; repair; maintenance; water supply; infrastructure

1. Introduction

Despite several years of interventions by international donors and national governments, access to water supply remains a significant concern in many African cities. Over the past 30 years, the persistence of the water supply challenge has sparked discussions among scholars and practitioners about the role of small-scale private actors in improving water access, as it has become clear that public water providers alone cannot meet the growing demand for water (Furlong and Kooy 2017; Peloso and Morinville 2014). The context of Ghana provides a concrete example of these private actors' vital role in water supply. Here, urban water supply is the responsibility of the Ghana Water Company Limited (GWCL), a state-owned water provider (Bartels, Bruns, and Alba 2018). However, in rapidly growing cities such as Accra, where rising water demand has outstripped GWCL's system's capacity, residents usually access water supply through a combination of public and various private providers such as vendors, tanker operators, and sachet water sellers (Peloso and Morinville 2014; Bartels, Bruns, and Alba 2018).

Private actors' role in water supply in the Global South has already been discussed extensively. However, the focus has been mainly on formalized public-private partnerships through management contracts (see Budds and McGranahan 2003; Adams and

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Zulu 2015; Dill 2009; Twum and Abubakari 2020) and how citizens informally collaborate with the state in co-producing water supply (Adams and Boateng 2018; Bartels, Bruns, and Alba 2018; Monstadt and Schramm 2017; Moretto et al. 2018; Allen, Dávila, and Hofmann 2006; Ahlers et al. 2014; Peloso and Morinville 2014). These studies have demonstrated the crucial importance of small-scale private actors in complementing water supply in the Global South, particularly in African cities. However, even though they are usually involved in maintenance and repair operations, these private actors' role in water supply systems maintenance and repair has rarely been examined. Instead, research on water supply has mainly approached maintenance and repair as a public task for which public utility providers are responsible (Alda-Vidal, Kooy, and Rusca 2018; De Coss-Corzo 2021; Anand 2017; Jambadu, Monstadt, and Schramm 2022). However, such conceptualization tends to neglect the vital role of private actors like users and plumbers in maintenance and repair operations (exceptions are Wahby 2021; Sanchez, Kemerink-Seyoum, and Zwarteveen 2019). In this paper, we thus investigate the role of private plumbers and users in the maintenance and repair of water supply in Accra, Ghana's capital and largest city. We aim to explain how the everyday practices of these private agents complement the practices of public water providers in co-producing maintenance and repair of urban water supply.

In Ghana's urban areas, the body responsible for the maintenance and repair of public water systems is the GWCL, but in rural and peri-urban areas, it is the Community Water and Sanitation Agency (CWSA) (Bartels, Bruns, and Alba 2018). However, individual households are fully responsible for maintaining and repairing their private water systems, although that task is usually outsourced to private plumbers. This article shows the dependence of water infrastructures' maintenance and repair on hybrid labor relations between public engineers and private plumbers in which formal and informal practices of all actors are combined.

This concept of hybridity enables us to advance three critical contributions in infrastructure maintenance and repair on the one hand and, on the other, private sector participation in water supply. First, by focusing on the role of private actors, we expand conceptualization in maintenance and repair beyond the state to emphasize the crucial role of users and private plumbers and how their practices routinely interplay with public utility officials in co-producing critical services. Second, we bring maintenance and repair into dialogue with broader literature on infrastructure co-production in the Global South, which allows us to shift the focus of co-production debates away from infrastructure provision to maintenance and repair – an aspect of water supply that has often been overlooked in co-production literature. Third, the findings provide helpful empirical insights on hybrid labor relations in maintenance and repair that can guide public utility providers and policymakers in the governance of water supply.

The article is based on two case studies conducted in the neighborhoods of Nima and Dodowa in the Greater Accra Metropolitan Area (GAMA). Accra was selected because research has shown that water scarcity is a significant stress on the city's resilience and its inhabitants' health and livelihoods (Adams and Vásquez 2019). Nima is an informal settlement, while Dodowa is a peri-urban area with different infrastructural and socioeconomic conditions. Thus, studying these two neighborhoods

has enabled us to understand the spatial dynamics of maintenance and repair and how they work in different urban contexts.

The rest of the paper is structured as follows: section two discusses the role of private actors in water supply, focusing on formal public-private partnerships and informal co-production modalities. Section three discusses the concept of hybridity, and section four introduces our research methodology. Section five discusses the findings under four subsections to show how formal and informal practices of private and public actors interplay in water supply. Section six concludes that private actors are crucial not only for ensuring water supply but also for maintaining and repairing water infrastructure. We argue that the state should recognize their importance for improving water supply in African cities.

2. Private actors' participation in water supply and maintenance and repair in Africa

In many African cities, water supply usually entails a combination of public and various private infrastructure arrangements and systems (Allen, Dávila, and Hofmann 2006). In current research and policy discourses the involvement of private actors in water supply has been discussed under two broad headings: public-private partnerships and co-production. Scholarly discussions since the 1980s have mainly focused on public-private partnerships (PPPs) and privatization schemes, highlighting how public water providers collaborate with private entities in urban water supply through formal management contracts (Budds and McGranahan 2003; Monney and Antwi-Agyei 2018; Twum and Abubakari 2020). Public-private partnership here means that the responsibility for water supply (initially taken on by the state) is outsourced to a private entity while the state remains the owner of the infrastructures and regulator of the service delivery (Allen, Dávila, and Hofmann 2006). For a long time, the World Bank framed and promoted PPPs in Africa as the best way to improve cost efficiency in public water supply (Bakker 2008; Budds and McGranahan 2003) and implemented various PPPs across many countries. However, PPPs are often controversial and highly contested by civil society and human rights activists (Darmame and Potter 2011; Mudege and Zulu 2011). Indeed, most have been short-lived in Africa, with disappointing impacts on urban water supply (Allen, Dávila, and Hofmann 2006).

The disappointing outcomes of PPPs have sparked discussions about other alternative models, such as co-production (Adams and Boateng 2018). Co-production discourses mainly focus on the role of small-scale private actors and how they collaborate with the state in water provision (Ahlers et al. 2014; Bartels, Bruns, and Alba 2018). Joshi and Moore (2004) define co-production in the context of long-term institutionalized collaboration between the state and organized citizen groups in public service delivery (Joshi and Moore 2004), whereby both actors contribute substantial resources (see Moretto et al. 2018). From this definition, co-production might suggest a harmonious cooperation between state and non-state actors, who work together to improve water supply. Ahlers et al. (2014), however, have cautioned that co-production is by nature characterized and shaped by tensions and conflictual relations between actors, due to power asymmetries and divergent interests (Ahlers et al. 2014, 2). Also, co-production entails hybrid arrangements in which the interactions between actors

shape and in turn are shaped by the socio-political, economic, biophysical, and infrastructural drivers, thereby constituting new practices (ibid.). Therefore, co-production is often seen as a means to enable and deepen user participation in water service delivery, and can empower local communities to take full responsibility for their water supply (Adams and Boateng 2018; Moretto et al. 2018). However, Pilo' (2017) cautioned that in societies where state authority is weak, co-production could create ambiguous roles and responsibilities between state and citizens, potentially challenging state power and authority.

Despite being a powerful conceptual lens, co-production has not adequately explained the role of small-scale private actors in water supply because it has mainly focused on institutionalized or recognized group collaborations, while often ignoring individual private actors. This has prompted some scholars (Ahlers et al. 2014; Peloso and Morinville 2014) to discuss the role of private vendors and small-scale providers concomitantly with binary formal and informal categories. In these discussions, formality is usually linked to the state's centralized networked infrastructure system, while informality is attributed to incrementally built systems (Maryati, Humaira, and Kipuw 2018; Peloso and Morinville 2014). Such conceptualization assumes that informal water supply systems have emerged due to failures of the formal supply systems and thus will disappear once the formal system becomes efficient. However, Ahlers et al. (2014) indicate that such a notion is inaccurate because informal systems (e.g. illegal networks) can be found in the so-called formal networks (Misra 2014), while formal systems also exist beyond centralized systems, e.g. water tankers operated by water utilities (Peloso and Morinville 2014). In practice, the boundaries between formal and informal systems are often blurred and intertwined through the everyday practices of actors (Ahlers et al. 2014).

Extending this line of scholarship to the practices of maintenance and repair, current research in the Global South has demonstrated how formality and informality interplay in maintenance and repair of electricity services in Maputo, where infrastructures are "always in the making" through the constant work of maintenance and repair (Baptista 2019). De Coss-Corzo (2021) built on similar thoughts to show that waterworks in Mexico City are often constituted and shaped by incremental patchworks of maintenance and repair – acts that are never based on standard rules or guidelines but instead are somewhat adaptive and ad-hoc improvisations that combine formal and informal practices. In this sense, maintenance and repair work is neither fully formal nor completely informal but instead combines elements of both (De Coss-Corzo 2021). In Cairo, Egypt, Wahby (2021) shows how the public maintenance and repair system has increasingly been challenged (and could potentially be replaced by) community-led repair interventions in gated communities. She traces the emergence of "gehood zateya" (individual and community repair efforts) to neoliberal land reform policies in Egypt, which has shifted the responsibility for maintenance and repair from the state (public utility) to the private real estate companies, thereby setting the stage for private actors' participation in maintenance and repair in water supply. While studying irrigation infrastructure repair in Cairo, Egypt, Barnes (2017) contends that maintenance and repair works are not meant only to fix broken artifacts but also to maintain state power and control over the infrastructures and the citizens who depend on them – a notion expressed earlier by Graham and Thrift (2007).

Despite growing interest in studying the maintenance and repair of water supply systems in the Global South, scholars have mainly focused on the practices of public utility providers, such as official engineers, while other private actors involved are usually neglected. A more precise conceptualization is thus required to explain maintenance and repair beyond the perspective of public utility providers that has dominated the literature to date. Building on these debates, we introduce the notion of hybridity in the next section to better explain how the everyday practices of private plumbers, users, and public utility officials interplay in co-producing maintenance and repair in public water supply.

3. Hybridity in maintenance and repair configurations

The concept of hybridity has been used to describe how different—i.e. networked and non-networked; public and private; formal and informal – infrastructure configurations work together in water supply (Furlong 2014; Ahlers et al. 2014; Wahby 2021; Cawood, Wahby, and Ferrara 2022) or electricity supply (Rateau and Jaglin 2022) in the global South and how these are governed (Yates and Harris 2018; Furlong 2014). Recently, Cawood, Wahby, and Ferrara (2022) defined hybridity in water supply as an arrangement “in which formal and informal supplies and practices blur in residents’ everyday lives as they negotiate to gain and maintain access to water” (ibid: 689). Unlike coproduction, which focuses on relations and collaborations between state and nonstate actors in service delivery (Rateau and Jaglin 2022; Ahlers et al. 2014), hybridity is concerned about the resulting different infrastructure delivery configurations and how they function together or against each other in cities (Rateau and Jaglin 2022; Cawood, Wahby and Ferrara 2022). In short, coproduction is often discussed in relation to the role of state and nonstate actors in the process of service delivery, while hybridity is discussed with reference to the diverse configurations resulting from the tensed and contested coproduction process (Rateau and Jaglin 2022). However, both concepts usually describe how different service delivery modes works beyond the state, where service provision usually combine the characteristics of market logics and public services (Pestoff 2014).

Although a robust explanatory framework, hybridity has been critiqued by scholars. For instance, Ahlers et al. (2014) argue that actors in water supply usually have multiple identities (which allow them to switch between public and private) simultaneously. This fluidity and plural identities create ambiguities in actors’ roles, responsibilities, and limits (Furlong 2014; De Coss Corzo 2019). At the same time, the ambiguity could result in an “identity crisis”, as it becomes difficult to differentiate the actors and from which position they operate at a specific time. Despite these critiques, hybridity remains a powerful conceptual lens through which we can move critical analysis of everyday practices in the global South beyond the binary of formal and informal or private and public to a “third space” (Sayegh 2008) where the transactions of all actors in water service delivery can be fully accounted for without falling into the trap of fixity and absolute categorization (ibid). In this article, the concept of hybridity helps us to explain better how public and private repair configurations not only interpenetrate but are linked to each other in water supply and the resulting power relations from the interactions between the actors involved (Ahlers et al. 2014; Pilo’ 2017). At the same

time, it enables us to understand maintenance and repair beyond the state and explain how maintenance and repair are co-produced through the interaction between state and nonstate actors, where market-oriented logics interplay with public services interest.

Building on the above literature, we use hybridity to describe a form of maintenance and repair configurations in which public and private schemes operate simultaneously, and actors involved combine formal and informal practices in their everyday operations (see Wahby 2021; Cawood, Wahby, and Ferrara 2022). Thus, the resulting hybrid configuration is neither entirely public nor private but combines specific characteristics of both (e.g. actors, materialities, knowledge, and practices). Moreover, all actors involved have multiple identities and can substitute each other but sometimes work complementary in sustaining water supply (Wahby 2021; Meehan 2014). Furthermore, the everyday practices of actors interplay between formality and informality (Ahlers et al. 2014). In this context, the categories of formality and informality are described as contingent, intertwined, and continually shifting through the everyday practices and interactions between actors (Misra 2014). We thus argue that although the formal and informal categories have analytical value, they are, in practice, often blurred and intertwined as a “series of transactions that connect different [maintenance and repair configurations] to one another” (Roy 2005, 148).

Furthermore, formality and informality are not synonymous with legal and illegal binaries (Ahlers et al. 2014). Rather, they describe slightly different urban conditions and practices. Thus, we argue that although the boundaries of these concepts often intersect in everyday urban practices (Roy 2005; Ranganathan 2014; Misra 2014; Ahlers et al. 2014), they have different meanings. In this study, legality and illegality are used to describe practices or configurations that contravene or comply with water providers’ laws and regulations. In contrast, formality and informality describe practices that conform (or do not comply with) technical standard operating procedures as defined by organizational guidelines (Ranganathan 2014).

4. Case study sites and methods

For this qualitative study, two case studies were conducted in the neighborhoods of Nima and Dodowa in the GAMA. Accra is particularly suitable for this study because acute water shortages have been identified as a significant stress on the city’s resilience (Adams and Vásquez 2019). The GAMA region (Figure 1) covers approximately 1585 km² and shares boundaries with the Eastern, Volta, and Central regions (Addae and Oppelt 2019). Accra is the national capital and the most populous city in Ghana, with approximately 5.4 million residents in GAMA (Ghana Statistical Service GSS 2021). Its growth is, however, driven primarily by informal construction practices (Silver 2014), and about 60% of the population lives in informal settlements (Adams and Vásquez 2019). Accra’s rapid growth means that peri-urban areas like Dodowa have become part of the urban agglomeration. This has brought together diverse neighborhoods with different socio-spatial and political configurations and has reconfigured institutional and urban boundaries of rural, urban, and peri-urban spaces.

In this study, we focus on the neighborhoods of Nima and Dodowa because they differ appreciably in terms of socioeconomic, infrastructure, and urban conditions. For instance, Nima is a densely populated informal settlement (Owusu, Agyei-Mensah, and

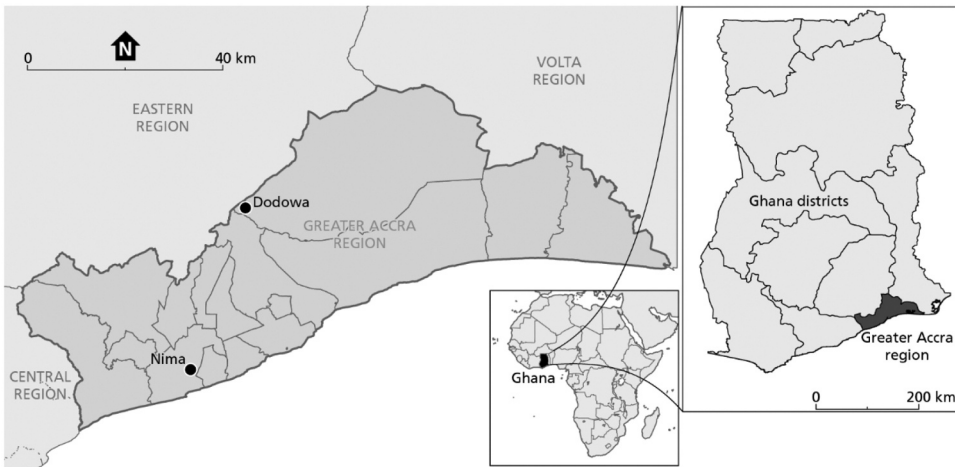


Figure 1. Map of Accra showing Nima and Dodowa, the case study locations.



Figure 2. Household selling GWCL water in Nima (March 25, 2020).

Lund 2008), while Dodowa is a rapidly expanding peri-urban area. Nima has about 80,000 inhabitants compared to 12,000 in Dodowa (Grönwall and Oduro-Kwarteng 2018; Adams and Vásquez 2019). Most inhabitants of Nima are classified as low-income, while those in Dodowa are regarded as middle- or high-income (Owusu, Agyei-Mensah, and Lund 2008; Ghana Statistical ServiceGSS 2014). Whereas most houses in Nima are in compounds and lack space for future expansion and



Figure 3. Private water connection in Dodowa supplied by GWCL (March 20, 2020).

infrastructure access, those in Dodowa are mainly constructed as semi-detached housing units intended for single families. These contrasting characteristics make it possible to understand the diversity of water supply systems and the hybrid labor relations and practices that underlie and shape their operations, repair, and maintenance in different urban contexts.

Empirical data for this study were collected through semi-structured interviews and field observations conducted in the two neighborhoods between 2018 and 2020. We interviewed 48 respondents, i.e. GWCL officials, local plumbers, residents, owners of small-scale businesses, and representatives of government administrations. The interviews covered water supply, maintenance and repair operations, the role of plumbers in repair, and their relationship with GWCL officials in their everyday operations. To better understand the practices of the actors, we followed private plumbers and GWCL engineers separately to different field operations to observe them while they were carrying out maintenance and repair in real-life contexts. This provided further opportunities to learn about their respective field operations and gain first-hand insight into their everyday practices on the ground and the underlying logics. During these field observations, we had informal conversations with repair workers to gather further information that might not have been captured in the semi-structured interviews. All qualitative interviews were transcribed, coded, and analyzed through content and thematic analyses. They are presented below under three main themes: starting with an overview of water provision in the Greater Accra Metropolitan Area, followed by maintenance and repair of water supply, and the role of private plumbers therein. The empirical data was complemented by reviewing various academic literature and official policy documents on water supply and maintenance and repair in Ghana and African cities.

5. Water supply in greater Accra and its diverse neighborhoods

The provision of water supply in Accra follows the general framework for Ghana, structured along the lines of rural/urban categories (Bartels, Bruns, and Alba 2018). In urban areas like Accra, responsibility for water supply rests with the GWCL, while in rural/peri-urban areas, it rests with the local assemblies and the CWSA. As a coastal city, seawater intrusion restricts groundwater use in large parts of Accra (Grönwall and Oduro-Kwarteng 2018). This means that water supply is mainly provided through the GWCL systems and other intermediary configurations, such as sachet water sellers, tanker operators, and public vendors (such as Figure 2), who resell GWCL's water in various forms and packages. GWCL's operation is regulated by the Public Utilities Regulatory Commission (PURC) and the Water Resource Commission (WRC), while the Ministry of Sanitation and Water Resources provides strategic leaders and policy direction (Government of Ghana, 2007; 2014). GWCL abstracts its water from the Volta and Densu rivers via Kpong and Weija treatment plants. These plants are complemented by a seawater desalination plant, which mainly serves the Teshie – Nungua areas.

GWCL's water system's supply capacity is about 215 million gallons per day, but the current demand for water in Accra is approximately 273 million gallons per day (Jambadu, Monstadt, and Schramm 2022). The demand gap is further widened by the considerable losses of up to 50% of all the water fed into the GWCL's distribution system due to technical leakages, water theft, illegal connections, and inadequate metering (Jambadu, Monstadt, and Schramm 2022; Ghana Water Company Limited GWCL 2018; Effah Ameyaw and Chan 2013). Consequently, GWCL's centralized supply system meets only approximately half (50%) of the city's daily water demand, while the remainder of the population accesses water through various private arrangements, including small-scale vendors (Peloso and Morinville 2014). GWCL's water supply is also erratic and intermittent due to rationing schemes (Effah Ameyaw and Chan 2013): everywhere in the city receives water twice or three times per week (Afriyie and Ferber 2018; Peloso and Morinville 2014). The rationing timetables are not usually transparent to households and are often not adhered to by local pump operators. As a result, most households in Accra typically have backup plans, including storing water in various containers and developing multiple water infrastructure configurations (Bartels, Bruns, and Alba 2018; Peloso and Morinville 2014). However, the forms of infrastructure configurations in a neighborhood depend on the prevailing socioeconomic, spatial, and urban conditions. The inhabitants of Nima and Dodowa, therefore, access water supply through different modalities and infrastructure configurations. In Nima, as in the rest of central Accra, underground boreholes and wells are not common because seawater intrusion makes water from these sources salty and unfit for human consumption. Hence, water supply is mainly provided through GWCL's centralized system and other intermediaries. Similarly, private water tanker operators are not common in Nima because the haphazard nature of the settlement makes it difficult for tanker trucks to navigate. The GWCL has installed basic water infrastructure in Nima, i.e. main transmission lines, distribution networks, and subsidiary networks. However, only a few individual households have private connections, not because residents cannot afford to pay but mainly due to the haphazard nature of the settlement, which makes it impossible to extend the primary networks

into individual households (Interview 1, 2020). As a result of these challenges, illegal networks and water theft are more common in Nima than elsewhere in the city. Even if the GWCL could provide private connections to households, it would be difficult to ensure their maintenance and repair and to collect payment for water bills (ibid, 2020). Because of this challenge, the GWCL mainly promotes public standpipes and commercial stand-posts across the neighborhood. Besides the GWCL networks, inhabitants also use sachet water, while those with private connections often sell water to their neighbors (Adams and Vásquez 2019; Bellaubi and Visscher 2014).

Dodowa presents a relatively different sociotechnical configuration in water supply. Unlike Nima, underground water sources such as boreholes and wells are common in Dodowa because it is about 30 kilometers from the Atlantic sea, and therefore the aquifer is generally free from seawater intrusion (Grönwall and Oduro-Kwarteng 2018). Hence, about 78% of households' drinking water is sourced from boreholes (Grönwall and Oduro-Kwarteng 2018). As Dodowa is a peri-urban area, the responsibility for its water supply officially falls under the mandate of the local assembly and the CWSA. However, the GWCL has also installed its water supply systems in Dodowa (such as in Figure 3), and they operate side-by-side with the decentralized systems installed by CWSA. The latter include communal boreholes, hand pumps, and shallow wells constructed by the local assembly and CWSA. In addition to these state-led systems, local entrepreneurs package and sell borehole or piped water to residents in various ways: tankers, vendors, and sachets (Grönwall and Oduro-Kwarteng 2018).

Approximately 4,000 customers were officially connected to the GWCL's network in Dodowa in 2019 (Interview 4, 2020). This number was achieved after the water company had collaborated with residents to expand the primary networks into most parts of the city, making it possible for many households to connect. In this collaboration, the residents agreed to contribute to "self-finance" the primary network, even though the network is the responsibility of the GWCL (Interview 3, 2020). While this intervention expanded the network's coverage, it raised the initial connection cost by more than half, making it difficult for low-income households to afford it (Interview 3, 2020). Hence, those without private connections usually rely on their neighbors' pipes and other common sources, i.e. boreholes, wells, hand pumps, sachet water, public stand-posts, and private tanker operators (Foppen et al. 2020; Grönwall 2016; Grönwall and Oduro-Kwarteng 2018). Table 1 highlights the different water infrastructure configurations in the two neighborhoods. The key differences include the level of coverage by GWCL networks and the diversity of other water supply systems, including boreholes and private tankers operators. In short, the water supply systems in Dodowa entail more diverse infrastructure configurations than in Nima. Thus, whereas inhabitants of Nima can access water supply mainly from GWCL's centralized system, their counterparts in Dodowa have various choices, including underground boreholes and tanker services, which are usually rare in Nima.

The maintenance and repair of the abovementioned water infrastructures require differentiated expertise, knowledge, and labor relations based on the local context. The following sections explore these place-based specifics, starting with an overview of GWCL's public maintenance and repair system in Accra.

Table 1. Summary of water infrastructure systems in Nima and Dodowa.

Variable	Nima	Dodowa
<i>Typologies of water systems</i>	<ul style="list-style-type: none"> ● authorized GWCL connections ● unauthorized networks ● Public standpipes ● Sachet water ● Neighbor's pipe 	<ul style="list-style-type: none"> ● GWCL connections ● Boreholes/handpumps ● Public standpipes ● Tanker operators ● Water sachets ● Shallow well
<i>Actors in water supply</i>	<ul style="list-style-type: none"> ● GWCL employees ● Entrepreneurs/vendors ● Users/Residence ● Private plumbers 	<ul style="list-style-type: none"> ● GWCL employees ● CWSA ● District Assembly ● Entrepreneurs/vendors ● Water and Sanitation Management Teams ● Users/residents ● Private plumbers

Source: Authors, based on fieldwork.

6. The maintenance and repair of Accra's centralized water supply system

The GWCL is the official maintenance and repair service provider for all public utility network infrastructures in Ghana. Within the GWCL, the actual task of maintaining and repairing water infrastructures is delegated to district-level offices across the city. The GWCL has about ten district offices in the GAMA region, which includes Dodowa and Nima. Each district has a maintenance and repair team of about 6–10 people (repairers, pipefitters, technicians, and supervisors). The everyday operation of GWCL's maintenance and repair teams is shaped by formal and informal rules, guidelines, and standard operating procedures developed by the company's management (Interview 5, 2020). Team members operate on the basis of their hydraulic knowledge, practical experience, and contextual knowledge gained through many years of working. Before the repair teams embark on routine field operations, the team leader (the operation and maintenance manager) usually issues brief instructions, summarizes the tasks at hand, and provides the necessary logistics and tools for carrying them out. He assigns specific tasks to members and supervises their work with the supervisors, whom team members refer to as *foremen*. The repair team usually works as a group (such as in Figure 4) but is sometimes split into subgroups working in different locations.

GWCL has no technology for discovering leakages and bursts in their networks. Instead, the repair teams often rely on principled residents' volunteering information. Anyone can report a leak or burst by calling a centralized call center or walking into their district offices to complain. An engineer in the Dodowa office describes the situation as follows:

We do not have any technology to discover leaks. We rely upon people to report to us, or our engineers discover them during field operations. However, we have a call center in the region that helps us to get reports from the public. When they call, we ask for the physical locations and directions using landmarks. I then dispatch my boys to go and check it up and close the valves first before we check about the repair

(Interview 2, GWCL employee, 2019).

This means that only those leaks and bursts that come to the notice of public utility engineers will be repaired; the unreported ones will persist unresolved.

When leakages/bursts problems are reported, e.g. by phone, the team leader logs and profiles the problem for tracing and identification by field staff. A fact-finding team is usually dispatched to locate the spot, conduct a preliminary assessment of the extent of the fault, and report to their leader for instructions. One team leader disclosed that they usually prioritize major leaks and quickly close the valve on any leaking line to reduce further losses before they contemplate repairing the leakage (Interview 4, 2019). In addition to the core repair team, districts have parallel emergency teams who usually operate at night (see schedules in Figure 5) and are meant to provide quick solutions to repair needs, especially for critical infrastructures and services such as the airport and hospitals.

The GWCL finances its public maintenance and repair scheme through internally generated revenue. The regional offices organize all necessary materials, logistics, and equipment for onward distribution to district operations. Among the significant challenges affecting maintenance and repair operations in GWCL are inadequate financing, limited repair staff, and inadequate access to materials, logistics, and technical tools (interviews 2, 4, and 5 2020). As discussed in the next section, these challenges often undermine the public repair system and require private plumbers' and users' informal interventions to fix maintenance and repair problems in public water supply systems.

7. The role of private plumbers in maintaining and repairing water systems

How the water supply systems in Nima and Dodowa are repaired and maintained in real life differs considerably from the ideal repair system described above. In practice, maintenance and repair entail private plumbers, users, and public engineers operating side-by-side and sometimes replacing each other. This section discusses how the practices of users and plumbers routinely intersect with GWCL's repair systems in the two sites.

7.1. Maintenance and repair in Nima

Under Ghana's water sector policies, households are responsible for maintaining and repairing their private water connections. However, that task is usually outsourced to private plumbers. The owner and commissioned plumber negotiate the cost, fees, and scope of maintenance and repair work. Private plumbers are mostly hired based on recommendations by friends and family members who have used their services and can attest to their competence. Whereas the maintenance and repair of legal private connections can be outsourced to any competent private plumber, that of illegal connections (which are common in Nima) are usually outsourced to the plumber who originally installed the network – a strategy that keeps the network a secret known only to the plumber and the owner (Interviews 10 & 11, 2020). To sustain this arrangement, the owner of the illegal networks occasionally rewards the plumber for his loyalty while the commissioned plumber repairs and maintains the systems.

Since the GWCL's scheme for maintaining and repairing the public utility networks in Nima is generally ineffective, private plumbers and users are just as crucial for the maintenance and repair of these networks too. Nima's networked infrastructure's

maintenance and repair is the responsibility of the Accra North district of the GWCL. However, because of the poorly planned nature of the settlement, GWCL's repair scheme has not been effective in Nima. An employee of GWCL indicated that:

[maintenance and repair] is a problem in Nima because of the layout. We have few [legal] connections there, but [...] the challenge is how [utility officers can] navigate there to do maintenance and read water meters?

(Interview 1, GWCL employee, 2019).

Our field observations in the area confirm that layouts are haphazard, with practically no space to install waterlines inside individual homes. Because of this situation, residents of Nima are notorious for their illegal water connections and often assault GWCL officials who visit there to disconnect illegal networks. An official of the water company said that:

“That place [Nima] is very problematic. They can beat you if you attempt to work there. I was once attacked when I supervised a disconnection exercise there. When they see our officers, they feel threatened that we are there to disconnect their illegal networks. Nowadays, when we are going there, we go with the police” (Interview 2, GWCL employee, 2020).

GWCL's repair scheme is also challenged by inadequate repair workers. For instance, the Accra North district – which is responsible for Nima – has only 24 such workers. According to the company's district manager, this workforce is woefully inadequate considering the district's size. Hence, the capacity of GWCL's repair workers is often overstretched, making it challenging to provide adequate and timely responses to maintenance and repair needs in all the areas.

These challenges often require private plumbers and users to intervene informally to sustain water supply in the public utility networks. For instance, it is common to see private plumbers repairing leakages in GWCL's public networks (as shown in [Figure 6](#)). A household or a group of residents who are affected by a leakage in the public system usually mobilize resources and hire private plumbers to fix the problem (Interview 3, 2020). Although the legality of these informal practices is often questionable, they are crucial for residents in areas like Nima that lack an adequate repair system, as they provide a way to ensure reliable water supply.

Residents and local plumbers often justify these informal interventions by arguing that the GWCL staff are generally reluctant and inefficient, especially in Nima. A resident of Nima who sells water to residents from his private connection said that:

If you call them [GWCL officers], they will not come. Sometimes it can take them weeks to respond to the problem. So, if you need the water, you have to get a plumber to fix the problem because it affects you and not the company

(Interview 6; Resident, 2020).

Another interviewee added that whenever he reports a leak to the company, they are likely to close off the water supply to the entire area for several days before they resume supply. Hence, he feels that residents should mobilize and fix the problem themselves rather than report to the utility company (Interview 7, resident, 2020). An employee of the GWCL, however, dismissed these claims, contending that:



Figure 4. GWCL’s officials repairing a pipeline, Accra–Agbogba junction (December 8, 2018).

**ACCRA EAST REGION
(ADENTA DISTRICT)**

2019 DUTY ROSTER
NIGHT SHIFT

TEL: 0271817799	31 ST DEC	1 ST JAN					
NAME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
FRANCIS AGBOSHIE	31 ST DEC	1 ST JAN	2 ND DEC				6 TH JAN
TEL: 0248879856	7 TH JAN	8 TH JAN					
BILLI BENJAMIN AGYEI	7 TH JAN	8 TH JAN	9 TH JAN	10 TH JAN	11 TH JAN	12 TH JAN	13 TH JAN
TEL: 0246618081	14 TH JAN	15 TH JAN					
JOSHUA WORLA AHIKU	14 TH JAN	15 TH JAN	16 TH JAN	17 TH JAN	18 TH JAN	19 TH JAN	20 TH JAN
TEL: 0545964923	21 ST JAN	22 ND JAN					
STEPHEN AHORSU	21 ST JAN	22 ND JAN	23 RD JAN	24 TH JAN	25 TH JAN	26 TH JAN	27 TH JAN
TEL: 0507120645	28 TH JAN	29 TH JAN					
STEPHEN DJAGBLATEY	28 TH JAN	29 TH JAN	30 TH JAN	31 ST JAN	1 ST FEB	2 ND FEB	3 RD FEB
TEL: 0243644220	4 TH FEB	5 TH FEB					
RICHARD LARBI	4 TH FEB	5 TH FEB	6 TH FEB	7 TH FEB	8 TH FEB	9 TH FEB	10 TH FEB
0273086963	11 TH FEB	12 TH FEB					
ERNEST YAW KONADU	11 TH FEB	12 TH FEB	13 TH FEB	14 TH FEB	15 TH FEB	16 TH FEB	17 TH FEB
TEL: 0271817799	18 TH FEB	19 TH FEB					

Figure 5. Duty roster for night shift maintenance and repair in Accra (December 8, 2018).

The people [of Nima] are very smart. I can tell you they do self-repair to hide their illegal networks from our officers. They know we will discover some illegal networks if we go there[...]

(Interview 9, GWCL employee, 2019).

These findings reveal the ineffectiveness of the GWCL repair systems and the fact that residents appear to have lost confidence in GWCL’s systems and are taking measures to meet their water infrastructure maintenance and repair needs outside the public



Figure 6. Private plumber repairing a burst pipeline in Nima (March 10, 2020).

systems through private plumbers. More importantly, these findings point to a clash between the logics of legality and necessity and indicate how the private repair systems can challenge the public utility's authority and power to carry out repairs. However, the divergent explanations by actors reveal different motives that often underlie maintenance and repair practices.

7.2. Maintenance and repair in Dodowa

The approach to maintenance and repair in Dodowa is somewhat different to that in Nima. Being a peri-urban area, responsibility for maintaining and repairing water systems falls to the CWSA. That responsibility is delegated to Water and Sanitation Management Teams (WSMTs) at the community level. Each WSMT is a small group of 3–5 residents that is formed to oversee decentralized water systems' management, maintenance, and repair. The WSMTs are directly responsible for maintenance and repair operations to boreholes, hand pumps, and wells installed for the community by the district assembly and CWSA. The team usually collects payment of water bills from users (on a pay-as-you-fetch basis) and uses the funds to finance ongoing maintenance and repair (Government of Ghana 2014). This decentralized approach is in line with Ghana's community water and sanitation management strategy, which seeks to empower rural communities to handle their water infrastructure needs (Government of Ghana 2014).

Although the WSMTs are usually trained in handling minor maintenance and repair, most still lack the necessary skills, expertise, and tools to maintain and repair major technical problems. Therefore, they usually outsource most of their major maintenance and repair needs to private engineers, commonly referred to as *area mechanics*.¹ As pointed out in the national community water strategy (Government of Ghana 2014),

inadequate funding and lack of adequate expertise and skills are significant challenges that undermine water infrastructure sustainability in most peri-urban and rural areas where boreholes are common. The role of CWSA in maintenance and repair is to provide technical training and working tools for WSMTs members and connect them to appropriate markets for spare parts and professional experts whom they can rely on for major maintenance and repair needs. These community-based repair systems coexist with the GWCL repair systems and various independent private experts in Dodowa.

8. Situating maintenance and repair in-between private and public labor relations

GWCL's repair system is more effective in Dodowa than in Nima. Hence, self-organized repair interventions by community members and local plumbers are rare in Dodowa. Instead, it is common to find GWCL employees doing maintenance and repair on people's private connections—a task not in their official remit—for extra income. The employees' primary justification for these “side jobs” is to earn extra income to support their families to help meet Accra's high cost of living. An employee of GWCL who also works as a private plumber revealed that he earns approximately 800 cedis [about 100 US dollars] per month from his side jobs and shares part of it with his two apprentices (not GWCL employees). He uses the remainder to supplement his regular income as a technician (Interview 12, personal communication, 2020). Although the GWCL authorities do not encourage employees' “informal” practices, they do not see them as a challenge that must be addressed. For instance, one utility official considers such practices unofficial, but legitimate private arrangements between individuals and therefore has no problem with them, as they take place outside the employee's working schedules (Interview 13, 2020). In short, maintenance and repair in Dodowa entail multiple actors and systems, including community-based systems, private repair systems, and public repair schemes, which operate together as a hybrid system in which formal and informal practices are combined. This further emphasizes the heterogeneous nature of water systems in Dodowa, which require different maintenance and repair systems to sustain. Private repairers' common challenges include limited access to working tools, inadequate expertise, and the lack of recognition by state water providers. These challenges undermine maintenance and repair and the full utilization of local resources for improving water supply.

The results above show that the actual operations of maintenance and repair of water supply in both neighborhoods entail hybrid labor relations between public and private engineers. In Nima, maintenance and repair are co-produced through the efforts of GWCL employees and private plumbers hired by residents. In Dodowa, however, they require the combined efforts of public utility employees, community-based actors, and private engineers.

In such a hybrid repair configuration, the practices of all actors are intertwined and overlapping because actors routinely change positions or roles by moving in and out of the private or public systems at different times. As the case of Nima shows, residents frequently hire private plumbers to perform the roles of public utility employees by fixing leakages in public utility networks, although this contravenes the water company's policies. Likewise, in Dodowa, GWCL employees sometimes operate as private

plumbers by maintaining and repairing residents' private connections. Moving in/out of the different repair configurations is possible because all actors have similar expertise and competencies.

However, these constant fluxes by actors make it difficult to differentiate on the ground between formal/informal or legal/illegal acts and the boundaries between private and public repair configurations. This means that formal/informal practices transcend the categories of public and private repair configurations and can be described as a set of discursive framings of the practice that actors perform in their everyday repair operations. As Wahby (2021) showed in the case of Cairo, the intricate connections between the practices of private and public engineers on the ground make it difficult to draw boundaries between formal/informal or legal/illegal maintenance and repair practices by all actors. The situation is made more complex by the fact that all actors can function in the public and private sectors, compete for similar contracts in the private labor market, and use similar tools in their operations.

These findings show that no single maintenance and repair configuration can work for all types of water infrastructure. In most parts of Accra, where water supply systems are highly fragmented and shaped by heterogeneous configurations (i.e., networked and off-grid solutions, illegal connections, public and private connections), a single repair scheme cannot work. Instead, hybrid approaches that combine different repair systems and actors with different expertise and knowledge in different material configurations is required.

Based on these findings, we contend that the private and public repair systems coexist as complementary service providers but sometimes act as alternative service providers because they can replace each other in the private market. Indeed, the fact that actors can change roles and operate on either side of the system indicates that the private and public systems are competitors rather than being complementary systems as often portrayed in the water provision literature (Kjellen 2010). This is because the private plumbers offer the same services as those provided by public utility officials. Hence, when they are hired to act in the position of public engineers, they not only replace the functions of the public repair systems but also inadvertently challenge the authority and power of the GWCL as the sole legitimate repair system in the city. Nevertheless, their operations are vital in meeting maintenance and repair needs that cannot be met through the public systems alone. Many households prefer private repair workers because their services are available and affordable and can also be negotiated and adapted to suit their specific financial and economic conditions.

Because actors in the hybrid system offer similar services, users can choose to meet their maintenance and repair needs from either system. However, since actors tend to compete in the same market, their interactions often produce tensions and conflicts in different forms and magnitudes, due to differences in competing interests. The case of Nima and Dodowa highlights different conflicts and how they work to enable and challenge the state's political authority. In Nima, neighbors often challenge GWCL workers and sometimes physically attack them because they see their presence in the neighborhood threatening residents' water access. Hence, residents work to protect their interests by deploying informal and self-maintenance and repair tactics to prevent public engineers from visiting the area. At the same time, GWCL workers must reduce water (and revenue) losses by reducing water theft and leaks. These clashes of motives

often result in conflict situations between residents and public engineers in Nima. The case of Dodowa presents a quite different conflict situation involving different actors. Here, private and public repair workers compete in the private market for repair contracts from users, which often results in other forms of tensions and conflicts between them, although they are not as confrontational as in Nima. Various studies have explained such tensions as the results of power struggles and asymmetries between the state and non-state actors (Barnes 2017; Graham and Thrift 2007), portraying maintenance and repair as inherently political (Baptista 2019). We have built on this line of scholarship to show how actors enact and contest the state's power through maintaining and repairing water systems.

9. Conclusion

This paper has analyzed the maintenance and repair of water supply through the lens of hybridity, focusing on two case studies in Accra. An important insight from the results is that there is often a difference between how infrastructures are imagined to be maintained and repaired and how the maintenance and repair work is actually done. We mobilize the empirical insight from these case studies to put forward three salient contributions that advance debates in infrastructure maintenance and repair studies, and debates on co-production in water supply. First, current research in water supply has often portrayed maintenance and repair as a public task handled solely by public utility engineers and showcases the public repair scheme as the ideal (Wahby 2021). Our case studies provide empirical evidence to challenge this notion by showing how maintenance and repair are co-produced through hybrid labor relations between private and public agents and users and how these actors negotiate maintenance and repair through the interplay of formal/informal practices in water supply. By deploying hybrid notions, we have shifted conceptualization in current research on maintenance and repair beyond the state, by repositioning private plumbers and users as equally important actors in co-producing maintenance and repair in water supply. In practice, all actors involved can move in and out of the public or private systems, and their roles or positions can change (even if only temporarily). This is what hybrid maintenance and repair entail—a dynamic process “always in the making” (Baptista 2019).

Second, our case studies further show how the state's power is enabled and sometimes challenged by private actors through maintenance and repair. The cases of Nima and Dodowa yield helpful empirical examples to demonstrate how residents and private plumbers subvert and contest the state's political authority (vested in the utility provider) and sometimes replace it with private and self-organized maintenance and repair. On the one hand, the water providers support the state's control and power by sustaining the water systems' function. On the other, this power is constantly challenged and subverted by residents and plumbers who bypass the GWCL authority to implement their informal and self-organized repair interventions in water supply. In this regard, citizens' active involvement in maintenance and repair could inadvertently challenge state power, as self-organized repair efforts replace or diminish the state's role and control over public infrastructure.

Finally, by demonstrating how public and private actors work side-by-side in sustaining water flow through maintenance and repair, we expand the debates on

water infrastructure co-production and private actors' participation in the Global South to show how infrastructures are repaired and maintained through hybrid labor relations. Indeed, the Nima and Dodowa case studies have shown that residents are not passive recipients of water supply but are actively involved in shaping how the water supply system is repaired and maintained. However, further research is required to understand how maintenance and repair are governed in contexts where hybrid infrastructure systems operate and the institutional challenges therein.

Note

1. These are trained mechanical engineers/technicians who specialize in hand pumps and boreholes and usually operate in rural areas where these infrastructures are found.

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