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Publication Date

2022-03-01

DOI

10.1016/j.worlddev.2021.105736

Peer reviewed

From Public Service Access to Service Quality: The Distributive Politics of Piped Water in Bangalore

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Abstract: Public service access in low- and middle- income countries is shaped by how much governments spend on services and where they choose to prioritize delivery. Accordingly, the local public goods and distributive politics literatures are largely focused on government spending and patterns of access. We argue that, even after access is granted, service quality can vary dramatically, and may vary with socio-economic and political characteristics. We provide one of the first analyses of a key dimension of service quality: intermittency, which affects vital services such as water and electricity for hundreds of millions of people. We illustrate how to study it by highlighting the specific facets of intermittency that must be managed within the network; we show that these dimensions may be manipulated separately, and that infrastructure network structure shapes the allocation of intermittency. The literature from urban India shows that access to water connections (like access to many other local public goods) is typically associated with higher socio-economic status. In contrast, we find that in our study sites in Bangalore, water flows through pipes more frequently and predictably in low-income areas—thereby underscoring the importance of studying intermittency, and service quality more generally, as phenomena distinct from access.

Keywords: Public goods; distributive politics; water; urban; India; intermittency

Acknowledgments: This project was funded by the Development Impact Laboratory, U.C. Berkeley (USAID Cooperative Agreement AID-OAA-A-13- 00002). We thank NextDrop, the Public Affairs Foundation, and the Bangalore Water Supply and Sewerage Board for their collaboration. The project has been approved through IRB protocol 2014-04-6259.

Highlights

*The intermittent delivery of infrastructure services, such as water and electricity, affects hundreds of millions of people, but is understudied within political economy

*We show how to study the allocation of intermittency services through a study of water flows in Bangalore, India

*We highlight the specific facets of intermittency that are salient to citizens and that may be manipulated independently

* Through a detailed analysis of water service quality in eastern Bangalore, we show how the layout of infrastructure networks shapes allocations of water and of intermittency

*Water flows through pipes more frequently and predictably in low-income neighborhoods than in more affluent neighborhoods in our study area

INTRODUCTION

The distribution of vital public services such as education, health, and electricity in low- and middle-income countries (LMICs) is a central theme in the study of political economy. Much of this research examines how politicians disproportionately channel service access to members of the same ethnic or religious group, whether politicians are more likely to target swing or core voters, and other socio-political factors influencing allocation (e.g. Blaydes, 2011; Briggs, 2021; Cammett & Issar, 2010; Golden & Min, 2013; Kramon & Posner, 2013). Identifying patterns of service access is essential to our understanding of whose needs are met or remain unmet under status quo arrangements. Service access, however, is not a guarantee of good quality service; given access, service quality can vary dramatically (Auerbach, 2016; Bohlken, 2021; Callen et al., 2020).

In this paper we argue that intermittency is a widespread, yet understudied, aspect of service quality in the developing world that is just beginning to attract attention within political economy research. Intermittent services are those that would ideally be delivered continuously, but are in fact discontinuous, often with unpredictable start and end times. For example, hundreds of millions of people with piped water access receive services just one or two days a week, for a few hours at a time (van den Berg & Danilenko, 2011). Many electricity systems deliver services discontinuously, with power interruptions occurring daily. Mass transit services may also be intermittent, with departure times diverging from official schedules, and health clinics may operate at unpredictable times. Intermittency, these examples show, is commonplace in low- and middle-income countries, and distinct from other dimensions of service quality, such as safety (e.g. the quality of water delivered through piped networks), or adequacy (e.g. electricity at sufficient voltage such that lights do not flicker).

Intermittency arises from a lack of resources to provide continuous services to all citizens. Urban customers in the least developed economies experience up to 100 times the service interruptions of those in the OECD countries, reflecting efforts to manage services in the face of insufficient supply.[1] In these contexts of scarcity, some groups may receive more frequent or predictable services than others. Such differences in allocations may reflect technical constraints, technocratic decisions made by the bureaucracies providing services, efforts by elected officials to reward supporters or court new followers, or responses to bribes. Yet relative to our rich understanding of how service access is allocated, scholarship has largely failed to conceptualize service intermittency as something to be allocated.

There are reasons to expect that patterns will differ between access and intermittency. First, the actors who control water flows often have different mandates and are exposed to different political pressures than those controlling access to the city's piped water system. In the water sector, legally-independent utilities—that could be organs of state rather than municipal governments, or even private concessionaires—often manage water allocations *within* piped water networks. In contrast, additional political actors influence the expansion of service network boundaries, and thus affect who can *access* the network; elected city-level officials or neighborhood associations, for example, often help finance service expansions to new areas. The unit at which targeting is feasible also differs for access and intermittency. A piped water connection can be granted at the household level provided there are supply lines in the vicinity, whereas once households possess network connections, water is distributed to (or withheld from) entire network segments.

This paper makes three contributions to the political economy literature on distributive politics and local public goods provision. First, we highlight the importance of service quality, and specifically service intermittency, as an understudied arena of distributive politics. Second, we outline a methodological approach to studying the allocation (and consequences) of intermittent services. We start by acknowledging that the distribution of intermittency within infrastructure networks is shaped not just by political priorities but also by engineering requirements. Therefore, it is essential to understand the physical layout of the infrastructure, as this shapes how the geographic distribution of services can be manipulated within the overall network. We also identify specific dimensions of service quality that are salient for citizens and that may be manipulated separately, such as predictability of service start and end times, service frequency, service duration, and throughput (i.e., pressure for water). We also argue that not all aspects of intermittency are equally manipulable. For example, in urban water systems that deliver water by zones or valve areas, a street-level bureaucrat can turn water off slightly later and make service duration longer in a particular valve area, but is less able to change the frequency with which water is provided. Whereas Kramon and Posner (2013) have shown that allocation patterns vary across different services, we show how different dimensions of quality can be differentially distributed within a single service.

Third, we illustrate our approach by studying the allocation of intermittently-provided piped water services in Bangalore, India, a city of roughly 8.5 million.[2] We base our study in a utility subdivision in Eastern Bangalore chosen for multiple reasons, including its variation in socio-economic indicators and patterns of intermittency faced by urban citizens in India more broadly. Basing our study in one utility subdivision also allowed us to hold the quality of water infrastructure constant across the sample. For data on intermittency, we analyze a unique dataset containing geo-coded household-level survey information about intermittency, rather than relying on citywide averages. [3] We further leverage fine-grained maps that depict each hydraulically distinct network segment of the water network, or "valve area" (VA). We find that VA-level characteristics predict variation in service frequency and predictability. Scholarship on infrastructural inequalities in India and elsewhere has consistently found that social and economic exclusion is associated with poor access to piped water networks. However, we find that VAs in which large fractions of the population are low-income[4] or from Scheduled Castes or Scheduled Tribes (SC/ST) receive more predictable and frequent service.

The last section of our paper considers potential explanations for these patterns of intermittency within our study area in Bangalore. We consider the hypothesis that there are political incentives to allocate more predictable water services to low-income and SC/ST voters because they comprise an important voting bloc with limited access to substitutes. A second hypothesis concerns the relative political insulation of Bangalore's state- (as opposed to city-) controlled water utility from local officials, and the resulting "professional" nature of the water utility. A third hypothesis is that the strong relationships between street-level bureaucrats and low-income communities may influence the more easily manipulable aspects of intermittency, such as supply duration. These hypotheses can serve as starting points for future research on how service quality, conditional on access, could deepen or alleviate existing social inequalities in LMIC cities.

THE DISTRIBUTIVE POLITICS OF INFRASTRUCTURE SERVICES

Intermittency is understudied relative to service access

An exhaustive search of published social science studies of local public goods provision in LMICs shows that the vast majority examines differing levels of expenditure on, and access to, services and distribution networks (see Table SI.22). This literature considers how social, economic, and political factors affect variation in access and expenditures. A large body of work in distributive politics analyzes how the allocation of local public services disproportionately benefits particular ethnic, racial, or caste groups (see Golden and Min (2013). In the Indian case, Besley, Pande, Rahman and Rao (2004) find that this unequal allocation of services happens because local government heads steer public goods to members of the same caste; Chandra (2004) argues that politicians in patronage democracies like India favor voters of the same ethnicity;[5] and Bertorelli et al. (2017) find that lower caste and income groups receive worse public services in Bangalore. Min (2015), however, observes that the rural poor in Uttar Pradesh enjoy improved access to electricity during election years, due in part to the rise of a party championing scheduled-caste interests.

Urban political ecology research on the water sector in India and beyond also suggests that characteristics such as income, caste, religion affect household access to the water network. Because connections with politicians help to secure either formal or informal access to the water network, slum residents, and particularly poor households in outlying slums, possess lower rates of network connectivity. In Mumbai, for example, the poor (Gandy, 2008; Graham et al., 2013) and Muslims (Contractor, 2012; Graham et al., 2013) have lower rates of network access.

A second body of scholarship on distributive politics emphasizes institutional and political variables over socio-demographic characteristics.[6] Studies examine whether democracies are more redistributive than autocracies in service-provision, especially to the rural poor (Min, 2015; Trotter, 2016). Scholars also debate the extent to which political actors steer access toward "core" supporters, as opposed to "swing" voters or districts, with active debates on whether higher levels of political competitiveness encourage more government spending on local infrastructures (Meseguer & Aparicio, 2012). In India, some scholarship finds that elected officials strongly favor core supporters (Breeding, 2011; Chandra, 2004; Min, 2015), or areas with dense networks of local party operatives (Auerbach 2016). Others find that elected officials target electorally vulnerable districts, or swing voters within such districts (Golden and Min 2013; on electricity, Baskaran et al., 2015; on roads, Bohlken 2021). In general, heads of governments appear to allocate funds preferentially to districts controlled by members of their own party (i.e., aligned districts), whether they are swing or core. The presence of local leaders and intermediaries—who are often party operatives—also helps communities and households to secure benefits (Auerbach, 2016; Jha et al., 2007).

Measuring intermittency

While there has been extensive scholarship on access and expenditures, the local public goods provision and distributive politics literatures have devoted far less attention to which groups secure *better* services within intermittent systems.[7] Other dimensions of service quality are addressed in fewer than one-fifth of these studies. Sector-specific work in other fields, however, recognizes intermittency in its own right. Studies on electricity have documented the prevalence of, and consumer dissatisfaction with, service disruptions and rolling blackouts (Aklin et al., 2016; Crane & Roy, 1992). Engineering research suggests that intermittent water supply can reduce household consumption levels to below internationally recommended levels (Kumpel et al., 2017), and increases the likelihood that water becomes contaminated before reaching households (Kumpel & Nelson, 2013). Intermittent service may also be *unpredictable* as official supply schedules are often inaccurate because of aging infrastructure systems, power outages, and administrative inefficiencies.

Intermittency tends to affect the poor disproportionately because they have less access to substitutes for state services. Low-income households receiving intermittent and unpredictable water services, for example, must wait to collect and store water; higher income households have pumps that automatically fill storage tanks when water services commence, and the load-bearing roofs that such tanks require. Alternative providers such as private water vendors emerge to supplement state provision (Kjellén & McGranahan, 2006; Solo, 1999), but water from these sources is costly (Post et al., 2017). While low-income communities may have become accustomed to or resigned to these arrangements, it is clear that they impose definite costs.

Like all aspects of service quality, intermittency is multi-faceted. Studying the distribution of intermittency systematically, therefore, should focus on multiple outcome variables. For example, several hours of water at low pressure and certain timing is not at all the same service as a short duration of flow with good pressure, arriving unpredictably. Household circumstances will determine which leads to higher coping costs. We identify four relevant dimensions: (a) the **frequency** of service; (b) the **predictability** of arrival times; (c) **throughput** (e.g. water pressure); and (d) the **duration** of supply intervals. These dimensions of intermittency impact households differently, tend to be affected by different infrastructural constraints, and afford bureaucrats and elected officials different opportunities to influence allocations. Table 1 illustrates these dimensions for a range of local public services. Households may cope with a specific dimension of intermittency differently across services. For example, a household able to store infrequently supplied water in a drum or other type of container may not be able to afford a battery to store infrequently supplied electricity. In this paper, we focus our study on just one service area, namely, piped water supply.

Table 1. Key Dimensions of Intermittent Services

	Water	**Electricity**	**Mass Transit**	**Primary Health Care**
Predictability	Whether or not piped water arrives at a specific time	Whether or not electricity blackouts or brownouts occur at specific times	Whether or not trains or buses arrive on schedule	Whether or not clinics are open consistently during working hours
Frequency	Number of times a week water is supplied	Number of times a week / month electricity blackouts or brownouts occur	Frequency of buses or trains, esp. relative to need	Frequency with which key services are available (vaccinations, exams, etc.)
Duration	Length of water supply sessions	Length of electricity supply session (or conversely of blackouts)	Length of service window during day (e.g. night services available?)	Hours per day when services are available

Throughput	Water pressure during supply session	Voltage (higher or lower than necessary for electrical appliances and lights)	Capacity of vehicles, relative to demand	Number of patients that can be seen at a time or in a day per facility

Targeting intermittency

Recent work on the political ecology of the Indian water sector suggests that factors similar to those predicting access to a piped water connection explain the allocation of intermittently-provided water within the network. In ethnographic studies of water allocations in neighborhoods in Mumbai, Anand (2012) and Björkman (Björkman, 2015, p. 161) argue that city councilors pressure utility employees to reallocate water from one neighborhood to another, to allocate less water less reliably to informal settlements, and to discriminate against predominantly Muslim slums (Anand, 2011, p. 430). Rusca et al. (2017, p. 142) find similar conditions in Lilongwe, Malawi, where poor neighborhoods receive poor quality water and with lower frequency.

Nevertheless, distributional patterns may look different elsewhere. After all, the political actors who extend water networks may not be the same as those who manage water flows within them; their political mandates could differ. Moreover, the technical constraints on manipulating services vary significantly between water connections and water flows.

The specific physical characteristics of infrastructure networks such as those for electricity, water or rail services, and the material characteristics of the resources they carry, shape the distribution of services. The ways in which physical infrastructure constrains political allocations are rarely analyzed in political economy scholarship. In electricity networks, power is allocated by substation-level distribution feeders within the transmission system. Urban water networks are constrained by the carrying capacities of water mains and distribution pipes to different sections of the city.[8] Elevation gradients within the system also affect flows.

For water infrastructure specifically, when urban utilities do not possess sufficient water to fully pressurize the network at once, they pressurize small segments of the water network— "valve areas" servicing roughly 50 – 200 households—in rotation, distributing water to hydraulically isolatable neighborhoods at different points in time (Andey & Kelkar, 2007; Hyun et al., 2018; Ilaya-Ayza et al., 2017). Staggered area-by-area distribution is the dominant form of managing water scarcity in cities in India and other low- and middle-income countries (see e.g., Gottipati & Nanduri, 2013; Vairavamoorthy et al. 2008; Sánchez-Navarro et al. 2021). Staggered zone-wise distribution is also commonly used to manage the scarcity of resources for other services, such as electricity.

In such systems, utilities typically cannot target individual households, but rather must grant or withhold services from particular network segments at any one time. If a city cannot cut off power to a hospital, for example, the homes on the same distribution feeder will not experience blackouts, whatever be their income, caste or political affiliation. In other words, networked services are a form of club goods.

Scholarship on distributive politics typically analyzes the allocation of club goods by placing projects within political units because this facilitates analyses of how services or infrastructure are targeted to elected officials and their constituencies. For example, Min and Golden (2014) aggregate data from electricity service divisions into political units. With detailed network map data, however, it is possible to examine allocations by network segments, which are often smaller than traditional political units. This allows for more fine-grained examination of patterns of service targeting *within* political jurisdictions. We take this more granular approach in our study.

OUR CASE: PIPED WATER SERVICES IN BANGALORE

We illustrate our approach to the distributive politics of intermittency by examining water flows within a section of Eastern Bangalore serviced by the utility's piped network. While patterns of *access* to the piped water network have been investigated in Bangalore (see below), there were no data sources on household-level experiences with intermittent water delivery when our study began. We undertook a large-scale survey of recipients of piped water to create a unique dataset capturing experiences with intermittency; this allowed us to assess the extent to which the main predictors of service access emphasized in the literature also explain water intermittency.

Piped water and sewerage services in the metropolitan area are provided by the Bangalore Water Supply and Sewerage Board (BWSSB). BWSSB is an organ of the state Government of Karnataka. The Karnataka government appoints BWSSB's governing board members, who must possess technical qualifications, and who cannot be elected officials. BWSSB's chairman is always a senior member of the prestigious and non-partisan Indian Administrative Service.

BWSSB is charged with serving one of India's largest cities: the 2011 Census put Bangalore's population at 8.5 million, but current (unconfirmed) estimates are closer to 11 million. It has been argued that BWSSB is a relatively well-functioning utility (Connors, 2005; McKenzie & Ray, 2009); comparisons with Delhi and Chennai from

2009, for example, show that Bangalore has good pipeline coverage, on average significantly more hours of water service per day (four times higher than Delhi), and a high revenue collection ratio (i.e. water paid for as a proportion of water sold).[9] Nevertheless, as late as 2000, roughly one-third of the population had partial or no access to the piped water network, with a lack of access concentrated among the poor (Benjamin 2000, 39).[10] In 2014, Krishna et al. found that households in newly settled slums with predominantly scheduled caste populations had no access to the city's water network (Krishna et al., 2014, p. 8).

In our study, we collected original data to capture variation in household-level experiences with intermittency.[11] We focused on one utility subdivision to make it feasible to develop a street-level sampling protocol, which was important given the inaccuracy of customer lists and other potential sampling frames. In consultation with BWSSB and a local social enterprise called NextDrop, we located our study in Subdivision E3 (see Figure 1), one of the utility's 32 subdivisions (AUTHOR 2018).[12]

Situating our study within BWSSB subdivision E3 offered several important advantages. First, it allowed us to control for a number of technical and administrative variables that could potentially affect water allocations.[13] This outlying area of ~200,000 inhabitants in Eastern Bangalore was connected to the utility's main network six years before our study, and thus possessed water supply infrastructure of reasonably consistent age and quality throughout.[14] The entire study area is served by a single reservoir, and is divided into 124 valve areas (VAs) that are pressurized in rotation (Figure 2). According to our survey data, 74% of households relied exclusively on the piped water supply, while the remaining 26% supplemented water received from BWSSB with that from other sources.[15]

E3 also exhibited what BWSSB engineers estimated to be representative variation in service quality. Our 2015 survey in E3 confirmed that the subdivision contained variable service quality, despite the uniform age and condition of the water network. Over 85% of households received water services only once or twice a week; 25% of respondents stated they were unable to store enough water on supply days and had to rely on substitutes such as bottled water or tankers.[16] At the same time, 22% of our sample received services once every day or two. About 70% of households reported that their water did not come at a predictable time, and the average time spent waiting for water was about one hour per supply session. Those experiencing unpredictability faced real costs: for the six months prior to being surveyed, respondents reported missing over two hours of work on average and 20% of households reported missing community events. In other words, there was clearly variation in service quality, along with its associated costs.

This area included a mixture of different income, caste, and religious groups, and the demographics of our site were similar to those of Bangalore more broadly. E3 contained a range of settlement types, from areas dominated by middle-to-high income apartment blocks, to areas of lower middle-class housing, to informal settlements. Consistent with the overall pattern in Bangalore,[17] these low-income clusters were very small, and sometimes contained religiously and ethnically mixed populations. The E3 income distribution was similar to the overall Bangalore population in broad terms, with roughly 33% falling within the bottom third of the city income distribution.[18] Furthermore, 12.5% of the households in the sample were Muslim families, compared with 13.9% of families in Bangalore overall according to the 2011 census. The subdivision had lower rates of extreme poverty than Bangalore as a whole, however: only 2% of the households in our sample possessed "kutcha" roofs (made from grass, thatch, mud, wood, or corrugated metal), whereas 2011-2012 IHDS data suggests that 15% of Bangalore households do. This difference is to be expected given that the poorest households live outside the reaches of the piped water network. Similarly, while the 2011 Indian Census reveals that about 42% of Bangalore's population comprises urban migrants, this number was about 34% in our sample.[19]

Figure 1. BWSSB Subdivision E3

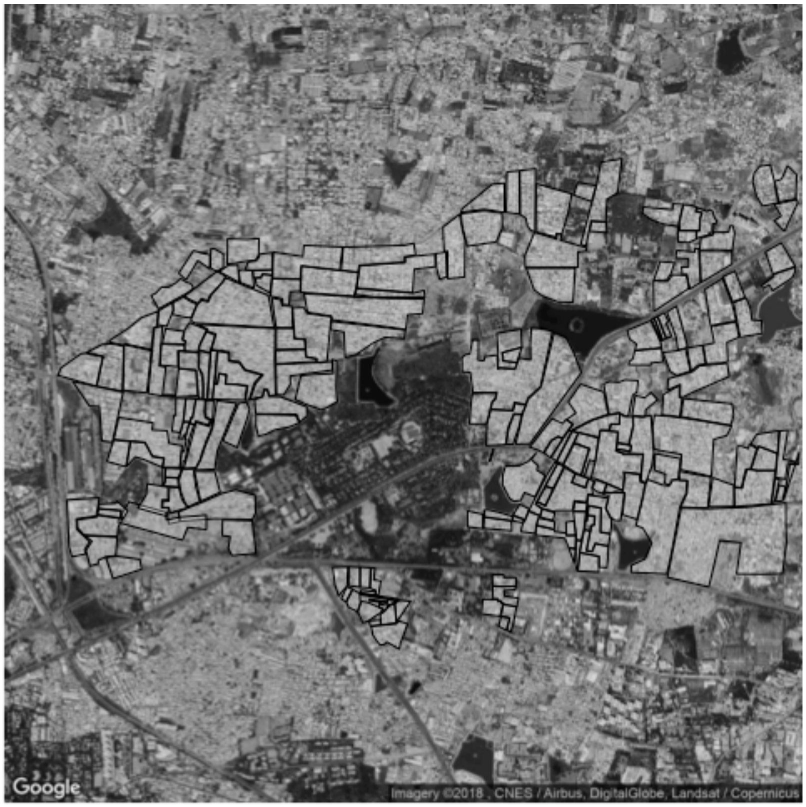


Figure 2. Valve Areas in BWSSB Subdivision E3

Source: Valve Area maps courtesy of NextDrop, superimposed over Google satellite imagery.

Expectations for targeting in Bangalore's E3 subdivision

Given these background conditions, which groups received better quality piped water supply, in terms of predictability, frequency, duration, and throughput? Here, we develop expectations for systems that allocate intermittent water through zones or valve areas. Given the social and economic diversity of our study site, we can examine whether valve areas serving members of particular social, ethnic, or income groups receive better quality water services than valve areas dominated by other groups. In particular, we can examine whether households living in valve areas with large numbers of SC/ST households, migrant households, Muslim households, low-income households, or those with a certain partisan affiliation received more intermittent services. Given that we administered our survey in 2015, a year in which city council elections were held, we collected our data when political affiliations and socio-economic characteristics may have been particularly salient.[20]

Targeting by social characteristics should be possible where social groups cluster together, and these clusters are large enough to comprise large fractions of valve areas. Low-income neighborhoods, for instance —though smaller in Bangalore than in many cities—are typically larger than most VAs in our study area. Similarly, some VAs had large concentrations of Muslim households or of Congress party (INC) supporters, suggesting that targeting by religion or party could also be possible (Figure SI.1).[21] Any correlations between household characteristics (such as income, religious affiliation) and service quality should be observable at the VA level.

While our focus is the targeting of specific social and economic groups at the VA level, we also control for features of municipal wards, the smallest political units within which valve areas are located. Following the distributive politics literature, we focus on political alignment and district competitiveness. Our alignment variable reflects whether or not the ward councilor comes from the same party as that governing at the state level. Given that BWSSB is legally independent of the municipal authorities and is governed by state appointees, we would expect the party in control of the state, rather than of the municipal government, to have more influence over BWSSB's activities. A party governing at the state level interested in consolidating power at the city level could pressure the utility to provide better services in more competitive local districts, for example. Given the size of our study area, these dynamics would be observable primarily in terms of variation across city wards rather than state-level legislative constituencies. [22]

As noted earlier, our approach emphasizes how households experience the various dimensions of intermittency, as the incidence of these dimensions may not be correlated. We extend standard intuitions from the literature on water access to the four dimensions we identified (Table 2), noting that some dimensions of intermittency are easier to manipulate than others within piped water systems. Given that the valves that allow water to flow in and out are operated manually, water service frequency and predictability could be allocated more generously to some VAs over others. Service frequency, however, is harder to manipulate in the short run than predictability because of interdependencies within the citywide water network.[23] Water pressure is also hard to allocate strategically because small hills and individually-owned "booster" pumps create elevation gradients within individual VAs. Households also care about some dimensions more than others; storage-constrained households would be concerned with frequency of deliveries because long intervals increase the risk of running out of water, whereas households whose members work away from home need predictable services more than those with an adult member at home in the day. Manipulating the duration of supply sessions could be a strategic move in some contexts, and is possible once the VA is being serviced, but the majority of households in our study area possessed household (rather than shared) taps and did not need to queue for water. A supply session of 2-3 hours would typically be enough time to fill a household's storage containers.

Table 2. Dependent Variables: Dimensions of Water Intermittency

Dimension	Expectations for Study Area	Operationalization

Predictability	Targeting attractive & possible (within constraints) at VA level	● Does water come at a specific time of day or specific day of the week? ● Are scheduled supplies ever cancelled?
Frequency	Targeting attractive & possible (within constraints) at VA level	● How many times a week does water arrive?
Duration	Targeting less attractive but possible at VA level	● How long does water stay on when it comes?
Throughput	Targeting attractive but very difficult	● How strong is water pressure during supply sessions?

THE DISTRIBUTION OF INTERMITTENCY IN BWSSB SUBDIVISION E3

Data and Sampling

To examine the allocation of intermittently-supplied water within E3, we created a geo-coded dataset of household surveys that we placed in VAs, the smallest units of water allocation in Bangalore. BWSSB and similar utilities in low and middle-income countries do not possess this information at such a granular level. This is the first time, to our knowledge, that such fine-grained data on the technical features of infrastructure have been incorporated into analyses of the distributive politics of water, or of infrastructure-based services beyond water.

We collected data in subdivision E3 through a two-wave in-person survey administered to the same set of households in April-May and October-November of 2015. The survey was designed and administered as part of a larger project, which included an impact evaluation of a text-message based system of notifications about water arrival times (AUTHOR 2018). We focus our analysis here on wave 1 data, which could not have been affected by the intervention. Within E3, we defined 10 low-income and 20 mixed income blocks to ensure that our study area was representative of the subdivision, and that it covered most of the residential area with piped water. We systematically sampled households within these blocks.[24] Enumerators asked to speak with the person responsible for managing the household's water supply, so 80% of our respondents were women. Given our sampling strategy and size of our sample (n = 2948), we do not expect that our study sample deviated significantly from the underlying population in the area, other than with respect to gender.[25]

Since we contend that services delivered through infrastructure networks must be allocated at the level of physical units, we measured valve-area as well as household level variables. We relied on maps that NextDrop had created so that they could place households within the correct VAs (see Figure 2). The utility itself did not possess maps of this infrastructure. VAs are invisible from the street level and have been modified extensively over time. Therefore the "water valvemen" charged with opening and closing valves were the ones with the best knowledge of VA boundaries. NextDrop personnel created the maps by walking the edges of the VAs with the valvemen and taking GPS coordinates. The maps thus represent a unique data source.

We placed our sample households in their specific VAs using household GPS readings we collected during our surveys.[26] Geographic coverage within these valve areas approximated the "every third household" sampling strategy we followed in our survey.[27] We sampled 23 households on average in each valve area. This allowed us to characterize each VA based on averaged survey responses from households residing in each area (see Table 3).

Table 3. Descriptive Statistics for Independent Variables

Variable	Mean	St. Dev.	Min	Max
HH level variables				
Elevation (technical control)	905.789	62.116	211.533	1,389.800
Cauvery Supply (technical control)	0.857	0.350	0	1
Muslim	0.124	0.330	0	1
Low income	0.300	0.458	0	1
Urban migrant	0.338	0.473	0	1
SC/ST	0.182	0.386	0	1
Congress supporter	0.196	0.397	0	1
VA level variables				
Muslim	0.140	0.242	0.000	1.000
Urban Migrant	0.349	0.228	0.000	1.000
Low income	0.309	0.230	0.000	1.000
Local Leader	0.451	0.500	0	1
SC/ST	0.232	0.263	0	1
Congress supporter	0.239	0.208	0	1
Ward level control variables				
Margin of victory	0.098	0.091	0.0005	0.237
INC Corporator	0.286	0.488	0	1

Dependent variables

Our survey questions captured all four dimensions of water allocation in intermittent systems (Table 2, above): (i) predictability of water arrival times; (ii) service frequency; (iii) duration, or the average length of a delivery session; and (iv) water pressure (i.e., throughput), which greatly affects the availability of water for different household uses. Table 2 (above) shows these dimensions, and the survey questions that operationalized them as dependent variables. For all dependent variables, a higher category indicates better service.

We used our household survey responses to measure the specific dimensions of intermittency (Table 4). To avoid concerns about the potential subjectivity of survey responses, we piloted our questions extensively, and found that respondents tended to describe supply schedules and conditions in similar terms.[28] Correlations between the responses of households living in particular VAs suggest that respondents perceived similar supply conditions with respect to particular dimensions of intermittency, especially frequency and predictability.[29] Figure 3 illustrates variation across VAs in the number of days between water supply sessions; notably, household-reported variation is far greater than that of the water utility's official supply schedule. However, the correlation between different dimensions of intermittency at the household level was low, underscoring our intuition that the logic of allocation for each dimension varies (Table 5). This lack of correlation also affects how citizens experience intermittency. For example, those who receive supply infrequently do not enjoy longer supply sessions than those receiving water more frequently (Table SI.21).

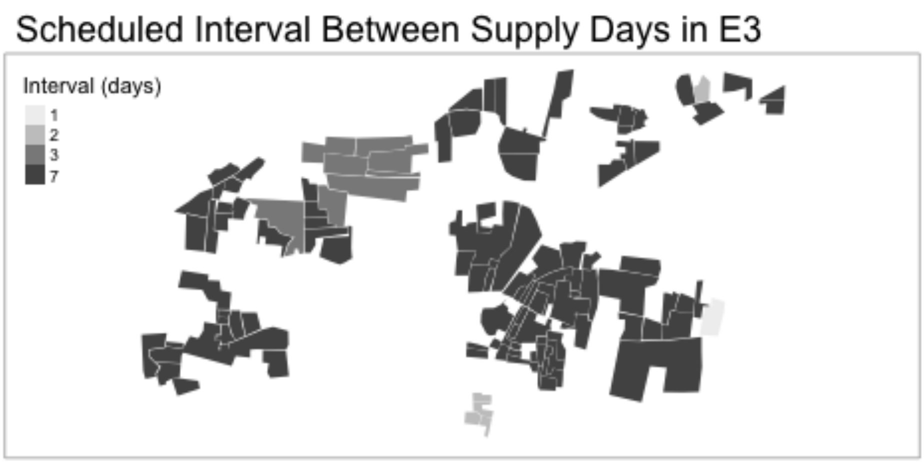
Table 4. Tabulated Responses for Dependent Variables

Variable Response option	N individuals choosing response
Whether water comes at a specific time	
Yes	805
No	2045
Interval between supply days	
Everyday	69
Every 2 days	409
Every 3-4 days	1434
Every 4-5 days	286
Every 6+ days	705
Duration of water when it comes on	
4+ hours	584
3-4 hours	711
2-3 hours	956
Less than 2 hours	548
Whether or not service is cancelled on supply days	
No	1030
Rarely	750
Yes	712

Water pressure level	
Strong	444
Moderate	1748
Weak	240

Table 5. Spearman rank correlation matrix for service quality measures at household level

	Predictability	Service Frequency	Duration	Lack of Cancellations	Pressure
Predictability	1	-0.02	0.06	0.34	0.07
Service Frequency	-0.02	1	0.08	0.04	0.05
Duration	0.06	0.08	1	0.15	0.12
Lack of Cancellations	0.34	0.04	0.15	1	0.07
Pressure	0.07	0.05	0.12	0.07	1



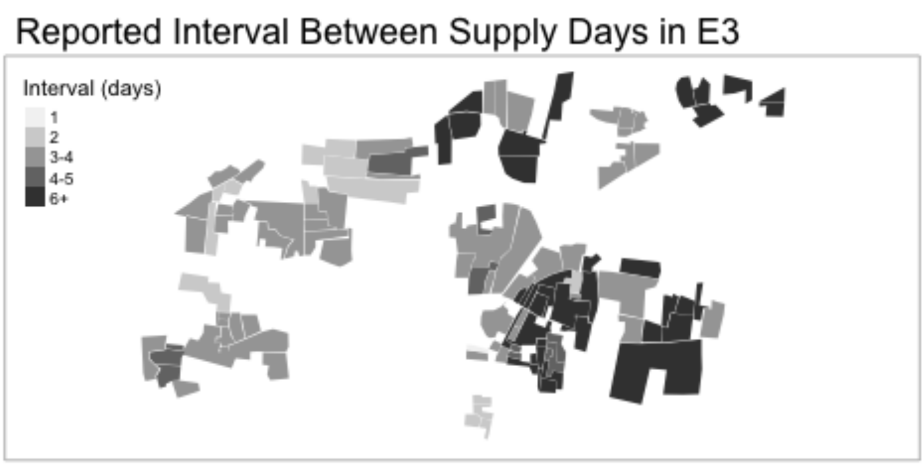


Figure 3. Day Intervals Between Water Supply in BWSSB Subdivision E3

Note: Scheduled supply day intervals from BWSSB. Reported interval map displays modal responses from household surveys geo-located in each VA.

Main independent variables

We collected data on household characteristics that the literature reports to be associated with more or less privileged access to services (Table 3). These include household income, religious affiliation, SC/ST status, migrant status, and partisan affiliation. We assessed household socio-economic status through multiple measures, including household assets (such as possession of a motorized vehicle), and self-placement in income brackets. We measure these variables at both the household and VA-level to reflect the fact that targeting might happen at either level. Figure SI.1 portrays VA variation in the percentage of low-income and Muslim households.

Technological controls

We also asked respondents whether or not they received water through the Cauvery system (i.e. through relatively new pipelines carrying river water) in addition to or instead of the legacy borewell systems, an older and inferior form of household piped supply. Given its recent installation, Cauvery service would likely be associated with better service on all intermittency dimensions. We also recorded the elevation of each household, as higher elevations are typically harder to service. We measure these variables at the household level, as these features can vary at the household level within VAs.[30]

Political controls

The literature on distributive politics has found patterns of political alignment to be correlated with the allocation of infrastructure and services. To address these arguments, we placed the VAs within wards, the main unit of political representation in Bangalore, to account for the possibility that governing parties may target "swing" or "core" districts. Eight of Bangalore's 198 wards fall into E3. We placed VAs in the wards based on where the majority of the populated territory fell.[31] For each ward, we collected data on the partisan affiliation of the ward representative (corporator), which told us whether s/he came from the same party as the party in control of the state in Spring 2015, the Congress (INC) party. This allowed us to control for the possibility that the governing Congress party targeted "core" constituencies by including a variable for Congress control at the ward level. To control for the possibility that Congress targeted "swing" wards, we calculated a margin of victory measure for the 2015 elections following Golden and Min (2013). We interacted this with Congress control, because these are the competitive districts in which Congress could claim credit for influencing water services. Given the small number of wards in our dataset, we treat these primarily as control variables in the empirical analysis. We also included a VA-level variable reflecting the presence of a local leader to whom residents could take their concerns, which was measured as the percentage of survey respondents reporting the existence of a local leader in their area.

Modeling Strategy

As our dependent variables are dichotomous or ordinal in nature, we estimate logistic and ordinal logistic models to assess the relationship between household, VA, and ward characteristics, and five dependent variables capturing the four different dimensions of water intermittency: predictability (of arrival time plus frequency of supply cancellations), frequency, supply duration, and pressure.[32] These models include not only household-level characteristics such as religion, but also VA attributes such as the percentage of Muslim households.[33]

Our modeling strategy acknowledges the strong correlations among several measures of valve area characteristics (Table SI.1). The low-income valve area variable is strongly correlated with the SC/ST valve area measure (0.59). Similarly, our percentage Muslim variable is strongly correlated with the percentage supporting the Congress party (0.46). We include each of the highly correlated variables on its own in the models, as well as place both in the model, to assess the strength of the relationship of each characteristic with the dependent variables.

We estimated four different models to allow for different patterns of unmeasured heterogeneity and pattern of errors. Model 1 contains all of our household and valve-area predictors, and clusters standard errors by VA. Clustering standard errors by valve areas helps account for any unmeasured heterogeneity between valve areas in terms of their underlying infrastructure. Model 2 substitutes ward fixed effects for clustered standard errors at the VA level to see if patterns are driven by unobserved ward-level heterogeneity. In Model 3, we add a variable reflecting whether the ward's corporator is aligned—i.e., from the same party as that which controls the state government (the INC for this period)—and again cluster standard errors by VA. In Model 4, we control for political background conditions by interacting alignment with the margin of victory in each ward during the 2015 election cycle.[34] All standard errors are computed using a bootstrapping technique.

Results

Our main results for predictors of supply predictability and frequency are presented in Tables 6 and 7. As a higher category for either dependent variable indicates better service in all models, a positive coefficient indicates that a given independent variable is correlated with better, or less intermittent, service. Results for both outcomes provide strong evidence that targeting of specific groups occurs at the VA level. Predictability and frequency are arguably the two most important dimensions in reducing the time needed to wait for, collect and store water. Low-income and SC/ST VAs receive more rather than less predictable water supply, and more frequent services. VA characteristics appear less important for other indicators of service quality (Tables SI.2-SI.4).

Table 6 reports results for whether water comes at a specific time. Here, the main variable consistently correlated with more predictable water arrival times, across specifications, is the percentage of households in the VA that are low-income. For Model 1, a one standard deviation increase in the low-income VA variable (a 19% increase in the proportion of low-income households in each VA), is associated with a 59% increase in the odds of water arriving at a specific time (see Figure 4).[35] This finding runs counter to the sizable consensus in the literature that economically marginal populations receive worse water services, if they receive water at all. Other VA characteristics we might expect to be important based on the literature are not consistently associated with predictability: the presence of local leaders is not significant across specifications, suggesting that local leaders are not always channels to better services; and variables reflecting a large Muslim or migrant population experience less predictability, but results are not significant across specifications. (Note that the number of VAs containing majority Muslim households is much smaller than the number of VAs with majority low-income households (Figure SI.1)). When Congress support is substituted for our household and valve area level Muslim variables, it is also not consistently significant across specifications (Table SI.7). The association between the low-income VA variable and predictable services remains statistically significant even when we control for the margin of victory in the latest elections and the corporator's alignment with the party governing at the state level. When the percentage SC/ST is substituted for the low-income valve area variable, we observe a similarly strong relationship with more predictable services (Table SI.5). When both of these highly-correlated variables are included in the model, the SC/ST relationship is the more robust (Table SI.9).

Table 6. Predictability of Water Supply in Subdivision E3, April-May 2015

	Whether water arrives at a specific time			
	(1)	(2)	(3)	(4)
Household-level characteristics				
Elevation	-0.001	-0.002*	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Cauvery Supply	0.252	0.201	0.273	0.221
	(0.357)	(0.131)	(0.361)	(0.125)
Urban Migrant	-0.083	-0.088	-0.082	-0.081
	(0.088)	(0.103)	(0.086)	(0.101)
Muslim	0.166	0.195	0.165	0.175
	(0.156)	(0.168)	(0.163)	(0.162)
Low income	0.084	0.090	0.084	0.087
	(0.099)	(0.102)	(0.098)	(0.101)
VA-level characteristics				
Urban Migrant	-0.526	-1.267***	-0.971	-1.577***

	(0.804)	(0.366)	(0.976)	(0.331)
Muslim	-0.288	-0.900**	-0.377	-0.951***
	(0.583)	(0.310)	(0.564)	(0.285)
Low Income	2.413**	2.184***	2.542**	1.756***
	(0.777)	(0.307)	(0.773)	(0.270)
Local leader	-0.172	-0.239*	-0.198	-0.174
	(0.248)	(0.101)	(0.247)	(0.096)
Ward-level characteristics				
Margin of victory				-5.750***
				(0.683)
INC Corporator			0.459	-0.026
			(0.323)	(0.135)
Margin X INC Corp.				-106.179***
				(5.404)
Constant	-0.680	0.763	-0.832	0.847
	(0.836)	(0.743)	(0.820)	(0.746)
Ward dummies	No	Yes	No	No
SEs clustered at VA	Yes	No	Yes	No
N	2,850	2,850	2,850	2,850
R^2	0.069	0.142	0.077	0.124
chi^2	140.992***(df = 9)	297.556***(df = 15)	156.118***(df = 10)	257.184***(df = 12)

*p < .05; **p < .01; ***p < .001. Logistic regressions were used to estimate models. The higher category indicates that water arrives at a specific time. A positive log odds coefficient indicates that as the value of the independent variable increases, the likelihood of having predictable water increases.

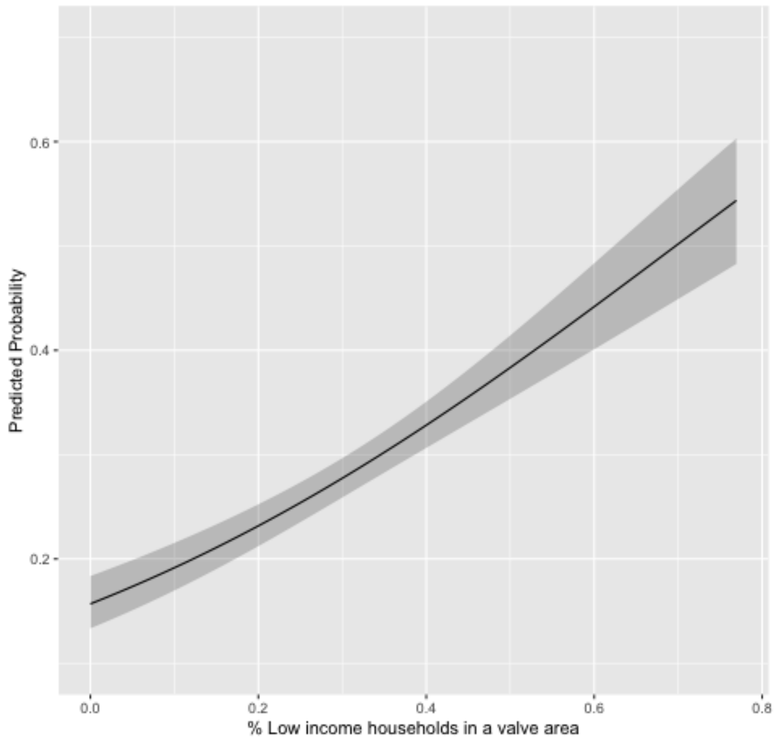


Figure 4. Predicted probability for whether water comes at a specific time (Model 1)

Our results from models of weekly service frequency (Table 7) show similar patterns. Valve areas more heavily comprised of low-income households receive more frequent supply in most, but not all, of our specifications.[36] A one standard deviation increase in the percentage low-income VA variable is associated with a 45% higher odds of more frequent service (Figure 5). When we substitute our percentage SC/ST valve area variable for the percentage low-income variable, we consistently observe a significant positive relationship; valve areas with larger SC/ST populations receive water supply more frequently (Table SI.6).[37] Valve areas with larger fractions of Muslims or urban migrants receive less frequent services in the specifications including ward fixed effect or ward-level political variables, but not in models including standard errors clustered by valve area, leaving us less able to reach firm conclusions regarding these patterns. The presence of local leadership in the VA is not consistently correlated with service frequency across specifications. These patterns remain unchanged even when we include control variables for the margin of victory, alignment, and the interaction between the two.

Results for our other dependent variables display no striking patterns of allocation (see Tables SI.2-SI.4). In these cases, no household-level predictors other than Cauvery supply exert a consistent effect; as we would expect, supply duration and water pressure are better for the relatively new Cauvery connections, and supply cancellations are less frequent. Valve area characteristics appear less important here, as well; however, valve areas with larger fractions of urban migrants do report receiving supply cancellations less often, which may indicate that migrants are settling in areas with more dependable services.

Table 7. Water Supply Frequency, Subdivision E3, April-May 2015

	Water Supply Frequency			
	(1)	(2)	(3)	(4)
y> =every 4-5 days	-0.042	-1.492	0.586	1.144
	(0.936)	(0.792)	(0.952)	(0.781)
y> =every 3-4 days	-0.541	-2.137**	-0.048	0.503
	(0.913)	(0.793)	(0.912)	(0.782)
y> =every 2 days	-2.942**	-4.849***	-2.696**	-2.150**
	(0.937)	(0.802)	(0.906)	(0.785)
y> =everyday	-5.089***	-7.054***	-4.864***	-4.313***
	(1.098)	(0.819)	(1.065)	(0.805)
Household-level characteristics				
Elevation	0.002*	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Cauvery Supply	-0.250	-0.348*	-0.397	-0.416**
	(0.341)	(0.135)	(0.390)	(0.139)
Urban Migrant	-0.078	-0.108	-0.109	-0.110
	(0.064)	(0.084)	(0.074)	(0.084)
Muslim	-0.042	-0.040	-0.053	-0.050

	(0.105)	(0.118)	(0.110)	(0.112)
Low income	0.013	0.003	0.001	0.001
	(0.074)	(0.086)	(0.082)	(0.087)
VA-level characteristics				
Urban Migrant	-1.488	0.710^{*}	0.559	0.436
	(0.935)	(0.282)	(0.864)	(0.255)
Muslim	-1.367	-1.032^{***}	-1.092	-1.319^{***}
	(0.824)	(0.281)	(0.802)	(0.249)
Low Income	1.930^{*}	1.074^{***}	1.517	1.217^{***}
	(0.933)	(0.252)	(0.907)	(0.248)
Local leader	-0.006	0.368^{***}	0.133	0.143
	(0.324)	(0.090)	(0.322)	(0.077)
Ward-level characteristics				
Margin of victory				-1.884^{***}
				(0.490)
INC Corporator			-2.476^{***}	-2.634^{***}
			(0.389)	(0.129)
Margin X INC Corp.				-31.260
				(77.041)
Ward dummies?	No	Yes	No	No
SEs clustered at VA	Yes	No	Yes	No
N	2,903	2,903	2,903	2,903
R^2	0.072	0.282	0.256	0.264
chi^2	200.138^{***}(df = 9)	877.614^{***}(df = 15)	782.919^{***}(df = 10)	811.251^{***}(df = 12)

*p < .05; **p < .01; ***p < .001. Ordinal logistic regressions were used to estimate models. A higher category indicates more frequent service. The reference category is "y=every 6+ days." A positive log odds coefficient indicates that as the value of the independent variable increases, the likelihood of getting more frequent service increases.

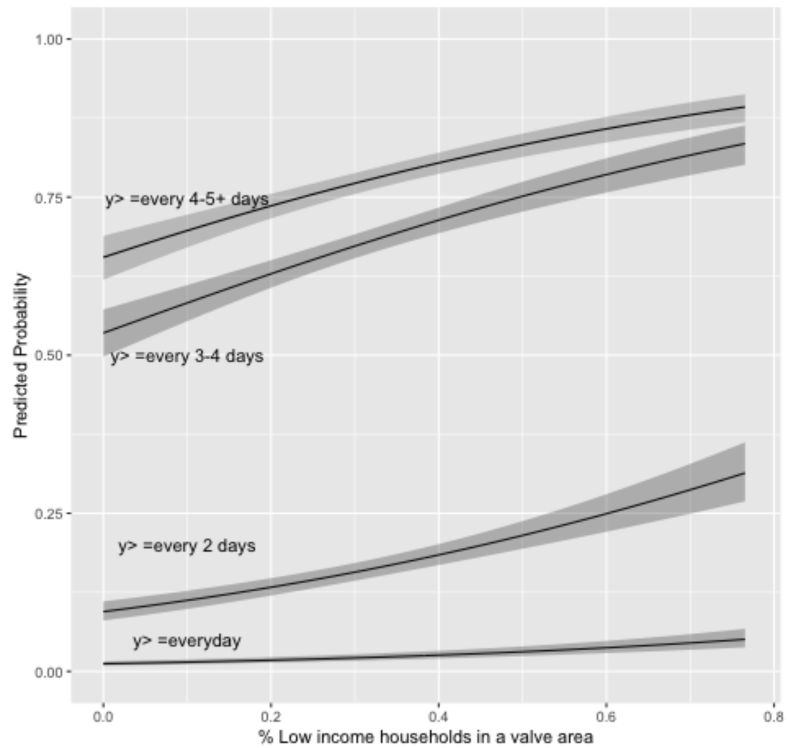


Figure 5. Predicted probability for water supply frequency (Model 1)

The strong association between lower VA socioeconomic status and more predictable and frequent service remains highly significant under a variety of additional robustness checks. To address possible measurement bias for our independent variables, we dropped from our analysis any VAs for which we had low levels of coverage by surveyed households.[38] Similarly, since many VA characteristics were calculated based on household responses, we dropped VAs with two or fewer household responses to questions regarding religion, household assets, migrant status, etc. (11 of the 123 VAs). Low-income (or SC/ST) populations remained strongly associated with more predictable service, and to a lesser extent with service frequency.

It could be argued that respondents from households with automatically filling water tanks (either within the household or in an apartment building) might be less informed about the frequency and predictability of water supply, and that this might have affected our results. We repeated our analysis on the subset of our sample without such tanks and obtained similar results.[39] To address the concern that the new Cauvery pipelines in E3 might have been systematically extended to particular groups—and that our Cauvery variable might therefore introduce post-treatment bias—we estimated our models with the only subset of households receiving some Cauvery supply, dropping the households that received only CMC supply.[40] This also allowed us to restrict our sample to the portion of the network supplied through surface water rather than local borewells, eliminating any potential effects of varying access to community-level supplies. Another robustness check employed an alternative method for classifying households as low-income, namely an indicator for whether they reported a household monthly income of less than Rs. 10,000 per month.[41] Results in all these cases were similar to those of our main models.

Finally, it is possible that rather than revealing real patterns of service delivery, our results are simply driven by measurement bias. Respondents from low-income households could be less likely to report dissatisfaction with their water service than higher-income respondents, because their expectations of government bureaucracies are low in general.[42] This measurement problem is likely to apply to Muslim respondents as well, as this marginalized group is likely to have even lower expectations of government bureaucracy than low-income households in general. For neither frequency nor predictability, however, do we see a consistent positive correlation between self-reported service quality and the fraction of Muslim households in a VA, suggesting that our results are not driven by measurement bias (Tables 6 and 7). Additionally, our household surveys reported high levels of satisfaction with BWSSB as a utility across class and caste.[43]

DISCUSSION

The strong and significant association between economically and socially marginalized populations and more frequent and predictable services in our study area is in contrast to almost all the literature on income groups and infrastructure access. While we observe these associations within just one part of the city, they are nonetheless striking, especially given the social and economic diversity of the district. The strength of the correlation, robustness to different modelling strategies, and the inclusion of numerous control variables suggest that the patterns are likely to be planned rather than occurring by chance. We are not in a position to offer a definitive explanation for these results, but we can offer some hypotheses that build on previous work and suggest fruitful avenues for future research.

One possible explanation is that politicians distribute benefits and services in these communities to create "vote banks" for elections (Breeding, 2011). State-level elected officials may know that low-income households struggle most with water intermittency and may therefore direct the utility to deliver more frequent and reliable services to predominantly low-income VAs. Scholarship has also documented instances in which low-income populations publicly communicate their needs to officials and local media through protests, neighborhood associations, and other forms of mass mobilization (Auerbach, 2017; Burt & Ray, 2014; Ranganathan, 2014). Moderate- to high-income households with automatic tanks, in contrast, are less exposed to the costs of intermittency. They would be less likely to shift their political support in response to modest improvements (or deteriorations) in supply. A predominance of SC/ST households in a particular VA may serve as a proxy for socio-economic status for utility employees who are interested in targeting low-income households—a reasonable assumption given that many SC/ST households are low-income. Additionally, elected officials may wish to specifically target SC/ST voters; this is plausible given reports of increasing partisan competition over the SC/ST vote in Karnataka.[44] Though the political variables included in Tables 6 and 7 serve as controls, our results provide some indication that particularly competitive wards received more predictable water services during an election year, especially when an "aligned" city councilor from the Congress party held office.

The patterns we observe may instead (or also) suggest that the BWSSB management exercises a substantial degree of autonomy from city officials and has decided to deliver more frequent services to populations it knows to be in need. Several factors could explain BWSSB's independence. First, BWSSB—unlike the highly politicized Mumbai water utility (Anand, 2011; Björkman, 2015)—is an organ of the state, rather than the city, government. Yet the elected representatives most active at the neighborhood level are corporators—city ward representatives. Their links with BWSSB officials are generally informal and indirect.[45] In addition, BWSSB is a legally independent, professionalized enterprise rather than a state government ministry, which means that even state-level elected officials may have limited influence on its operations. Benjamin (2000) critiques this institutional format for water service in Bangalore precisely because elected officials are bypassed. Yet independence from city-level politics may allow the utility to technocratically pursue policy and equity goals, such as providing better service to low-income or SC/ST-dominant areas. BWSSB has shown itself willing to improve services for slum residents in the past through network extension projects into poor districts (Connors, 2005), which lends some credence to this perspective.

A third possibility is that economically and socially marginal VAs may enjoy better service because the valvemen responsible for opening and closing water valves exercise some discretion as they move water around. Our ethnographic research (AUTHOR, 2018) in another district in Bangalore, however, found that though many valvemen felt strong connections with low-income communities (see also Björkman (2015) on Mumbai), and did have some control with respect to duration of flow, they did not generally have control over service frequency, predictability, or cancellations. We therefore find the first two structural explanations to be more compelling than the one centered on valveman discretion.

CONCLUSION

In this paper, we highlighted the importance of service intermittency, and the delivery of service quality more broadly, as a mode of distributive politics in the developing world. We argue that intermittency has multiple dimensions, such as frequency, predictability, and duration of supply which are related to one another, but are not necessarily allocated according to the same criteria. We also argue that, when studying the allocation of service quality within a network, knowledge about physical networks can help to explain political patterns shaping service delivery.

We demonstrate this approach through a study of water service intermittency in Bangalore's E3 utility subdivision. Survey data on the incidence of four different dimensions of intermittency reveals that all forms of service quality are not correlated. Our analysis highlights the extent to which the benefits and burdens associated with these delivery dimensions can be distributed differently. While low-income and SC/ST VAs in our study experienced more predictable and frequent services, they did not receive noticeably different water pressure levels or fewer supply cancellations. Research on the distributive politics in other infrastructure-based sectors, such as electricity and public transit, or on other services more broadly, would profit from examining how dimensions of intermittency in these services work to cement or alleviate urban inequalities.

From a policy perspective, our findings suggest that it is possible to allocate more frequent and predictable services to areas in which large numbers of low-income citizens live. While engineering research (e.g. Gottipati & Nanduri 2013; Vairavamoorthy et al 2008) has advocated staggering water flows through valves for system-level optimal flows, our analysis suggests that strategic staggering can reduce the burden of intermittency among segments of the population least able to cope through the use of tanks or private substitutes. Our survey serves as a model of the type of data that may help inform such efforts.

Of course, the feasibility of such policy recommendations depends on underlying political economy conditions, such as electoral systems, the structure and dispersion of power within multilevel governance systems, and other variables that might affect the behavior of individual actors within the water system (Kurian and Yujima 2021, p. 37). In our study, electoral incentives, BWSSB management's relative insulation from local politics, or some combination of these, could explain why the patterns of allocation we observe *within* the water network in Subdivision E3 do not reflect patterns of *access to* the water network observed by other scholars in the Bangalore metropolitan area, as well as elsewhere. *Within-network* allocations may, under conditions such as those in our study area, be more pro-poor.[46]

Our findings should therefore prompt further research on infrastructure and inequality. First, patterns of intermittency may not favor poorer settlements in other settings. Scholarship should assess whether similar patterns are observed elsewhere in Bangalore, in more residentially segregated cities,[47] in cities with different institutional arrangements for water management, or cities with older or more poorly-maintained water infrastructure. In addition, understanding how elected officials interface with legally-independent utilities, the organizational structure and financing of service provision, and the behaviors of street-level bureaucrats in local public goods provision would provide a better understanding of the *implementation* of distributive politics (Williams, 2017) and the conditions under which policies favoring the needs of the poor may be feasible. Studying agency norms as codified in charters, circulars, and other official documents may complement the data collection efforts highlighted in this paper (Kurian and Yujima, p 89). Finally, researchers should explore whether and how bureaucracies set priorities for service delivery, and the conditions under which it makes political sense to follow a pro-poor or equity-motivated agenda.

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[1] Ratio calculated from values reported in Gertler et al. (2017, p. 25). On the prevalence of electricity blackouts in LMICs, see also Min (2015, pp. 43–44).

[2] Population figure from the Indian census, 2011.

[3] E.g., IBNET reports average hours of service per day for water utilities across the globe.

[4] "Low-income" is a relative term. Our main proxy for low-income household status is lack of possession of a motorized vehicle, such as a scooter. The lowest-income residents of the city are less likely to be connected to the piped water system.

[5] Recent scholarship suggests that caste favoritism, and even identification, may be decreasing in urban India (Banerjee & Somanathan, 2007; Dunning & Nilekani, 2013; Thachil, 2017).

[6] For a review, see Golden & Min (2013).

[7] See Table SI.22. Exceptions include Murillo (2009) and Min (2015), who discuss the repercussions of intermittent electricity service but do not examine its distributional incidence. Min (2015) examines year-by-year aggregate variation in electricity delivery, rather than everyday fluctuations. On the other hand, Miguel (2004) examines variation in the flow rate of well water, a measure of intermittency, in rural East Africa. Min (2019) examines the targeting of power outages in Ghana, and Bertorelli et al. (2017) incorporate gaps in water and electricity supply into their service delivery index.

[8] See Tiwale et al. (2018) on the Lilongwe, Malawi case.

[9] These data are from the urban water benchmarking group IB-NET; website http://database.ib-net.org/quick?goto=one_click accessed August 2017. Bangalore and Delhi data were only available for 2009.

[10] In some areas, populations received no services despite being on the network and paying for services (Connors, 2005; Ranganathan, 2014).

[11] Data for this study is already published through Dataverse; a link will be provided upon publication.

[12] This study was conducted jointly with an impact evaluation of household water notification services provided by NextDrop. See below for more detail.

[13] The network is divided into six zones, each of which draws on different supply reservoirs that can provide differing levels of water service to utility customers. The Eastern zone, for example, receives comparatively low levels of water per capita: 83 liters per day compared with 149 liters in the South (Manohar and Mohan Kumar 2014, 614).

[14] These relatively new infrastructure upgrades were financed using multiple sources, including loans from the World Bank and the Japan Bank for International Cooperation, as part of the Greater Bangalore Water and Sanitation Project (commonly known as GBWASP). A small set of areas still received service from legacy piped "borewell" systems that included household connections. These were built by village and town governments before BBMP annexed this area.

[15] All respondents indicated that they received piped supply. Our 2015 survey is described in greater detail below.

[16] Households may have been unable to store sufficient water due to storage constraints faced by those living in smaller houses along with health and sanitation concerns surrounding storing water in the home for prolonged periods of time (Clasen & Bastable, 2003; Jensen et al., 2002; Levy et al., 2008; Manga et al., 2021).

[17] In 2011, Bangalore's officially recognized slums contained an average of only 1209 residents. Newer, unrecognized slums are typically smaller in size.

[18] The 2011-2012 India Human Development Survey (IHDS) reports that 63% of the Bangalore population possessed a scooter or other type of motorized vehicle; in our study

area, approximately 70% did. This is a similar ratio to urban India overall (75% for metropolitan areas, 73% for other urban locations) according to the IHDS. See: https://ihds.umd.edu/.

[19] Even those categorized as "urban migrants" in our sample are generally not new to the city. Those in our sample who have not lived in Bangalore since birth report having lived in the city for 19 years on average, and just 1.5% of the sample has lived in Bangalore for one year or less.

[20] The municipal election was held in August 22, 2015.

[21] Maps showing the VA-level concentration of other household characteristics available upon request.

[22] There are 198 wards, and only 28 state legislative (MLA) constituencies, in Bangalore. These wards each encompass roughly 15 valve areas.

[23] Even given the nature of water supply infrastructure in places like Bangalore—which include informal connections, booster pumps, and the constant threat of new pipe bursts—utilities still rotate water pressure throughout their grids on rough schedules and can deviate from these when necessary; services outages may occur upon occasion, of course, because of the fragility of the system.

[24] SI Section II describes the data collection in greater detail.

[25] Some households did not respond to all of the survey questions, so the N for each of the regression tables varies.

[26] Three GPS readings with at least five-meter precision were taken for each household, and then averaged. We used QGIS to place households in VAs based on these coordinates. See SI. Section II for greater detail.

[27] Though our sampling protocol involved surveying every third household, households uniformly covered territory within VAs to different degrees due to variation in residential density. We therefore rated the "coverage" of each VA so as to conduct robustness checks with our analysis, ensuring results were robust to including only VAs with large numbers of household observations and good geographic distributions.

[28] For example, respondents who received regular service would generally be able to name specific supply windows, such as "Tuesday mornings."

[29] The intra-cluster correlation (where a valve is considered a cluster) for the number of days between water supply sessions is 0.54, and for whether or not water arrives at a specific time is 0.29.

[30] In a number of cases (14.2%), households retained access to the legacy borewell (CMC) system while also receiving new Cauvery services, and a small number of households (4.8%) received piped water from the CMC system only.

[31] We used Google Earth satellite imagery to place VAs in wards. One VA was split evenly between two wards, so we dropped it from the analysis.

[32] There are several flavors of ordinal logistic regression. Here, the outcome of interest is observing a particular value of the dependent variable or greater.

[33] We also estimate "naïve" models that examine the relationship between intermittency and household characteristics cited in the literature--such as religion and income--but ignore the location of households in VAs. The results of these analyses are presented in Tables SI.19 and SI.20. They suggest that unless one accounts for VA-level variables, it appears that household characteristics are associated with differing service quality.

[34] We cannot include ward fixed effects in Models 3 and 4 because our data is cross-sectional and we include ward-level variables. We do not have sufficient variation in the data to fit a model containing clustered standard errors in Model 4.

[35] To calculate the odds ratio, we used the formula OR = $e^{\beta * a}$, where β is the log-odds regression coefficient and a is the change in X for which we are calculating a change in the odds ratio.

[36] When INC support at the household and valve area level is substituted for our Muslim variables, the VA area level variable is inconsistently associated with less frequent service.

[37] When we include both variables in the model, both variables lose significance, reflecting their strong correlation (Tables SI.9 and SI.10).

[38] To code the survey coverage of each VA, we first calculated the total acreage occupied by each VA using QGIS and categorized VAs as small (under 10 acres), medium (10-20 acres), or large (greater than 20 acres). Coverage categories of poor, fair, good, or very good were then assigned to each VA. Poor coverage VAs were those with surveyed households only on the edges for small VAs or in one corner for medium or large VAs. Only areas occupied by households were included in this process; areas occupied by vacant land or a lake were ignored. Results for predictability and frequency are in Tables SI.13 and SI.14.

[39]See Tables SI.15-SI.16.

[40] As an example: if lower income areas were less likely to receive Cauvery service, then a regression estimating the association between low-income VA status that controls for

Cauvery service might underestimate the impact of low-income VA status on service quality (See Tables SI.11-SI.12).

[41] See Tables SI.17-SI.18.

[42] Franceys and Jalakam (2010) found that low-income populations in Hubli, India, adjusted their expectations after becoming accustomed to poor service quality.

[43] We asked respondents to respond to whether they believed that BWSSB was a competent service provider. On a scale of 1 to 3, with 1 corresponding to "agree" and 3 corresponding to "disagree," the average responses to this question was 1.38, or somewhere between "not sure" and "agree." The high levels of satisfaction with BWSSB services likely reflects the recent introduction of a new water supply source in E3 (see above), and the associated general improvements in services.

[44] For example, see: https://timesofindia.indiatimes.com/india/the-caste-factor-in-karnataka-why-rahul-gandhi-and-amit-shah-are-mutt-hopping/articleshow/63725848.cms.

[45] Our conversations with BWSSB engineers corroborated this point.

[46] However, we acknowledge that the poorest of the poor, including newer migrants in makeshift settlements, typically reside outside water networks, but would be included in studies assessing city-wide network access patterns.

[47] See Gayer and Jaffrelot (2012) on variation in segregation across Indian cities.

WORKS CITED

Aklin, M., Cheng, C., Urpelainen, J., Ganesan, K., & Jain, A. (2016). Factors Affecting Household Satisfaction with Electricity Supply in Rural India. *Nature Energy*, *1*, 1–6.

Anand, N. (2011). Toward an Anthropology of Water in Mumbai's Settlements. In I. Clark-Deces (Ed.), *A Companion to the Anthropology of India*. Wiley-Blackwell.

Anand, N. (2012). Municipal disconnect: On abject water and its urban infrastructures. *Ethnography*, *13*(4), 487–509. https://doi.org/10.1177/1466138111435743

Andey, S. P., & Kelkar, P. S. (2007). Performance of water distribution systems during intermittent versus continuous water supply. *Journal AWWA*, *99*(8), 99–106. https://doi.org/10.1002/j.1551-8833.2007.tb08011.x

Auerbach, A. M. (2016). Clients and Communities. *World Politics*, *68*(01), 111–148.

Auerbach, A. M. (2017). Neighborhood associations and the urban poor: India's slum development committees. *World Development*, *96*, 119–135.

Banerjee, A., & Somanathan, R. (2007). The political economy of public goods: Some evidence from India. *Journal of Development Economics*, *82*(2), 287–314.

Baskaran, T., Min, B., & Uppal, Y. (2015). Election cycles and electricity provision: Evidence from a quasi-experiment with Indian special elections. *Journal of Public Economics*, *126*, 64–73. https://doi.org/10.1016/j.jpubeco.2015.03.011

Benjamin, S. (2000). Governance, economic settings and poverty in Bangalore. *Environment and Urbanization*, *12*(1), 35–56. https://doi.org/10.1177/095624780001200104

Bertorelli, E., Heller, P., Swaminathan, S., & Varshney, A. (2017). Does Citizenship Abate Class? Evidence and Reflections from Bangalore. *Economic & Political Weekly*, *52*(32), 47–57.

Besley, T., Pande, R., Rahman, L., & Rao, V. (2004). The Politics of Public Good Provision: Evidence from Indian Local Governments. *Journal of the European Economic Association*, *2*(2–3), 416–426. https://doi.org/10.1162/154247604323068104

Björkman, L. (2015). *Pipe Politics, Contested Waters: Embedded Infrastructures of Millennial Mumbai*. Duke University Press.

Blaydes, L. (2011). *Elections and Distributive Politics in Mubarak's Egypt*. Cambridge University Press.

Bohlken, A. T. (2021). Development or Rent-Seeking?: How Political Influence Shapes the Provision of Infrastructure. *British Journal of Political Science*.

Breeding, M. E. (2011). The Micro-Politics of Vote Banks in Karnataka. *Economic and Political Weekly*, *46*(14), 71–77. https://doi.org/10.2307/41152055

Briggs, R. C. (2021). Power to which people? Explaining how electrification targets voters across party rotations in Ghana. *World Development*, *141*, 105391. https://doi.org/10.1016/j.worlddev.2021.105391

Burt, Z., & Ray, I. (2014). Storage and Non-Payment: Persistent Informalities within the Formal Water Supply of Hubli-Dharwad, India. *Water Alternatives*, *7*(1), 106–120. eih.

Callen, M., Gulzar, S., & Rezaee, A. (2020). Can Political Alignment be Costly? *Journal of Politics*, *82*(2), 612–626.

Cammett, M., & Issar, S. (2010). Bricks and Mortar Clientelism: Sectarianism and the Logics of Welfare Allocation in Lebanon. *World Politics*, *62*(3), 381–421.

Chandra, K. (2004). *Why Ethnic Parties Succeed: Patronage and Ethnic Head Counts in India*. Cambridge University Press.

Clasen, T. F., & Bastable, A. (2003). Faecal contamination of drinking water during collection and household storage: The need to extend protection to the point of use. *Journal of Water and Health*, *1*(3), 109–115.

Connors, G. (2005). When utilities muddle through: Pro-poor governance in Bangalore's public water sector. *Environment and Urbanization*, *17*(1), 201–218.

Contractor, Q. (2012). Quest for Water: Muslims at Mumbai's Periphery. *Economic & Political Weekly*, *47*(29), 61–67.

Crane, A. T., & Roy, R. (1992). Competition, trading, and the reliability of electric power service. *Annual Review of Energy and the Environment*, *17*(1), 161–186.

De Marchis, M., Fontanazza, C. M., Freni, G., La Loggia, G., Napoli, E., & Notaro, V. (2011). Analysis of the impact of intermittent distribution by modelling the network-filling process. *Journal of Hydroinformatics*, *13*(3), 358–373.

Dunning, T., & Nilekani, J. (2013). Ethnic Quotas and Political Mobilization: Caste, Parties, and Distribution in Indian Village Councils. *American Political Science Review*, *107*(1), 35–56. https://doi.org/10.1017/S0003055412000573

Franceys, R., & Jalakam, A. (2010). *The Karnataka Urban Water Sector Improvement Project: 24x7 Water Supply Is Achievable* [Field Note]. World Bank.

Gandy, M. (2008). Landscapes of Disaster: Water, Modernity, and Urban Fragmentation in Mumbai. *Environment and Planning A*, *40*(1), 108–130. https://doi.org/10.1068/a3994

Gayer, L., & Jaffrelot, C. (Eds.). (2012). *Muslims in Indian Cities: Trajectories of Marginalisation*. Harper Collins Publishers India.

Gertler, P. J., Lee, K., & Mobarak, A. M. (2017). *Electicity Reliability and Economic Development in Cities: A Microeconomic Perspective* (3.2; EEG State-of-Knowledge Paper Series). Oxford Policy Management.

Golden, M., & Min, B. (2013). Distributive Politics Around the World. *Annual Review of Political Science*, *16*, 73–99. https://doi.org/10.1146/annurev-polisci-052209-121553

Gottipati, P. V., & Nanduri, U. V. (2014). Equity in water supply in intermittent water distribution networks. *Water and Environment Journal*, *28*(4), 509-515.

Graham, S., Desai, R., & McFarlane, C. (2013). Water Wars in Mumbai. *Public Culture*, *25*(1 69), 115–141. https://doi.org/10.1215/08992363-1890486

Hyun, C., Post, A. E., & Ray, I. (2018). Frontline Worker Compliance with Transparency Reforms: Barriers Posed by Family and Financial Responsibilities. *Governance*, *31*, 65–83.

Ilaya-Ayza, A. E., Martins, C., Campbell, E., & Izquierdo, J. (2017). Implementation of DMAs in Intermittent Water Supply Networks Based on Equity Criteria. *Water*, *9*(11), 851.

Jensen, P. K., Ensink, J. H., Jayasinghe, G., Van Der Hoek, W., Cairncross, S., & Dalsgaard, A. (2002). Domestic transmission routes of pathogens: The problem of in-house contamination of drinking water during storage in developing countries. *Tropical Medicine & International Health*, *7*(7), 604–609.

Jha, S., Rao, V., & Woolcock, M. (2007). Governance in the Gullies: Democratic Responsiveness adn Leadership in Delhi's Slums. *World Development*, *35*(2), 230–246.

Kjellén, M., & McGranahan, G. (2006). *Informal water vendors and the urban poor* (Human Settlements Discussion Paper Series). International Institute for Environment and Development London. http://www.mumbaidp24seven.in/reference/informal_water_vendors.pdf

Kramon, E., & Posner, D. N. (2013). Who Benefits from Distributive Politics? How the Outcome One Studies Affects the Answer One Gets. *Perspectives on Politics*, *11*(02), 461–474. https://doi.org/10.1017/S1537592713001035

Krishna, A., Sriram, M. S., & Prakash, P. (2014). Slum Types and Adaptation Strategies: Identifying Policy-Relevant Differences in Bangalore. *Environment & Urbanization*, *26*(2), 568–584.

Kumpel, E., & Nelson, K. L. (2013). Comparing microbial water quality in an intermittent and continuous piped water supply. *Water Research*, *47*(14), 5176–5188.

Kumpel, E., Woelfle-Erskine, C., Ray, I., & Nelson, K. L. (2017). Measuring household consumption and waste in unmetered, intermittent piped water systems. *Water Resources Research*, *53*(1), 302–315. https://doi.org/10.1002/2016WR019702

Kurian M. and Y. Kojima. (2021). *Boundary science: re-imagining water-energy-food interactions in the context of a data light approach to monitoring the environment-development nexus*. Elsevier.

Levy, K., Nelson, K. L., Hubbard, A., & Eisenberg, J. N. (2008). Following the water: A controlled study of drinking water storage in northern coastal Ecuador. *Environmental Health Perspectives*, *116*(11), 1533–1540.

Manga, M., Ngobi, T. G., Okeny, L., Acheng, P., Namakula, H., Kyaterekera, E., Nansubuga, I., & Kibwami, N. (2021). The effect of household storage tanks/vessels and user practices on the quality of water: A systematic review of literature. *Environmental Systems Research*, *10*(1), 18. https://doi.org/10.1186/s40068-021-00221-9

Manohar, U., & Mohan Kumar, M. S. (2014). Modeling Equitable Distribution of Water: Dynamic Inversion-Based Controller Approach. *Journal of Water Resources Planning and Management*, *140*(5), 607–619. https://doi.org/10.1061/(ASCE)WR.1943-5452.0000368

McKenzie, D., & Ray, I. (2009). Urban water supply in India: Status, reform options and possible lessons. *Water Policy*, *11*(4), 442–460.

Meseguer, C., & Aparicio, F. J. (2012). Migration and Distributive Politics: The Political Economy of Mexico's 3x1 Program. *Latin American Politics and Society*, *54*(4), 147–178.

Min, B. (2015). *Power and the Vote: Elections and Electricity in the Developing World*. Cambridge University Press.

Min, B. (2019). *Political Favoritism and the Targeting of Power Outages* (Working Paper E-89442-GHA-1). International Growth Centre.

Min, B., & Golden, M. (2014). Electoral cycles in electricity losses in India. *Energy Policy*, *65*, 619–625. https://doi.org/10.1016/j.enpol.2013.09.060

Murillo, M. V. (2009). *Political competition, partisanship, and policy making in Latin American public utilities*. Cambridge University Press.

Post, A. E., Bronsoler, V., & Salman, L. (2017). Hybrid Regimes for Local Public Goods Provision: A Framework for Analysis. *Perspectives on Politics*, *15*(4), 952–966.

Ranganathan, M. (2014). Paying for Pipes, Claiming Citizenship: Political Agency and Water Reforms at the Urban Periphery: Political agency and water reforms in Bangalore. *International Journal of Urban and Regional Research*, *38*(2), 590–608. https://doi.org/10.1111/1468-2427.12028

Rusca, M., Boakye-Ansah, A. S., Loftus, A., Ferrero, G., & van der Zaag, P. (2017). An interdisciplinary political ecology of drinking water quality. Exploring socio-ecological inequalities in Lilongwe's water supply network. *Geoforum*, *84*, 138–146. https://doi.org/10.1016/j.geoforum.2017.06.013

Sánchez-Navarro, J. R., Sánchez, D. H., Navarro-Gómez, C. J., & Peraza, E. H. (2021). Multivariate analysis of the pressure variation in intermittent water supply systems and the impact ondemand satisfaction. *Water Supply*.

Solo, T. M. (1999). Small-scale entrepreneurs in the urban water and sanitation market. *Environment and Urbanization*, *11*(1), 117–132.

Thachil, T. (2017). Do Rural Migrants Divide Ethnically in the City? Ethnographic and Experimental Evidence from India. *American Journal of Political Science*, *61*(4), 908–926.

Tiwale, S., Rusca, M., & Zwarteveen, M. (2018). The Power of Pipes: Mapping Urban Water Inequities through the Material Properties of Networked Water Infrastructures—The Case of Lilongwe, Malawi. *Water Alternatives*, *11*(2), 314–335.

Trotter, P. A. (2016). Rural electrification, electrification inequality and democratic institutions in sub-Saharan Africa. *Energy for Sustainable Development*, *34*, 111–129. https://doi.org/10.1016/j.esd.2016.07.008

Vairavamoorthy, K., Gorantiwar, S. D., & Pathirana, A. (2008). Managing urban water supplies in developing countries–Climate change and water scarcity scenarios. *Physics and Chemistry of the Earth, Parts A/B/C*, *33*(5), 330-339.

van den Berg, C., & Danilenko, A. (2011). *The IBNET Water Supply and Sanitation Performance Blue Book: The International Benchmarking Network for Water and Sanitation Utilities Databook*. The World Bank. http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-8582-1

Williams, M. J. (2017). The Political Economy of Unfinished Development Projects: Corruption, Clientelism, or Collective Choice? *American Political Science Review*, *111*(4), 705–723