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The co-production of a constant water supply in Mumbai's middle class apartments

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Abstract

The lush gardens and gleaming cars that surround Mumbai's middle class apartment buildings hint at plentiful water supplies. However, piped mains water is only supplied for a few hours per day. This research explores the pragmatic choreography of water sources to co-produce a constant supply. The storage of mains water, bottled water, wells and water trucks, and increased use of rainwater harvesting, has elevated this to an important instance of service co-production. This paper suggests that introducing rainwater harvesting creates opportunities for more water use in these households and allows a re-consideration of water provision and governance city-wide.

Key words: water; infrastructure; middle classes; Mumbai; co-production

1. Introduction

Water infrastructure is the focus of several key debates centred on cities in the Global South (see Bakker *et al.* 2008; Gandy 2004; Laila Smith and Ruiters 2006) and there has been a great deal of research conducted in Mumbai, particularly focussing on housing and water infrastructure of the urban poor majority (see for example Gandy 2008; McFarlane 2008b). The infrastructure deficits of both these systems shape the everyday experience for the 60% of Mumbai's residents who live in informal settlements, but are also felt to some extent by the middle classes. Studies of urban India have therefore rightly focussed on the urban poor majority, sometimes using the elites as a counterpoint to demonstrate inequalities but there is limited academic research on the Indian middle classes and their access to infrastructure (Lemanski and Lama-Rewal 2013; Mawdsley 2004). However, as Harvey (1996) points out, it is resources that are needed by all society, including the wealthy middle classes, that gain the attention of politicians and businesses and thus water provision is a focus of action in Mumbai. This highlights justice debates around the focus of responses by political elites that promote solutions which benefit the middle classes, whilst research focusses on the urban poor. This paper therefore aims to understand how the middle classes achieve constant domestic water supplies through co-production with the municipality and the creation of decentralised water supply routes. Two key questions are addressed: How do Mumbai's middle classes achieve constant domestic water supplies through co-production with the municipality and the creation of decentralised water supply routes? And; what implications might these decentralised approaches to water provision have on Mumbai's water supply? This focus on decentralised water provision by the middle classes leads to the implications this might have for the provision and governance of water supplies in Mumbai.

This paper firstly discusses co-production as a conceptual framework for this research into domestic water supplies. Secondly, I introduce Mumbai's middle classes and their housing. Thirdly, I explain the careful choreography of supply routes of water in these apartments. The storage of mains water, bottled water, wells and water trucks are all part of this co-produced water service. This research also explores how rainwater harvesting is being installed in buildings to increase the water quantities and to replace some of the other (expensive) supply routes. This takes the co-production of the water supply beyond the management of supply by the residents and servants to also create the domestic building as site of service provision. Finally, this enquiry in to middle class service provision reveals how the co-production of a constant water supply is part of being middle class in Mumbai and suggests some of the positive and negative justice implications that could arise from promoting co-production as a response to water shortage.

2. Co-production of a domestic water supply from many sources

Co-production is a process of service delivery that involves multiple actors from different organisations (or no organisation) and in many instances citizens are involved in the production of services that they consume (Alford 2014; Ostrom 1996). This participation of citizens in service production can increase their power and improve trust between partners (Fledderus *et al.* 2014). Thus, the concept of co-production has been looked to for the provision of public services for the urban poor; however, it is also a useful framing for understanding the ways in which the middle classes and elites gain access to services in many parts of the world. If we take the example of an urban water supply, it may be that several organisations are involved in the production of service provision from one supply. A domestic water supply may be delivered from several sources and each of these might be provided by a different set of actors. Brandsen and Pestoff (2006) have identified three levels of co-production – co-governance; co-management; and co-production, although it should be noted that the levels can also work together and be present in the same arrangement. If we use this tighter definition of co-production, then co-production only truly takes place when multiple actors are also producing at least part of a service (Brandsen and Pestoff 2006). This is the case for domestic water supply in Mumbai, where a seamless water supply can be created by a portfolio of water sources from public and private organisations, and sometimes the residents themselves.

Disconnection from the mains water supply occurs on a daily basis in Mumbai. ‘Disconnection produces learning, adaptation and improvisation. All infrastructural systems are prone to error and neglect and breakage and failure, whether as a result of erosion or decay or vandalism or even sabotage’ (Graham and Thrift 2007, p. 5). However, this shortage and disconnection of water is not just through accident or sabotage but also by design to distribute water from a mains system that was never envisaged for universal supply. Decentralised supplies of water and electricity are considered by residents of many cities across the world to be only secondary systems to supplement centralised mains supplies, even as decentralised sources become more popular. As Karen Bakker (2010, p. 4) says ‘The network is assumed to be the norm, and the continued existence within urban areas of nonnetworked technologies of water supply provision controlled by communities is often portrayed as problematic.’ Several water systems are part of each building’s assemblage in Mumbai to increase resilience and new ways are being found to increase the water supplies to keep up with demand. When water was stretched further by light monsoons many residents took action to secure their own supplies by retrofitting rainwater harvesting systems to fill the gap in provision and reduce flood risk. This decentralised infrastructure through harvesting rainwater creates a new role of housing as a place of service provision. This gives control of resource supply to the residents and builds the middle classes as a resilient group towards environmental stresses, particularly water shortage.

Joshi and Moore (2004, p. 31) point out, 'There is much agreement that monopolistic provision entirely through state agencies is unfeasible, undesirable, or simply rather old fashioned'. And so these decentralised systems are being promoted by the municipality through information campaigns to co-produce the water supply and build resilience to water shortage. This is not the co-production of one source but the supply of various sources by different actors, which can be drawn together to co-produce one constant water supply. Having a constant, sufficient supply of good quality water is a signifier of middle class or elite status (Bakker, 2010; Kaika and Swyngedouw, 2000) but for many residents this is becoming increasingly difficult to maintain when *per capita* water provision is reduced by the municipality because of Mumbai's rapidly growing population, coupled with a changing climate and extreme weather events (Mall *et al.* 20016). The official population of the Mumbai metropolitan area calculated in the 2011 census was 18,394,912, making it the most populous urban area in India (Census Population Data 2015). This is a significant increase from 16,360,000 reported from the previous census in 2001 and stretching the city's infrastructure (Risbud 2003). Mumbai's water supplies have been under particular strain due to poor monsoons in recent years and the municipality have responded to preserve water levels by cutting the water supply by 20% to domestic properties and up to 50% decrease in water supplied to businesses (H.T. Correspondent 2016; Venkatraman 2015). Therefore many middle class residents are looking for other sources to maintain constant water supplies. This paper qualitatively explores how Mumbai's middle classes react to these regular disconnections with a variety of ingenious adaptations and improvisations to supplement the centralised water service and thus co-produce a plentiful supply to their homes.

The ways in which various water sources are drawn together to create a seamless water supply begins our understanding of the co-management of this water supply. Zerah has previously written about some strategies as ways of coping with water shortage in Delhi in the 1990s. Zerah (2000)) surveyed a variety of households at different income levels in Delhi with in-house piped water connections to discover the proportion of households used strategies and equipment to cope with water shortage. A decade later in Mumbai, I found that the collection and storage of rainwater has been added as an important new strategy that makes housing a site of water supply co-production. This research explores how several methods are used on a daily basis to produce an adequate water supply and begins to consider the wider implication of some residents of Mumbai co-producing adequate water supplies when there is a shortage city-wide. This will further develop understandings of co-production by highlighting how the domestic scale as a site of analysis requires also paying attention to the co-management of networks that extend far beyond the confines of a home.

In this paper I present research carried out in Mumbai between November 2009 and February 2011. Water provision and everyday use were examined using empirical data drawn from site visits including ethnographic observations and interviews with cooperative (in both senses) housing secretaries and presidents, other residents and servants at twenty-two residential properties in Northern Mumbai, particularly in the areas of Bandra, Andheri and Powai. The apartments and buildings used in this study range from the modest apartments in five storey buildings to large apartments in high-rise developments and townships. This range is demonstrative of the different buildings that the middle classes reside in, but the general commonality of apartment living has been used to define the middle classes within this research. The majority of middle class buildings are run as co-operatives with elected presidents and secretaries. This has implications for the individual home in terms of governance, resource provision and boundaries. Some decisions can be made by the representatives alone, or with a majority support, whilst others need all parties to be in agreement particularly when funds must be collected to provide the capital to install new infrastructure. Co-operative societies are also involved in employing servants to carry out tasks relating to the whole building, such as security and waste management. It is these co-operative buildings and the apartments inside them that are the site and scale for this investigation into everyday water practices. The biggest challenge of researching middle classes in their homes was access, which is an issue that Katherine E. Smith (2006) also encountered. It was very difficult to get residents to engage with me even in buildings where the society secretary or building manager (who could be considered a 'gatekeeper') was enthusiastic. Thus research with the middle classes and professional respondents for this study was limited to traditional methods of interviews, ethnographic observations and site visits, supported by taking photographs and videos. I combined these research methods with auto-ethnography of my time residing in middle class apartments in Mumbai to reflect my own experiences and enrich the study.

3. Mumbai's middle classes

India's middle classes are growing rapidly, and nowhere is their presence more evident than in Mumbai. In 2006 the journal *Critical Asian Studies* ran a special issue on class in South Asia that decries the decline of class analysis in the subcontinent (Chibber 2006; Herring and Agarwal 2006) and points to a renewed focus on India's middle classes (Fernandes and Heller 2006; Harris 2006). There are notable difficulties in defining India's large and heterogeneous middle classes (Fernandes 2011; Mazzarella 2011), however, the global, crosscutting nature of the Indian middle classes places them as a significant population to study (Brosius 2010; Fernandes 2000; Varma 2007). Estimates of the number of middle classes in India vary between 50 million and upwards of 400 million people

(Fernandes 2006; Mawdsley 2004; Varma 2007). Lemanski and Lama-Rewal (2013) report that the figure has been put at anywhere between six and fifty-four percent of the entire Indian population. This uncertainty arises from the difficulties in forming a general definition of the Indian middle class(es) because of their multi-faceted, heterogeneous and ever changing nature (see for example Fernandes 2006; 2011; Qayum and Ray 2011; Varma 2007). The task of defining the middle classes is complicated by employment, education, spending patterns, caste, language and regional variation within India, leading India's middle classes to be one of the most diverse in the world and especially difficult to define (Beteille 2001; Dickey 2012). Nijman (2006) points out that incomes and costs in Mumbai are higher than elsewhere in India, and so a direct comparison between middle classes across the country is unfair because Mumbai is an extreme outlier¹. For the purposes of this research and to side-step the difficulty of finding an over-arching definition of India's middle class (Brosius 2010; Mazzarella 2011; Nijman 2006), housing is used in this article to frame Mumbai's middle classes as: living in apartment buildings where the residents employ servants. This research has identified three necessary attributes for the middle class apartment: Firstly, it must be solidly constructed with occupancy permits in place (in Mumbai middle class housing is usually legal); Secondly the building management and the individual families within will employ servants to keep their apartments safe, clean and comfortable; Finally the building must be connected to services and the residents will aim for a convenient 24/7 water supply.

The land and property prices are extremely high in Mumbai and so bungalows, or detached villas, set within their own grounds are the preserve of some elites. The middle classes reside in apartments of varying size, position, age and quality. I have determined two main sub-groups: the small established suburban apartment block and the new multi-storey luxury towers in South Mumbai. The small suburban apartment block is between four and twenty storeys tall and is generally occupied by what would be termed the traditional middle class, but also attracts young white-collar migrant workers taken in as paying guests². These apartment buildings are sometimes extended vertically to increase the number of floors, and other buildings are demolished and rebuilt into much taller buildings, with the original residents making a profit from the sales. Such a building is represented in the novel *Last Man in Tower* in which a developer wants to demolish the building for redevelopment, a timely illustration of the shift in trend from old established buildings to new buildings that display wealth (Adiga 2011). The book is a parable of the changing norms of middle class aspirations that have also been observed by Varma (2007), Quayam and Ray (2011), and Mazumdar (2007). The new build

¹ Mumbai's role as economic capital of India mean that it attracts young ambitious people from all over India, and indeed the world, particularly for employment in the financial sector.

² Lodgers

apartment buildings particularly attract residents who would fit into the 'new' middle class: the young globalised group who value conspicuous consumption (Fernandes 2006). These buildings usually have extensive grounds and will often have their own gymkhana with swimming pool for the exclusive use of residents. It is the smaller co-operative buildings and the apartments inside them that are the site and scale for this investigation.

The extent of servant employment in India is high and hiring servants can provide the convenience and lifestyle desired (Dickey 2000; Qayum and Ray 2011; Varma 2007). The employment of servants is central to the creation of both middle class status and lifestyle (Varma 2007) and all the middle class apartment buildings visited for this research employed watchmen in the grounds as guards and handy men. Each apartment employs a maid for at least an hour every day (apartments in the same block may or may not share the same maid as relationships of trust between maid and employer are often more important (Qayum and Ray 2011)). The water supplies are managed by the servants in a middle class home and so they are a key part of the co-production of water supplies. Zerah (2000) points out that storing water or accessing alternative supplies can be time consuming, however I found that the middle classes in Mumbai both install technology to help with this and employ servants to make water access convenient. This careful choreography of water also allows many more practices to be undertaken that reinforce the middle class status of the residents.

'The labour is so cheap you get used to all this, you know, it's so comfortable. We have a couple of people working at home and everything is just set the way you want it and you don't have to do anything.' Developer (Interviewed in Mumbai, 16/12/2009)

It is these dual aspects of affordability and convenience that makes the employment of others within the home an almost universal practice for the Mumbai middle classes and convenience is experienced through the use of labour, rather than labour saving devices. It is cheaper and easier to hire a person than to purchase several machines to aid the same practices: a dishwasher or washing machine for example (Shove 2003). The employment of domestic servants to perform everyday practices distances the resident from some of the material and maintenance aspects of the home, and this can have an effect on the uptake of technologies as the resident would not directly interact with them and there would be no direct benefit of convenience to the resident.

4. Portfolio of middle class household water supply

'The landlord had a tap turned to stop the water of a dripping pipe in my flat but unfortunately this also stopped the supply to the water filter that gave us drinking water.'

My landlord explained that there are three separate supplies to my flat in Mumbai, but he's not sure which supplies what. The first is the direct mains connection, the second comes from roof/attic tanks (filled by BMC [mains] water) and the third source is a bore-well (this water is mainly used for flushing toilets). This differentiated system works well to help the residents cope with the unreliability of the water supply.' Excerpt from author's research diary (Mumbai 08/01/2010)

Drawing on my own experiences of living in Mumbai I learnt about the differentiated nature of the water supply to middle class homes and how it can impact on lives when it is misunderstood. The above excerpt from my research diary demonstrates the complexity of the water supply routes at the building level and how residents may not be aware of them. The schematic diagram (below) was developed to explain water infrastructure in Mumbai by showing that middle class apartments are the nexus and point of use of many water supplies and allowing each part of the co-produced supply to be considered from this starting point. It should be noted that not every apartment has access to all these water supplies and the residents will use a variety of coping strategies (Zérah 2000) that are available and most suitable to deal with water shortage.

Figure 1: Schematic diagram of water supplies to middle class housing in Mumbai (Source: Author)

The water supplies to a middle class home are differentiated on entering the building compound. The main split is between potable and non-potable water, which correlate with specific taps and other outlets in the building, as shown in the schematic diagram in fig. 1. The alternative sources include bore wells (used to access groundwater and aquifers) and underground storage tanks filled with water delivered by water-tankers, which can be ordered in times of water shortage. This leads to water being controlled by an enmeshed network of public and private actors (Anand 2011; Gandy 2008). The

municipality are just one of the actors in a system of supply and governance (Bulkeley and Betsill, 2003; Graham *et al.*, 2013; Zerah, 2008). Beyond the centralised supply, several other institutions and individuals are involved in the water provision portfolio to co-produce a system of water supply, such as the provision of tankers by private enterprises (Nallathiga 2006). The Municipal Corporation of Greater Mumbai (MCGM, also known as BMC) acknowledges that there is a shortfall in this supply and this has led the municipality to implement water-saving tactics and to shift responsibility on to the consumer in ways already enacted in middle class residences, in what Roy (2009) terms ‘calculated informality’.

For poorer households, mains water connections are often from stand-pipes in the street, shared between several households and water must be collected in buckets whenever the taps spring to life (Anand 2011; Graham *et al.* 2013). Many other informal residents have no mains connection at all, leading to a reliance on expensive water tankers run for profit by middle men or the creation of illegal connections to mains water pipes (Graham *et al.* 2013). These connections may not always appear illegal to the residents, who may have even paid money to government officials, only to later discover that corruption was involved and their water supplies are illegal and they are removed. Co-production of water supplies by the middle classes has the potential to free-up mains water supplies for poorer residents but could also have the opposite effect and actually decrease water availability through changes in governance or extended practices of water use.

In this section I use the portfolio of water supplies to the middle class home by investigating the main water sources in turn (as depicted by ovals in fig. 1). This tracing of the water supply begins with a discussion of the largest water supply into Mumbai’s middle class homes, the municipal-supplied mains system. I then briefly discuss the use of bottled water to supply further potable water. The use of water trucks is explained from both the point of view of the middle-class domestic building and the supply to informal settlements, to consider some of the justice issues around water supply in Mumbai. Ground water drawn from wells is then considered as the fourth major source of water. Finally rainwater harvesting is discussed in relation to the other sources.

4.1 Mumbai’s direct mains water supply

Mumbai is a mega city on the west coast of India and one of the cities most vulnerable to climate change exacerbated droughts and floods; due to its position, the density of its population and the high levels of urban poverty (Nicholls *et al.* 2008; Timmerman and White 1997). These issues are putting additional strain on Mumbai’s water infrastructure, as indicated by the current temporary cuts after 2015’s poor monsoon. This is in sharp contrast to the devastating flooding caused by heavy monsoon rains in 2005, and demonstrates the unpredictability of the monsoons and vulnerability of local water

supplies in a changing climate (Mall *et al.* 20016; Revi 2008). The mains water infrastructure in Mumbai has roots in the colonial planning of the city. The Water Department was created in 1860 to supply water from lakes through a centralised infrastructure system, provided and controlled by the government, because the existing wells and tanks became insufficient due to drought and urbanisation (Gandy, 2008; Zérah, 2008; Graham and Marvin, 2001; Anand 2011). The colonial government did not have aspirations that mains water would be universally provided and only supplied water to wealthy households (Anand 2011; Gandy 2008). The water system was popular with wealthy residents and an increase in the number of connections, combined with droughts led to the extension of the original Vehar system and creation of the Tulsi scheme by 1879 (both of which still serve South Mumbai), followed by the ambitious Tansa scheme completed in 1948 (Gandy 2008). Even with these expansions there were still insufficient and uneven water supplies into the city at the time of India's independence. Post-independence there have been several more schemes bringing water from distant lakes. The most recent of which is the Bhatsai scheme completed in several phases from 1983 until the present day and there are preparations under way for several more schemes to increase water supplies (Bambale 2012). Thus the legacy of this centralised system is a reliance on a mains water supply network that falls short of the technical ideal, does not supply all residents and is only updated, and new water sources tapped, when water shortages are felt by wealthy residents.

Mains drinking water now comes from these reservoirs or lakes outside the city (BrihanMumbai Municipal Corporation 2003; Sule no date) but water is only supplied to buildings that the municipality consider legal which means that water is not supplied to informal settlements constructed after 1st January 2000 (previously 1995) (Bambale 2012). The residents of newer informal settlements will not be granted individual connections and this can lead to expensive alternative water sources (Graham *et al.* 2013). Although the network of supply pipes has been extended, it has not kept up with urban growth and a shortage of water supply has been created. Water connections are given by the municipality in a stratified manner that takes into consideration whether the property is in a formal area and the purpose of the connection (Anand 2011). For a connection in a formal area this can include connections for construction work and drinking water for labourers (Municipal Corporation of Greater Mumbai (M.C.G.M.) 2016b). To apply for a water connection to a property in a slum (as per the MCGM's wording), the applicant must prove that the structure was standing before the beginning of 2000, and also proof of residency before then (Municipal Corporation of Greater Mumbai (M.C.G.M.) 2016c). By 2003 the municipality had acknowledged the water shortage and that the problem had accelerated faster than expected (BrihanMumbai Municipal Corporation 2003). The MCGM states that current water supply levels to Mumbai are 180 litres per person per day, which is higher than supplies in London (Bambale 2012). However due to not all residencies being supplied, the poorly maintained

and inefficient network, leakages and thefts, the actual *per capita* water supply is much lower than that and the dream of a 24/7 supply for all residents is a long way off (Graham *et al.* 2013; McKenzie and Ray 2009).

The MCGM technically still bears the sole responsibility for water supply in the city, unlike the privatised electricity supplies (BrihanMumbai Municipal Corporation 2003; Zérah 2008). Ruet *et al* (2002) explain that the water supply is still public because of the economic benefits as the returns far outweigh the expenditure, making water a lucrative source of revenue for the MCGM. Although this in some ways limits the commodification of water resources, the lack of an autonomous water agency reduces the efficient management of the system (Bakker 2010). Ruet *et al* (2002) also point out that the number of divisions within the MCGM with responsibilities for part of the water infrastructure, and the large number of other institutions involved at the state level in provision of water, has created a very complicated system that has led to failures and corruption is also a serious problem across all parts of the water supply system (see also Asthana 2008). The mains water is not enough to ensure an adequate supply for residents, therefore those who have the means co-produce a plentiful domestic water supply by adding other sources to this principal centralised supply.

4.2 Mains supplies and roof top tanks

Mains water remains the major source of water for Mumbai's middle classes but, even to middle class domestic buildings, the centralised mains supply provided by the municipality is not constant and is supplied only for approximately 2-3 hours per day. The hours that the supply flows depends on the area in which the building is situated and the supply rolls out across the city from the treatment plant at Bandup (or one of the three smaller plants) (Gandy *et al.* 2007). To cope with this intermittent supply from the municipality, storage tanks are installed by residents in the roof spaces of apartments or on the roof terrace of buildings and filled daily during the few hours of mains supply for later usage. Zérah (2000) found this strategy is also popular in Delhi and she highlights that only the wealthy residents have this kind of equipment, whilst other residents collect the water in buckets. In middle class housing an illusion of constant mains supply is created through the storage of mains water in these tanks to be used throughout the day, and supplemented by other decentralised water sources for non-potable purposes, such as tankers and borewells.

The watchman in an apartment building usually carries out the process of managing the water storage, with instructions from the co-operative society members, to ensure a constant supply to point of use in the building. This is achieved by monitoring when the municipal supply is flowing and turning taps to ensure that the roof tank is filled and that it can then be accessed a few hours later when the municipal supply has stopped again. The municipal water is used for indoor practices, such as bathing,

and this is also the drinking water in most middle class homes. The MCGM are proud of the quality of their water supplies, saying “We ensure that the quality of water supplied to our Connection Holder each day is in compliance with Indian Standard ISI 10500:2012.” (Municipal Corporation of Greater Mumbai (M.C.G.M.) 2016a). However, it should be noted that in middle class homes mains water will be passed through an ultraviolet filter in the kitchen before it is considered potable and, in some households, mineral water is bought for drinking and cooking (as discussed below). However the MCGM says that its water supply is potable and the majority of the population (who have little choice) do not filter it (Bambale 2012; Ruet *et al.* 2002). A major issue of water quality is the way in which the water is delivered to the residents and how it is stored, with the materials and cleanliness of pipes and tanks necessitating the (re)treatment of water in many homes (Gandy *et al.* 2007).

4.3 Bottled and packaged water

Bottled water is another supply of potable water for the middle classes and elites. Some elite and middle class citizens of Mumbai do not drink the water from the taps, even after filtering, believing that this packaged water is of higher quality. Therefore in a minority of apartments the drinking water is differentiated even further and separated from the city’s system of pipes entirely with mineral water delivered in refillable 20 litre bottles each with a tap at the bottom for ease of use and delivered from a local supplier on a hand cart. The Bisleri water-bottling plant at Andheri in Northern Mumbai is a controversial moment in the metabolism of water flowing through the city as it draws in ground water to filter, add minerals and package (Bisleri 2013). This could reduce residential supplies to the rest of the city and means that the packaged water industry could benefit from the many domestic rainwater harvesting systems (described in section 4.6) that are being installed to recharge ground water.

The main benefit of this system to a resident is the lower capital costs and maintenance requirements of bottled drinking water compared to installing a water filter that then needs maintenance. The use of bottled water also creates a whole new water source outside of municipal control, but is an expensive way of accessing drinking water. Thus the rich are creating an alternative water pathway that excludes many Mumbaikars whilst using the city’s ground water. This is the one part of the portfolio of supply that cannot be hidden to create part of the seamless illusion of water provision but is perhaps seen as a prestigious and safe source of drinking water.

4.4 Water tankers and underground tanks

Water tankers are a main source of water supply to many informal settlements, especially those not recognised by the municipality as being legal. Water tankers are used to deliver water to properties and individuals without a water connection but also used by the middle classes to top-up their supply by filling large underground tanks with water for non-potable use (in contrast to the small roof tanks

used for storing potable water). The tankers are often filled with water from the municipal mains supply by municipal workers or private water vendors, either legally, illegally or as a result of bribing officials (Gandy *et al.* 2007; McKenzie and Ray 2009). The water is thus technically potable water, although by the time it has been in the tanker and then sat in an underground tank the quality has been impaired by particulate matter and micro-organisms, and no longer potable. Corruption and racketeering is endemic in the provision of water tankers, leading to this loosely connected group of people involved in water vending as being described as the ‘water mafia’ (Gandy *et al.* 2007; Graham *et al.* 2013). In fact sometimes tankers full of drinking water are even diverted to building sites or to Bollywood sets (Graham *et al.* 2013). In times of political wrangling, such as elections, water tankers are sometimes publicly delivered to informal settlements in a move to secure votes from the residents.

Mumbai’s infrastructure of water provision is visible, differentiated, and therefore adaptable. The water tanker sums up these three interlocking properties of supply by being highly visible, used only for certain practices and capable of being called to any area at times of shortage to substitute for another water source. This is possible partly through the differentiation of the supply to middle class housing, meaning that the private water tanker can be used to fill the tank and that water will only be used for certain practices, critically it will not be sent to kitchen taps and so not used as potable water. This differentiation is key to unlocking possibilities for co-producing water supplies as different water sources can be supplied to different parts of the building. The underground tank is filled and used when necessary – the accessibility and differentiated nature of the water supply to housing allows for different sources to be supplied for different practices around the building. These tankers are another expensive way to secure a water supply and some middle class residents are now turning to rainwater harvesting as a cheaper option to fill their underground tanks that also gives them more control.

4.5 Wells

Middle class domestic buildings have water pipes snaking up their façades with red painted pipes denoting borewell or tubewell water. They must be painted red as borewell water is prohibited from being used for bathing, cooking or drinking due to high bacteria and particulate content as well as discolouration and often an unpleasant smell. The many visible pipes on the façade demonstrate the differentiated nature of the water supply, allowing different water sources to be more easily incorporated into the supply portfolio.

Wells have been used for supplying water in India for hundreds of years. The use of dug up wells (groundwater) and bore wells (aquifer) in urban areas has been growing in recent years. The ground water table is dropping, and aquifers are being emptied, so new wells must be dug deeper and old

wells are drying up. This also leads to the encroachment of saline water into the ground water supply, which becomes unusable in Mumbai (Bapat and Agarwal 2003). In reaction to this there are now strict regulations on the digging of new wells in an attempt to regulate the amount of water drawn from the ground. Rainwater harvesting is one way of replenishing the ground water and could help to push back the seawater encroachment.

4.6 Rainwater harvesting creates new water supplies

Rainwater harvesting was identified as the leading response to water shortage in Mumbai during my preliminary fieldwork. This is unsurprising due to the insufficient centralised water infrastructure and increasing pressures from urbanisation and climate change. In simple terms rainwater harvesting is the collection of precipitation but there are many different ways to configure a rainwater harvesting system depending on the specific circumstances and thus the process itself. Rainwater can be substituted into the domestic water supplies to fill a tank or to replenish a well. Rainwater harvesting can be used as an adaptation to water shortages by collecting and using the rainwater which in turn reduces consumption of treated mains water often drawn from outlying areas. It also reduces localised flooding by collecting the water thus helping the citizens to adapt to extremes of weather.

Rainwater harvesting has been discussed as a solution to water shortages in the Global South; both in rural (Kahinda *et al.* 2007) and urban (Handia *et al.* 2003) contexts. Pandey *et al.* (2003) use historical data to suggest that some communities in India may have developed rainwater harvesting to adapt to changing climates in the past, rather than migrating to other areas. The emergence of rainwater harvesting in Indian cities, and the uptake into legislation as mandatory for new constructions, is a reaction to this unreliability and the difficulty in securing the water supply for a rapidly increasing population. The catastrophic Mumbai flood of 2005 was followed by poor monsoons in subsequent years, exacerbating water shortages, demonstrating the disruptive agency of water (Revi 2008). This led many residents to secure their own water supply by retrofitting rainwater harvesting, which also reduces localised flood-risk. Middle class residents are installing rainwater harvesting systems to maintain their constant water supplies as ground water supplies are being depleted and water tankers are expensive. This is encouraged by the municipality who are trying to reduce demand on the mains water in an attempt to keep up with rapid urbanisation (Gandy 2006). The municipality provide information on their website and in leaflets distributed by the dedicated rainwater harvesting officer. Rainwater harvesting was observed during fieldwork mainly as retrofits, primarily instigated by residents. Small established suburban middle class apartment buildings are where rainwater harvesting retrofits are taking place to secure water supplies, reduce local flooding and address environmental concerns. Thus rainwater harvesting is being retrofitted in buildings to increase the

water quantities and to replace some of the other (expensive) supply routes. This not only creates new water supply but also new suppliers of water, as the residents become both the users and the utility suppliers (Button Forthcoming). In these new build projects the rainwater harvesting systems were generally used to percolate the water into the ground, which replenishes the groundwater and can reduce localised flooding in the grounds of the building, as suggested by Prabhu (Municipal Corporation of Greater Mumbai (M.C.G.M.) 2013), but does not directly augment the water supply of the building and are often there only to meet the targets for occupancy certificates. This kind of rainwater harvesting can create new pathways for water through the city and be used by other urban residents.

5. The significance of a plentiful and seamless domestic water supply

The lush gardens and gleaming cars that surround Mumbai's middle class apartment buildings hint at a plentiful water supply and affluent lifestyle. Residents (individually or as housing co-operatives) and the municipality are co-managing water sources and provision, leading to an adequate supply in many homes as a strategy of calculated informality (Roy 2009). This co-production, as Brandsen and Pestoff (2006) have termed it, when rainwater harvesting is added to the portfolio and residents begin to create their own water supplies. The installation of decentralised water infrastructure to create this is part of being middle class in Mumbai. Kaika and Swyngedouw (2000) consider infrastructure networks as not merely fulfilling a function but as a status symbol and Karen Bakker (2010) argues that access to a mains water supply is a 'material emblem of citizenship'. The middle classes in Mumbai may use their access to sufficient water supplies as proof of status. The provision of a constant supply of water from several sources in the middle class home so that it appears to be seamlessly provided from one source is an illusion choreographed by cooperative society leaders or building managers and carried out by their employees, as discussed above. Fledderus *et al.* (2014) suggest that co-production increases trust by building up relationships between partners. However, in the situation presented here, co-production seems to be a way of side stepping the lack of trust to increase reliability of water supply. This is because co-production here is seen as different organisations and individuals providing a range of water sources to co-produce one water service, thereby increasing individual control over water supplies. This constant provision of water allows practices to be performed that indicate middle class status, such as frequently washing cars and maintaining gardens. Thus if having access to mains water is an emblem of citizenship (Bakker 2010), then having a plentiful supply in your building that allows you to water plants, shower twice a day and have your car kept gleaming, is an emblem of middle class status.

Watering gardens with collected rainwater can increase water consumption as there is no longer a need to water sparingly with scarce and expensive municipal or tanker-delivered water and in this way the middle class lifestyle is secured. This has led to lush green gardens surrounding many buildings with rainwater harvesting, which is good for well-being and for the microclimate but is an example of an environmental technology being used to facilitate increased usage rather than conserve resources. Changing expectations of provision from new sources and increased quantities of water supply can increase consumption and be at odds with environmental strategies (Shove *et al.* 2008). Bakker *et al.* (2008) point out that the fragmented infrastructure of cities in the Global South is often designed into the system and the highly differentiated modes of urbanisation that have taken place since the colonial era have led to uneven distribution of services that prioritises wealthy areas and residents (Kooy and Bakker 2008; McFarlane 2008a). Ananya Roy (2009) also points out that this calculated informality is not just used by the poor and can be instigated from above. The urban poor also draw together a portfolio of water sources to secure their water supplies, however, they are limited by costs and especially by space constraints. Collecting and storing water takes up a large volume and rainwater harvesting needs an even larger area of land or roofscape, meaning that systems within informal settlements are rare. The poorest residents of Mumbai struggle to access sufficient and good quality water, and pay the highest prices for water from vendors (Gandy 2008; Graham *et al.* 2013). This differentiation of water supplies does two things: Firstly, it increases the number of actors with a role supplying water. Secondly, it means that the service provided to different citizens is inconsistent. Those middle class residents with a mains connection are also those with the means to be involved in co-producing their water supplies by installing additional sources. It is frustrating that those with the most to gain are unable to participate in this way, and hope that the co-production by the middle classes might make more water available to others.

The municipality draw attention to the water that is pilfered by the residents of informal settlements who have no legitimate access to the mains supply, and the media promote this narrative by often showing the pumps removed in the newspapers (Graham *et al.* 2013), which reflects wider global trends such as the vilification of 'benefit scroungers' in the UK. However the losses from leaks of the ailing system and illegal selling of water for tankers play a more substantial role in the reduction in water supply. The media depiction of the poor as the ones at fault for their desperate actions to get water is highly problematic and feeds the well-rehearsed narratives of wealthier residents to clear informal settlements (see Baviskar 2002; Fernandes 2006; Mawdsley 2004). This concentration on blaming the poor for theft and encouraging the middle classes to save water through education campaigns (including the promotion of rainwater harvesting by the Mumbai municipality) could divert attention from investment in the current mains supply to remove leakages. It has been noted before

that the middle classes have disproportionate political influence (see Baviskar 2002; Mawdsley 2004). We can take this further by applying Diana Mitlin's (2008) ideas about co-production as a way of increasing political influence. Co-production can be seen as a mechanism for the neighbourhood organisations described by Zérah (2007), and seen widely in Mumbai, to gain power. Co-operative housing associations join together into neighbourhood groups that work in conjunction with local government to improve their neighbourhoods. The ability to coproduce a constant water supply with input from the municipality shows power and status. Anand (2011) points out that the ways in which water is accessed in Mumbai are inherently political and tend to be more successful when a community comes together. The middle classes gain the benefits of collective actions as they co-produce their water supplies. These residents, or representatives of their neighbourhood groups, develop working relationships with officers in the municipality and this can aid future interventions in a neighbourhood (Zérah 2007). The inadequacies of centralised services have not escaped developers, who offer increasingly more private services in their new luxury apartment buildings (water, electricity, fire services etc.). The desire to create the illusion, and preferably reality, of a plentiful water supply is a reflection of being part of the global middle class.

The co-produced water supply in middle class Mumbai homes could be a golden opportunity to relieve stress on the mains supply and allow for more water to be supplied to the poorer residents of the city. However, although this would be the ideal scenario, it looks unlikely for two reasons. Firstly, the creation of a plentiful water supply unlocks the potential to consume more water for new or extended practices. Working and hidden infrastructure causes separation from particular ideas about nature and thus has been shown to cause increased consumption by reducing awareness of the provision mechanisms and increasing convenience (Kaika 2005; Shove 2003). Thus it could be argued that supplementing the supply with other sources to give the illusion of plentiful resources might increase consumption and negate any social and environmental benefits. Secondly, it shows the municipality that (at least some of) Mumbai's residents can supply and secure extra water resources and co-produce an adequate supply with the municipality. Co-production can increase political capital through greater control over resource provision, which can have beneficial consequences for those involved (Mitlin 2008). This could therefore set a precedent by which the municipality expects the citizens to co-produce their water services, allowing the state to roll-back aims for universal provision (see Button Forthcoming). In this way co-production may not increase overall resilience to water shortage and does little to address current inequalities.

6. Conclusions: Co-producing the illusion

The MCGM is unable to provide the desired 24/7 plentiful piped water supply that many people take for granted and so the middle classes of Mumbai co-produce their supply, in particular using rainwater harvesting to become truly producers of water supplies. In Karen Bakker's (2010) terms this is a small-scale community service provision and a system that goes beyond privatisation. An ingenious portfolio of water supplies is choreographed to maintain constant water provision and aim to create the appearance of one seamless source in middle class and elite apartments in Mumbai. A constant, sufficient supply of good quality water is becoming increasingly difficult to maintain. Therefore, many middle class residents are looking for other sources. In this paper I have explained how the middle classes draw together several sources in their homes to co-produce the illusion of one plentiful water supply with the municipality's support. The provision of a constant supply of water from several sources in the middle class home so that it appears to be seamlessly provided is an illusion encouraged by the municipality and choreographed by cooperative society leaders or building managers and carried out by their employees.

Plentiful water supplies in middle class homes, from certain viewpoints, could furthermore create the illusion that the city has enough water and the residents are coping with the limited mains supply. The concern presented in this paper is that the seeming abundance of water displayed by the middle classes and elites of Mumbai will be interpreted as an overall abundance and used as justification for the rolling back of centralised supplies. This could have wide reaching unintended consequences for the urban poor, who are unable to build-up the levels of resilience to water shortage demonstrated here by the middle classes. Thus, whilst applauding the encouragement of decentralised solutions to water shortage and environmental change to co-produce an adequate water supply, I urge caution when providing solutions to Mumbai's endemic water crisis.

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