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Inclusive development of urban water services in Jakarta: The role of groundwater

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ABSTRACT

This paper applies the perspective of inclusive development to the development goals – past and present – for increasing access to urban water supply. We do so in order to call attention to the importance of ecological sustainability in meeting targets related to equity of access in cities of the global south. We argue that in cities where the majority of urban water circulates outside a formally operated centralized piped systems, inequities in access are grounded in conditions of deep ecological vulnerability. We examine this relationship between environment and equity of access in the context of Jakarta, Indonesia, where failure to address contamination and over abstraction of groundwater has exacerbated inequalities in access to water within and beyond the centralized piped network. We first present research results from in-depth interviews with key informants and secondary data to document the role of shallow sub-surface and deep contained aquifer groundwater within urban water services and causes and implications of declining groundwater quality. We then explore the uneven impact of this degradation through a comparative case study of water access strategies in two low-income settlements. Survey results reveal the significance of shallow sub-surface groundwater services for the poorest residents, and negative impacts of declining groundwater quality on equity in terms of cost and volume of consumption between income groups. We conclude that for urban water services to be inclusive, environmental and social priorities need to extend beyond piped water.

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1. Introduction

The year 2015 marked the year of transition from the Millennium Development Goals (MDGs) to the post-2015 development agenda set out in the Sustainable Development Goals (SDGs). While the MDGs devoted one out of eight goals to environmental sustainability, ecological dimensions take a much more prominent stage among the SDGs. Almost all goals aim to be (ecologically) sustainable, as ecological sustainability is seen to be fundamental for economic, environmental, and social development. The challenge for the present and future of development is the integration of ecological sustainability with social inclusion. Experience shows that in practice, sustainability often leads to trade-offs in favour of economic goals at the expense of social inclusion (Gupta, Pouw, & Ros-Tonen, 2015). Sustainability approaches of the large development institutions have been critiqued for reconciling economic growth with environmental preservation,[1] and ignoring - or exacerbating social inequalities (Atkisson, 2013).

The concept of inclusive development responds to these critiques of the approaches to sustainability (see Schwartz and Gupta, this issue). While agreeing with emphasis on the urgency of addressing environmental issues, the perspective of inclusive development stresses the necessity of taking into account how these (and the measures taken to address them) are distributed

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[1] See, for instance, the World Bank's 'inclusive green growth', which aims to "reconcil[e] developing countries' urgent need for rapid growth and poverty alleviation with the need to avoid irreversible and costly environmental damage (World Bank, 2012, p. 2).

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through society. This paper is part of a Special Issue dedicated to understanding the role of inclusive development in achieving urban water services in the global South. For, despite the achievement of the MDG in increasing access to water at a global level being met in 2010, this overall success conceals considerable variations between and within countries. Critiques of the MDG achievement have highlighted the lack of attention to equity of access, as well as failing to consider ecological dimensions such as the quality of water delivered (Onda, LoBuglio, & Bartram, 2012) and continuity of access (Burt & Ray, 2014).

In addition, for urban water supply, scholars and practitioners have highlighted the insufficient attention paid to water sources and service delivery strategies which lie outside - or alongside - access to a piped network (Andreasen & Møller-Jensen, 2016; Obeng-Odoom, 2012; Satterthwaite, 2016). In this paper, we argue that extending inclusivity to consider these sources and services is urgent in light of the SDGs, as it is precisely these "alternative", "informal", or "out-of-network" supplies used alongside or in place of utility which remain reliant on ecological services – and, as a consequence, vulnerable to- and constitutive of ecological degradation. The realities of urban water services in many Southern cities mean that residents – across all income classes – rely on diverse water sources and modalities of service provision which may be outside of the formally recognized piped water network. This includes groundwater (Wright & Jacobs, 2016), rainwater (Nastar, 2014), or even wastewater (Meehan, Ormerod, & Moore, 2013). These complex configurations of urban water supply were not "counted" within the MDGs (Nganyanyuka, Martinez, Wesselink, Lungo, & Georgiadou, 2014) and goals of both equity and environmental sustainability for access to water sources outside the network or through informal service providers are overlooked (Chakava, Franceys, & Parker, 2014; Srinivasan & Kulkarni, 2014).

As the SDGs renew commitment of improving access to water, we highlight the need to look not only at the ways in which social priorities are included within pathways to sustainability, but – given the reality of access in cities of the global South – how sustainability impacts equity. We explore this relationship between social inclusion and ecological sustainability of urban water services within the context of Jakarta, Indonesia. Although the MDG target with regard to improved water access in Jakarta was met in 2010, the achievement relied on improved access to groundwater – not piped water - sources. Water from the shallow subsurface, and the contained aquifer below, provide the largest volume of water for bulk water, and is the second most preferred drinking water source, after bottled water (BPS, 2012). The dominance of groundwater from the contained aquifer in meeting urban water needs presents concerns for ecological sustainability, as the massive overuse is linked to salinization of the upper layer, land subsidence, and increased flood risk (Delinom, 2008; Kagabu, Shimada, Delinom, Nakamura, & Taniguchi, 2013). In turn, the degradation of shallow subsurface water quality carries larger implications for equity of access.

In the following section of the paper we review the concept of inclusive development and identify its relation to the SDGs for urban water services. In Section Three we describe our research methodology and survey sites, Section Four presents the result of the semi-structured interviews and secondary data to document the role of groundwater in Jakarta's urban water services. Section Five analyses the results of a household survey to identify the impacts of groundwater quality on access strategies and equity of access.

2. Inclusive development and water

The call for inclusive development as a particular development approach linking social and ecological goals emerged in response to the process of drafting the SDGs. Although the translation of the term into a theory of inclusive development is recent (see Gupta et al., 2015), the roots of this perspective go back to many development traditions, such as Amartya Sen's capabilities approach of human development (Sen, 1999, 2000). Concerned with exclusion from development, marginalization, and inequality, an inclusive development approach emphasizes fairness and social justice, and participation in development (Beall & Fox, 2007; Figueiredo & Perkins, 2013; Sachs, 2012; Sultana, 2009). Gupta et al. (2015) revisit these priorities in the wake of the Anthropocene to include the dimension of environmental sustainability. Recognizing that goals of social development are no longer plausible without attention to the environment – all of development, now more than ever, depends on the condition of the Earth – they define inclusive development as 'development that includes marginalized people, sectors and countries in social, political and economic processes for increased human well-being, social and environmental sustainability, and empowerment.' (p. 546).

The revival and re-emergence of inclusive development during the transition of global development policy from MDGs to SDGs has taken the original concerns with exclusion, marginalization, and inequality into the calls for environmentally sustainable development. Advocating for inclusive development responds to the concerns of how sustainable development is implicated in practice (Dubash, 2012; Lele, 1991). Efforts to 'green the economy', or to making growth inclusive marginally work to redress/readjust economic growth for development in the current context of a global environmental crisis. The resulting neglect of social inclusion for the sake of creating environmentally sustainable economic growth has led to 'weak' sustainable development, in which one component of sustainability has become secondary to the other two (Gupta, 2014). Inclusive development thus responds to the prioritization of environmentally sustainable growth, over concerns of equity and inclusion.

Applying the concept of inclusive development to urban water services offers an opportunity to (re)consider relations between ecological sustainability and equity of water access. A look at the MDGs reveals that this relationship was not considered sufficiently, if at all. Target 7C pledged to halve, by 2015, the population of people without access to an improved drinking water source and sanitation facility. Although Target 7C is part of Goal 7, which is concerned with ensuring environmental sustainability, environmental dimensions of access to water and sanitation are not considered – the indicators mainly register quantity (proportion of population) of access, with the only quality-criteria being that the water source or sanitation facility is 'improved'. This is primarily a matter of categorisation and is not (directly) concerned with either equity of access or environmental interrelationships which favour or hinder this access. Thereby, although the target for drinking water was achieved ahead of time in 2010, this overall success conceals inequities in water access, such as big differences of access between the poorest and the richest households within cities, gender-related challenges in access, and barriers for persons with disabilities (WHO/UNICEF JMP, 2015). Moreover, measuring access in absolute numbers of households connected excludes the quality of the access, such as the number of hours a day a household is connected, the quality of the water itself, the sustainability of the water access, the sociotechnical barriers in accessing the facilities, or the ways in which households combine different sources of water to meet their water needs (Satterthwaite, 2016).

The limitations of the MDG indicator and its measurement for access to water are to some extent addressed in the SDGs. For instance, Goal 6.1 now includes equity of drinking water access, in addition to being affordable, safe, and universal. At the point of

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writing, the concrete indicators are still being debated, but as of now it seems that the Inter-Agency Expert Group on SDG indicators (IAEG-SDGs) holds on to the basic requirement of people having access to an improved water source or sanitation facility. However, the definition has been expanded and now additionally includes the 'population using a basic [i.e. improved] drinking water source, which is located on premises and available when needed and free of faecal (and priority chemical) contamination' (IAEG-SDGs, 3rd of March 2016). Emphasising the connection between contamination and water sets a first step towards acknowledging the environmental dimensions of water access. In addition to indicators of rural/urban residency and socioeconomic class, the proposed indicator also integrates 'other stratifiers of inequality (subnational, gender, disadvantaged groups, etc.) … where data permit' (IAEG-SDGs, 3rd of March 2016).

However, while the SDG agenda has taken some steps towards addressing the urgency of integrating considerations of environment and equity in water access (and sanitation), it remains to be seen specifically what types of access, to what variety of sources, will be considered as part of the SDG indicators. While there is increasing documentation of how the majority of water supply in cities of the global South is accessed outside of formal service provision and/or centralized networked systems (Foster, Hirata, Misra, & Garduno, 2010; Nganyanyuka et al., 2014), and despite their ubiquity and permanence in the urban fabric, these forms of access, and reliance on variety of sources, are still presumed to "fade away" with an expansion of the centralized system. Subsequently, attention to the equity of access, and addressing issues of environmental sustainability, for these sources/services has been largely absent. We believe that the perspective of inclusive development, and its focus on the relationship between social inclusion and ecological sustainability, offers an opportunity to redress this gap in urban water services. We turn now to consider this in Jakarta, looking specifically at how sustainability of groundwater impacts equity of water access.

3. Methodology

We undertook two periods of six months of research in Jakarta, over 2014 and 2015.[2] Data was collected with assistance from local enumerators, and included residents from the research sites. To document the role of groundwater in urban water services we conducted semi-structured interviews with urban water authorities, development agencies and groundwater agencies. Data on groundwater quality, subsidence patterns, and salinization of the unconfined aquifer for all Jakarta was collected from secondary sources, and interviews with researchers from government agencies.

Understanding the role of groundwater within water services for all of Jakarta is complemented by a neighbourhood level analysis of the role of groundwater, specifically for low-income residents. In this study, we follow the Indonesian Ministry of National Development Planning (BAPPENAS) in considering poor any household with a monthly income of less than IDR 4.4 million (USD 323).[3] According to this classification more than half of the households surveyed (51%) are poor using this definition. This is not to disregard the contestations concerning the use of income as indicator of poverty, or the ambiguity of poverty more broadly, particularly in an urban setting (see, for instance, Mitlin & Satterthwaite, 2013).

Following this classification, a household survey was conducted in two low income sub-districts in North and South Jakarta ($n = 189$). The survey was used to document what water sources were used and in what combinations, volume, cost, and through what mechanism of access (formal/informal). Results were then analysed to understand the role of groundwater quality in achieving equity of water access. Inclusion – or equity of access – is analysed by looking at differences in sources, volumes, and costs between income levels, comparing poorest residents with highest income residents.

Groundwater quality analysis focused on the degree of salinity, rather than microbial (e-coli) contamination. Microbial contamination was assumed to be present for all of the shallow groundwater, as this has been previously documented for all of Jakarta (Delinom, 2008; Tribunnews, 2011). Like the other 98% of Jakarta residents, households in the research sites relied on on-site sanitation system popularly called septic tanks Analysis of salinity in the groundwater was based on a primary assessment of smell and taste, and we selected research sites which were either highly saline or non-saline. To understand how the quality - or specifically - the salinity of groundwater affected inclusion/differences between Q1 (the lowest income group) and Q5 (the highest income group) was explored by comparing the two locations.

3.1. Selection of household survey research sites

The household survey was conducted between April and November 2014 in two areas of the city: one, Penjaringan, which stretches along the Northern coastline of the city, and two, Gedong & Ciracas in the hillier South. The selection of these research sites was informed by the following considerations: to begin with, all areas are characterised by a higher percentage of low-income households, which responds to the concern inclusive development holds for the poor and marginalized. The lowest income group in these settlements are amongst the lowest income residents across the city – with the exception of squatter populations. All respondents in the survey have KTP (*Kartu Tanda Penduduk*, Citizenship Card) and can show proof of PBB (*Pajak Bumi & Bangunan,* Land & Building Tax) payment receipt, except when the respondents are renters. By regulation, those who can produce those documents (KTP & PBB) are eligible for a piped water connection on premise. The locations were covered by the centralized piped water network, therefore it was possible for the residents to opt for piped water connection on premises, either directly or indirectly by purchase from their neighbours. Finally, the areas represent different geographic contexts in relation to quality of groundwater, with the assumption that this would have an influence on household strategies to access water sources.

Penjaringan is a *Kelurahan*, or Sub-District, located in the municipality of North Jakarta, with a very high density of low income communities. Historically characterised by high incidents of informal settlements, many of these settlements under toll roads, alongside riverbanks, and over garbage dumps have been evicted. Alongside employment tied to the harbour industry, small scale industry and commercial land use are prevalent. Given its coastal location, the shallow subsurface groundwater in Penjaringan is saline and flooding is common. The high degree of salinity is obvious, and immediately apparent based on taste, odour, colour of groundwater. Here, networked water connections are under administration of Palyja, the private sector water supply company responsible for the Western half of the city, including Penjaringan.

Gedong and Ciracas are two adjacent *Kelurahan* in the East Jakarta municipality, peripheral to Depok City, one of Jakarta's

[2] Jakarta is defined as a special administrative district, so it is simultaneously a province, and a mega-city, containing the five municipalities of North, South, Central, East, and West Jakarta - and a regency of Thousand Islands on the Java sea.

[3] We note that Poverty calculations by BAPPENAS are significantly higher than the Indonesian Bureau of Statistics, which use 500,000 IDR/month for their poverty classification (BPS, 2015).

'satellite cities'. Previously a rural area, but enveloped within urban expansion in the 1980s, it changed its land use from agricultural to residential and commercial, as reflected in the presence of wet markets and factories. It is less densely populated than comparable low-income areas in North Jakarta, with plots sub-divided and sold or rented as Jakarta expanded into this peri-urban area. Like in Penjaringan, most households lack formal land ownership documents, but many have some administrative claim to their land, for instance in the form of proof of tax payments which is required for the application for networked water supply. With regard to water access, Gedong and Ciracas are served by Aetra, a private sector water supply company covering Eastern half of Jakarta.

Together, these areas represent the very different quality of shallow groundwater sources in Jakarta, thereby enabling investigation of the relationships between social and environmental dimensions of access to clean water for the city's low-income residents.

3.2. Quantitative data collection and statistical analysis

Empirical data was collected by means of a stratified sample household survey (N = 189), with 104 surveys collected in East Jakarta (Gedong N = 55 and Ciracas N = 49) and 85 in the North. Socioeconomic quintiles were generated based on an assessment of self-reported income data of the survey respondents. The total household income was computed from three indicators: (1) regular salary of all household members, (2) side income generated through household-based enterprises, and (3) additional income from remittances and/or donations. To improve the reliability of income data, together with the enumerators we rechecked the survey result twice and, when necessary, revisited the respondent to validate their answers. The total sampled units were divided into five equal-sized groups (20% of each), resulting in each income-quintile consisting of a rounded-up number of sample units. Another important variable concerns household water expenditure, which describes the ratio of total water expenditure (bulk and drinking water) to total income. This way the portion of monthly household income spent on water could be estimated.

4. The role of groundwater in Jakarta's water services

In this section of the paper we document the historical reliance of Jakarta residents on both shallow subsurface and contained aquifer groundwater sources to emphasize its relevance for any measurements in development goal targets on water quality and equity of access. We then document the environmental impacts of this reliance on both shallow and deep groundwater systems, highlighting in particular how the groundwater systems and subsequent ecological issues are connected. We do this in order to highlight the inequitable distribution of ecological impacts as shallow sub-surface systems used by lower income residents are affected by over-abstraction of contained aquifer by higher income domestic, and industrial users.

Achieving the MDG target for increasing access to water in Jakarta in 2010 depended on improving access to groundwater, as 60% of the "improved access" was to groundwater sources.[4] This reflects the city's reliance on groundwater, which has remained constant even over the last 100 years of the expansion of the centralized piped water network system (Colbran, 2009). By design or by default the centralized networked water supply system has never served the majority of the city's residents or its water needs (Kooy & Bakker, 2008). Service coverage of the network is now at a historical high of 40%, but the piped water supply system still struggles to provide more than 50% of the water needs in the city (Badan Regulator Penyediaan Air Minum, 2014; 2015).[5]

Jakarta's water supply services have received international attention due to the private sector contract signed in 1997 between the Indonesian government and French and U.K based international water companies (Harsono, 2003, 2004).[6] Unsurprisingly, analyses on Jakarta's water supply have focused on the impact of the private sector partnership on access by low income households (Argo & Laquian, 2004; Bakker, 2007), while acknowledging the legacy of previous decades of public management, which also systematically excluded low-income residents (Kooy & Bakker, 2008). In 2006, less than 10% of network consumers were from the lowest tariff bracket (Kooy & Bakker, 2008), and initiatives of the private water supply companies to extend access to poorer areas in the last decade have been limited due to financial priorities of both private and public sector (Menzies & Setiono, 2010; Noordegraaf, 2016). However, analyses of water access also show that those not connected to the centralized network are not only the poor. Between 1998 and 2005, new connections were preferentially targeted at middle and upper-income households, but the numbers of new connections within this class of consumer were much lower than desired (Bakker, 2007). This pattern has not changed significantly over the last 10 years, as analysis of the numbers of customers per tariff band reveals that it is the very poor—but also the rich—who are still not using the city's piped water supply. Currently, the middle class—and lower middle class—consumers represent the largest number of customers of both private sector water service providers.[7]

This reflects that the majority of water meeting domestic, commercial, industrial needs in Jakarta comes from groundwater - both in terms of total volume of supply, and in terms of serving the majority of the population. Moderate estimates calculate that groundwater sources account for at least more than 60% of total urban supply.[8] For domestic use most Jakarta residents continue to use groundwater from the shallow subsurface, especially for bathing and laundry (BPS, 2012). Some residents combine this with piped water from the centralized networked system - using shallow groundwater for consumptive uses and piped water for

[4] However, note that there is no continuous and systematic monitoring and evaluation on the quality of groundwater or for the design and construction of the wells.

[5] Current estimates of service coverage by the water providers range from 53 to 59%, depending on how many people are assumed served per connection, and which population figures are used. Jakarta Dalam Angka records 9.6 million people (2013), Population and Civil Registration Agency records 10.18 million people (2011), the population data used by Palyja and Aetra is 9.3 million (2013). Interviews with the Ministry of Public Works show that the service coverage is much lower (39%) when considering the percentage of service area that does not receive water.

[6] The contracts in 1998 were signed with Thames Water International, from the U.K., and Suez Lyonnaise des Eaux, from France. Since then Thames Water has withdrawn, selling its shares to an Indonesian consortium based in Singapore (Aetra). Suez (via local entity of PAM Lyonnaise des Eaux/Palyja) has reduced its involvement by selling 49% of its shares to an Indonesian partner, and has tried to withdraw completely via sales to Manila Water, albeit unsuccessful. Currently both contracts are now again up for debate as in 2015 the Constitutional Court has annulled the regulation (Water Resources Regulation) that serves as a basis for water privatization.

[7] In the eastern half of the city, the largest number of customers are middle and lower-middle income households (21 and 46%), only 10% of customers in the upper tariff bands (Badan Regulator Penyediaan Air Minum, 2014; 2015). This mirrors the situation in the western half, where the majority of piped water customers are middle and lower-middle income households (12 and 21%) (Badan Regulator Penyediaan Air Minum, 2014; 2015).

[8] Analyses done by the Jakarta Water Resources Council (Dewan Sumber Daya Air Jakarta) estimated that groundwater supplies more than half the city's water needs, with annual demand of 1 billion m^3, 630 billion m^3 is from groundwater, and the remaining 370 billion m^3 from piped water (Kompas, 2013).

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bulk supply, or the reverse - as the quality of either supply depends on one's geographical location (proximity to network pipes, degree of salinity in groundwater). The quality of piped water supply is highly variable across the city, as less than half of piped water meets standards set for water pressure.[9]

The quality of shallow groundwater varies as subsurface pollution and saline intrusion are spread differently across the city[10]. Both pollution and salinity renders shallow groundwater useless for even most non-potable uses especially further north and closer to the sea (Delinom, 2008; 2016), while 45–90% of Jakarta's shallow groundwater is contaminated by *E*-coli from wastewater and more evenly spread.[11] With less than two percent of Jakarta served by a centralized sewerage system the degree of contamination of water from shallow wells varies according to the depth of well households can afford to dig, and the distance from their own - and their neighbours - septic tanks (Kosasih, Samsuhadi, & Astuty, 2009). Most residents - across all income classes - rely on two or more water sources for drinking/cooking vs. non-potable uses. Different water sources, of different qualities, are provided by formal/informal suppliers for specific uses such as drinking, cooking, home industry, bathing, indoor cleaning, laundry, and outdoor use.

Potable groundwater comes from the contained aquifer accessed by boreholes which reach between 100 and 200 m in depth. Deep groundwater is much more expensive than shallow sources, and is primarily used by industrial and commercial users, with city block mega malls, high income housing estates and apartment residences included in the latter. Deep groundwater is preferred over piped water because of its superior quality and reliable supply. Also, until the new groundwater taxation regulation[12] was enacted in 2009, it was less expensive than piped water for large volume users (Siswanto & Suharno, 2010). Until the late 1990s, coinciding with the privatization of Jakarta's piped water, use of deep groundwater for industrial/private sector growth was encouraged by official policy, even in areas where piped water was provided (Colbran, 2009; Kooy, 2014). The main motivation to regulate extraction from the contained aquifer seemed not to come from environmental concerns, but economic motives - as stricter regulation came into effect with the private sector concession contracts for Jakarta' piped water network. However, despite the continued efforts of the private sector water operators, shifting high value (key account) commercial users from deep groundwater to piped water consumption has been difficult (Zamzami & Ardhianie, 2015). Interviews in 2015 with the private sector water operators and the public wastewater utility (PD.Pal) revealed that recent increases in groundwater tariffs is leading to more wastewater recycling, rather than increase their consumption of network water supply.

The environmental impacts of over withdrawal from the contained aquifer have been well documented. Warnings of over-abstraction were noted already in the 1980s, and is now linked to land subsidence, increased flood risk, and salinization of shallow subsurface layer (Abidin, Andreas, Djaja, Darmawan, & Gamal, 2008; Delinom et al., 2009). Regulation to address the environmental impacts has been late in setting limits, and unevenly enforced (Amrta Institute for Water Literacy, 2014; Colbran, 2009). While regulation has set progressively more stringent requirements for applications, permits, and higher tariffs from 1997 onwards,[13] officials responsible for regulating groundwater report figures of 4000 illegal deep wells in Jakarta, in addition to those registered users who are under-reporting actual consumption (Agustinus, 2016). Other estimates state that between 50% and 120% of total abstraction is unregistered (CNNIndonesia, 2016; Deltares, 2015; Soetrisno, 1998). Therefore, while government agencies have reported a decline in total abstraction from deep wells since 2009 (which is parallel with the enactment of new regional regulation on groundwater taxation in the same year), this is challenged by researchers and activists who present a mismatch with models built from monitoring wells, discrepancies with reduction in rates of subsidence or salinization, and gaps between official and unofficial water balances (CNNIndonesia, 2016; Deltares, 2015; Soetrisno, 1998).[14]

The government priorities regarding slowing - or halting - groundwater extraction from the contained aquifer are to reduce land subsidence and flood risk. Increased flood risk as a result of subsidence represents significant economic loss, and if continued will negate the protection of current investments in flood measures (Deltares, 2015). The impact of over abstraction on the shallow subsurface layer and the unconfined aquifer itself, is less of a concern for government regulation. Domestic use of groundwater from the shallow layer is allowed without a permit (except for ‘affluent households’, *rumah tangga mewah*), and there is no systematic monitoring data on either water quality or water balance by government agencies.[15] As a result of the over abstraction in the contained aquifer, the shallow groundwater system is no longer recharged by deep groundwater. The water resource research agency in the Ministry of Public Work (Puslitbang SDA) reports that, whereas the contained aquifer used to discharge into the shallow aquifer in the Northern areas of Jakarta, the condition is now reversed. The dropping of groundwater heads by more than 50 m in the contained aquifer have transformed North Jakarta into a recharge area for the deep groundwater system. As a result, there is a horizontal influx of seawater, with a parallel vertical flux of groundwater from the shallow to the deep layer (Kagabu et al., 2013). This process is happening through Northern areas, but is also shifting into Central areas where there are higher density of high-rise public and private buildings. Accordingly, shallow groundwater is being salinized in the North, and now Central, districts of Jakarta.

Increased salinity and wastewater contamination has led to, first, the reliance on bottled water. Prior to 2003, most residents in Jakarta reported groundwater as their drinking water source. After 2003 it shifted to piped water and hydrants (Balitbangkes, 2012; Prabaharyaka, 2014). In 2008 this shifted to bottled water,[16] and in 2012 65.5% of residents report reliance on bottled and refill water

[9] With 47% in western half, and 44% in the eastern half of the network customers provided with more than 0.75 atm. While 62% of customers in the eastern part of the city get 24 h service, only 45% do in the western (Badan Regulator Penyediaan Air Minum, 2014; 2015).

[10] Interviews with private drillers recorded in De Vries (2015) state that wells in the North or Central Jakarta need to be between 50 and 100 m to reach sufficient quality, whereas in East, West, and South Jakarta a depth of between 20 and 30 m is sufficient.

[11] At least 45% of Jakarta groundwater was contaminated by Coliform according to an estimate made by the National Development Planning Agency (Detik, 2013) and it was even higher (90%) according to the Regional Environmental Management Agency (Tribunnews, 2011).

[12] Governor Regulation No. 37 Year 2009.

[13] Following the stipulation of two regional taxation regulations (Regulation 18/1997 & Regulation 34/2000) by the central government.

[14] 7 million m^3/year versus 20–35 million m^3/year.

[15] The little research that has been done on the water balance for the unconfined layer estimates it as positive, based on volume of recharge from surface run-off and percolation of wastewater from septic tanks and soak pits (De Vries, 2015).

[16] Bottled water includes two main forms: branded bottled water (1–19 L) and non-branded refill water (*air isi ulang*). Branded bottled water is mostly produced by large-scale industries located outside of the city. Most of raw water source for refill water is spring water from terminals in the outskirts of the city and delivered with tanker trucks. After that it is treated through membrane-based filtration, and sold in 19-L containers from decentralized, independent small businesses, majority of which are unregulated.

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for drinking (BPS, 2013). Second, there is an increased demand for piped water by domestic users for other household uses. Valued more for its quantity than its quality, a formal connection to the piped water network provides the second lowest cost per unit option for bulk water supply, after shallow groundwater. As in North Jakarta, even very low income residents who buy bottled water from refill water kiosks use saline groundwater sources for whatever non-potable bulk uses possible in order to reduce expenses of buying piped water from neighbours or other informal providers. The increase in demand for piped water by low-income residents in locations where groundwater is saline, versus those locations where it is not, explains the availability of (non-saline) groundwater as a criteria for current pro-poor water supply interventions in Jakarta (Noordegraaf, 2016).

Perversely, where demand for formal access to the piped water network is high, inclusion is most limited. The lowest income residents who are most affected by saline shallow groundwater are also excluded from formal access to the piped network. Both the private sector providers and government regulators work to maintain an average tariff rate, meaning that higher tariff consumers balance subsidized tariff consumers.[17] Therefore, if higher-value consumers cannot shift their deep groundwater consumption to piped water, low income consumers are shut out. Compounding the exclusions which are generated by the average tariff calculation is the lack of infrastructure investment into both network maintenance and additional water sources. This under-investment in network maintenance is a by-product of the disappointing profits for the private sector.[18] Interviews with private operators and local NGOs in North Jakarta reported low income areas without water for two months in the fall of 2015, leaving private operators reluctant to connect additional consumers without being able to guarantee additional supply.

We now move to examine the role of groundwater in urban water services in two low income communities where the shallow sub-surface groundwater quality is very different. We examine equity of access to water in each community in terms of differences in source, volume, and cost of water between income levels. Our comparative analysis of the differences between incomes between the two research sites seeks to answer the question of how groundwater quality influences equity of access.

5. Water access, equity, and groundwater quality in low income neighbourhoods in North and East Jakarta

This section presents the results of a household survey conducted in 2014 in the two low-income neighbourhoods of Penjaringan in North Jakarta and Gedong & Ciracas in East Jakarta. We describe the survey results for Penjaringan and Gedong & Ciracas and document the link between groundwater viability and equity of water access use by highlighting the most striking differences and commonalities between the two sites.

5.1. Penjaringan: household water supply sources across income levels

Where subsurface groundwater quality is poor, as in Penjaringan, residents rarely utilize it for bulk water supply. None surveyed reported groundwater use, although we observed some residents outside of the survey area accessing unprotected shallow wells for non-potable uses. Given the absence of viable groundwater, all residents are connected formally (directly) or informally (indirectly) to the piped network. Table 1 shows the numbers for in-house access via a formal connection climb from 11.76% in Q1 to 88.24% in Q5, indicating that the higher the income category, the more likely a household is to be connected directly to the piped network.

In the absence of viable groundwater, those without a piped-water connection buy bulk water from their neighbours. This is an informal practice colloquially called *nyelang*[19]. As increasing income implies more piped water access, the practice of *nyelang* decreases with higher income residents: in Penjaringan, a majority (88.23%) of poorest residents buy water from their neighbours, as compared to only 11.76% of the most well-off residents in our sample (Table 1). Since *nyelang* is an informal practice based on person-to-person agreement (e.g. rough estimation of certain amount of payment in exchange for a period of water transfer), there is no fixed pricing, resulting in a wide range of per-unit price from IDR 13,000 to IDR 89,000 per m^3. This is much higher than the average price for piped water via a formal household connection, which ranges from IDR 1050 to 9800 per m^3 (see Table 5). Therefore, not surprisingly, on average poorer households spend a proportionately larger share of their monthly income on water (Q1: 5.89%; min. 2.56% max. 14%) than better-off households (Q5: 3.73%; min. 0.73% max. 6.34%).

Even when connected, very few households rely on the piped network alone: instead, most respondents across all income quintiles combine multiple water sources. Most notably, the combination of branded bottled water with either resold *nyelang* water (Q1, Q2, and Q3) or with in-house piped water (Q4 and Q5) is most prevalent. We find that only 5.80% of households in Q1 drink piped water from their neighbours but 17.65% of households in Q5 drink piped water from their own connections (see Table 1). The remaining households are making use of alternative drinking water sources, even if it comes at a higher price. Since branded bottled water and *nyelang* water are two of the most expensive water sources in terms of per-unit price, the poorest residents rely on the two most expensive water sources (see Table 1).

In volumetric terms, indirect piped-water purchase contributes to the poorer households' disadvantage: due to technical constraints, such as the maximum size of water storage against size of housing, in the lowest quintile, the average monthly volume obtained from water resale is around 4.5 m^3. This is a lot lower than the 15 m^3 of average monthly piped water consumption reached by those with a direct piped water connection on their premise. Likewise, when comparing total water consumption in volumetric terms, numbers increase drastically with socioeconomic level, ranging from an average of 19.72 m^3 in Q1 to 113.44 m^3 in Q5.

To summarize, where groundwater viability is low as in Penjaringan, the majority of upper income residents access water from formal piped connections and purchase bottled water for drinking. The majority of lower income residents access water via an informal connection from their neighbours and purchase bottled water for drinking. Comparatively, higher income households consume more water, and pay - proportionately in terms of income - less than the poorest households. What is more, highest income households have more access to the lowest per unit cost source (formal piped water connection) than do poorest households.

[17] Pro-poor water supply projects now implemented under international development programs for poorest areas of the city set a tariff at cost-recovery rate, approximately three times higher than the tariff bracket for low income residential customers (Noordegraaf, 2016).

[18] Physical losses from the piped water system have only decreased by 4% over the last 11 years, going from 45% in 2003 to 41% in 2013 (Badan Regulator Penyediaan Air Minum, 2014).

[19] *Selang*, adopted from Dutch word *slang* meaning 'hose', is used as a device that transfer the water from a house to another in a dense settlement.

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Table 1
Summary of water source combination in Penjaringan; in %.

	Q1	Q2	Q3	Q4	Q5
Piped Water	0.00	11.76	17.65	5.88	17.65
Piped Water + Branded Bottled Water	5.88	17.65	41.18	58.82	64.71
Piped Water + Refill Water	0.00	5.88	5.88	5.88	5.88
Piped Water + Branded Bottled Water + Refill Water	5.88	0.00	0.00	5.88	0.00
Total HHs connected (direct)	**11.76**	**35.29**	**64.71**	**76.46**	**88.24**
Nyelang Water	5.88	23.53	0.00	5.88	0.00
Nyelang Water + Branded Bottled Water	52.94	35.29	23.53	11.76	11.76
Nyelang Water + Refill Water	23.53	5.88	11.76	5.88	0.00
Nyelang Water + Branded Bottled Water + Refill Water	5.88	0.00	0.00	0.00	0.00
Total HHs connected (indirect)	**88.23**	**64.70**	**35.29**	**23.52**	**11.76**

5.2. Gedong and Ciracas: household water supply across income levels

Gedong & Ciracas have similar trends in access to piped water: higher income residents are more likely to have a formal connection than lowest income residents, 62% (Q5) vs. 35% (Q1). This relationship is reversed for groundwater: 70% of lowest income residents rely on access to shallow groundwater vs. 38% of highest income residents (see Table 2). The practice of water resale does not exist, as the poorest households, who cannot or chose not to connect to piped water, access groundwater. More than 70% of households in the lowest quintile have an electric pump on their premise and consume on average 39.5 m^3 per month for less than IDR 20.000 (see Table 2). However, reliance on groundwater is not limited to the lowest income quintile, as all residents across income groups reported groundwater use, with percentage of users in Q2 and Q4 similar to the lowest income group. Moreover, the average monthly consumption of groundwater for all income levels is higher than average monthly consumption of piped water: groundwater consumption for Q1-Q5 ranges from 40 to 50 m^3/month and piped water consumption from 15 to 42 m^3/month (see Tables 3,4).

We also observe higher prevalence of using a single water source for bulk supply and drinking, which corresponds with higher access to both piped water and groundwater. In Gedong & Ciracas, 35% of households in the lowest quintile have a piped water connection on their premise, but only 5% use it for drinking water. In the highest quintile, no household drinks piped water, although 61.9% are connected to the network. In comparison, more residents utilize groundwater for drinking in Q1 (25%) and even some of the higher-income households in Q5 (9.52%) drink from groundwater too. In short, in all quintiles, fewer residents rely solely on piped water (0–9.5%) for both bulk and drinking water, as compared to households only relying on groundwater (9.5–25%). This suggests that there is a lower trust in piped water and a higher trust in groundwater, even though it may require boiling before consumption[20]. This does not diminish the importance of bottled water consumption as 70% of the poorest residents purchase bottled water and more than 90% of the households in the fifth quintile.

When comparing financial burdens concerning water access - as in Penjaringan - poorer households in Gedong & Ciracas spend a larger share of their monthly income on water than those in the higher income quintiles. While households in Q1 spend 4.65% of their income on water every month (min. 0.17%; max. 18.54%), households in Q5 spend only 2.28% on average (min. 0.03%; max. 8.39%). However, these numbers are lower than those observed in Penjaringan in each of the income quintiles (see Table 5). Likewise, at 93.38 m^3, households falling into the highest income quintile in Gedong & Ciracas consume almost twice as much water as those in the lowest. And yet, at 54.89 m^3 average monthly water consumption, the poorest households in Gedong & Ciracas are better off than their counterparts in the North. The existence of viable subsurface groundwater sources enables significantly higher volumetric consumption in all quintiles.

5.3. Comparative analysis: groundwater and inequalities of access to urban water services

Trends in Penjaringan as well as Gedong & Ciracas reflect broader configuration of urban water services across Jakarta, where all residents combine water sources across income levels. Where subsurface groundwater is still viable in terms of quality and quantity, it becomes a key supply for domestic use. Used in combinations with other sources its role in relation to piped water supply depends on the quality and quantity of piped water access. When groundwater is abundant, there is reduced bottled water consumption alongside higher trust in groundwater—which implies that the residents perceive it as safer to drink than piped water. This is risky in terms of health and hygiene, as there is always a chance subsurface groundwater contaminated from septic tanks' leakage or wastewater. Demand for piped water supply is highest where shallow groundwater quality is poorest – across all income levels. Groundwater remains the key water source for poorer residents, but the same affordability also keeps upper income residents attached to groundwater use, even with larger volume consumption.

Clearly, access to groundwater of sufficient quality for non-potable uses influences the sources, volumes, and costs of household water supply. Residents who live in areas with adequate groundwater quality and quantity, be it poor or rich, are likely to use groundwater for bulk water supply. What is more, they do so in a surprisingly equal manner. Differences between volumetric consumption of groundwater are much more equal than for piped water and differences in proportion of income spent on water are less between the richest and the poorest. Likewise, households across income levels exploit groundwater where possible, indicating that socioeconomic class is not a decisive factor influencing abstraction. In contrast, for piped water, differences in consumption between lowest and highest income categories are substantial for both research sites: 15.0 m^3 to 41.3 m^3 per month in Penjaringan and 15.1 m^3 to 42.7 m^3 per month in Gedong & Ciracas.

In addition, our results confirm the growing importance of bottled water in the urban drinking water context. In our sample, most households use bottled water. With 82.35% in Penjaringan and 76.92% in Gedong & Ciracas, bottled water is the most used water source across survey sites and quintiles. In this context, we

[20] In an interview, a man showed how he drank groundwater directly from the tap. He then explained how his family had been drinking groundwater for more than three decades.

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Table 2
summary of water source combination percentage in Gedong & Ciracas; in %.

	Q1	Q2	Q3	Q4	Q5
Piped Water	5.00	9.52	4.76	0.00	0.00
Piped Water + Branded Bottled Water	10.00	4.76	33.33	19.05	28.57
Piped Water + Refill Water	10.00	14.29	14.29	14.29	23.81
Piped Water + Branded Bottled Water + Refill Water	5.00	9.52	0.00	4.76	9.52
Groundwater	25.00	14.29	28.57	14.29	9.52
Groundwater + Branded Bottled Water	25.00	28.57	14.29	42.86	23.81
Groundwater + Refill Water	10.00	14.29	4.76	4.76	4.76
Groundwater + Branded Bottled Water + Refill Water	5.00	0.00	0.00	0.00	0.00
Piped water + Groundwater	0.00	4.76	0.00	0.00	0.00
Piped Water + Groundwater + Branded Bottled Water	5.00	0.00	0.00	0.00	0.00
HHs connected to the piped network	**35.00**	**42.85**	**52.38**	**38.10**	**61.90**
HHs using groundwater	**70.00**	**61.91**	**47.62**	**61.91**	**38.09**

Table 3
Average volume of water consumption in both research sites; in litres.

	Penjaringan				
	Q1	*Q2*	*Q3*	*Q4*	*Q5*
Piped Water	15,000.00	11,833.33	32,272.73	31,307.69	41,333.33
Nyelang Water	4555.50	5435.45	4770.00	4462.50	11,820.00
Groundwater	0.00	0.00	0.00	0.00	0.00
Branded Bottled Water	81.18	122.44	86.36	270.38	287.92
Refill Water	76.00	133.00	205.67	133.00	60,000.00
	Gedong&Ciracas				
	Q1	*Q2*	*Q3*	*Q4*	*Q5*
Piped Water	15,142.86	18,416.67	23,210.00	14,875.00	42,692.31
Nyelang Water	0.00	0.00	0.00	0.00	0.00
Groundwater	39,500.00	46,350.00	33,954.55	60,115.38	50,250.00
Branded Bottled Water	95.00	112.94	110.55	110.20	149.29
Refill Water	155.17	292.13	209.00	133.00	285.86

may invoke popular association of type of bottled water with socioeconomic class: the assumption goes that branded bottled water is for the more affluent classes, while non-branded water is for the poor. However, this association is challenged by our results. In our sample, the proportion of Gedong & Ciracas‘ residents that combines piped water and non-branded refill water climbs from 10.00% in the first quintile to 23.80% in the fifth quintile. Here, where groundwater is viable, consumption of bottled water increases with income. However, in Penjaringan it is the reverse, as the lowest income residents have a higher reliance on bottled water: the percentage of residents that drink bottled water in combination with bulk water from water resale is decreasing from 52.94% in Q1 to 11.76% in Q5.

Bottled water can be understood in relation to other sources of drinking water, mainly piped water and groundwater, and the threat of wastewater contamination. It is a drinking water source that may avoid risk of contamination, particularly in the case of sewage leakage/seepage into the piped water network and groundwater sources. However, increased consumption of bottled water means higher water expenditure and increased financial burden for poorest income residents, not to mention the increased plastic waste generation from the packaging. Nevertheless, there is no clear-cut correlation between bottled water use and progression of socioeconomic quintiles. Both branded bottled water and non-branded refill water are consumed across income quintiles and research areas.[21]

Table 4
Average price per unit water sources (averages).

Water source	Price (USD/m^3)
Bottled water	57.90
Refill water	18.90
Nyelang	2.20
Piped water[a]	0.40
Groundwater[a]	0.07

[a] excl. installation costs.

Table 5
Summary of average monthly water expenditure as share of income; in %.

	Penjaringan					Gedong & Ciracas				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
Average	5.89	4.69	5.14	4.71	3.73	4.65	3.87	2.65	2.04	2.28
Min.	2.56	1.95	1.36	1.26	0.73	0.17	0.07	0.14	0.17	0.03
Max.	14.00	9.47	21.88	9.68	6.34	18.54	10.83	6.88	5.17	8.39

6. Discussion and conclusion: access to groundwater and social inclusion

This paper reviewed the concept of inclusive development in relation to the MDG and SDG for increasing access to water, specifically for urban areas. We analysed how it conceptualizes relations between ecological sustainability and social inclusion, and identified how it can be applied to better acknowledge the relationship between sustainability and inclusion - or environmental conditions and equity of access - to urban water. We argued that this relationship is particularly relevant given the realities of water

[21] With one exception: In Q5 in Penjaringan only one sample of refill water consumption was recorded.

access in cities of the global South, where inequities in access to urban water services may be grounded in conditions of deep ecological vulnerability.

In applying the concept of inclusive development to look at relations between ecological sustainability and equity of access to urban water services in Jakarta, we documented that the role of groundwater in influencing equity and sustainability of urban water services has been ignored. We identified two key gaps. First, analyses of equity of access to water in Jakarta ignore groundwater. While groundwater is used by most residents, studies have not considered equity of access to different quality and quality of supply between the contained and uncontained aquifer sources, or within each source. Second, the linkage between ecological degradation of groundwater systems and equity of access to piped water has been ignored. As a result, those who could afford to opt out of the piped network and rely on private supply from the contained aquifer means that those who need to opt in - cannot. This is both because the over-abstraction of water from the contained aquifer has salinized the shallow groundwater system, but also because reliance on groundwater for high volume, high value consumers have prevented the investment into network extension and rehabilitation.

The results of the household survey demonstrate the role of environmental sustainability - salinization of the contained aquifer - on achieving goals of social inclusion. Differences in volumes of water consumed, and prices paid, between income groups is less pronounced in areas where shallow groundwater is not highly saline. In contrast, in the Northern part of the city, where salinity of groundwater makes it unviable even for non-potable uses, inequity in access is perversely exemplified by the high prevalence of water resale by higher-income households to poorer ones at exorbitant prices much higher than the tariffs for piped water. As the quality of groundwater - and piped water - is compensated through the increasing reliance on bottled water for drinking, it is lack of access to large volumes of non-potable water which determine water poverty.

For Jakarta, but also for the majority of cities in the global South without universal access to piped water, achieving inclusive development of the city's water services will require attention to equity of access to services across different types of providers, and to different sources. Undoubtedly the role of provision through centralized piped system is important in this. However, so too is the water which circulates outside the formal network. This demonstrates the urgency of reassessing the way urban water access is conceptualised in the current international development policy and SDG measurements. It becomes clear that a singular focus on access to piped water runs the risk of neglecting important alternative dimensions beyond water infrastructures through which exclusion from access takes shape in cities of the global South. For the concept of inclusive development - and for the implementation of SDGs - the results highlight that social goals in relation to water access require more attention to ecological conditions.

In conclusion, we suggest that approaches to increase both equity of access, and environmental sustainability of urban water services need to be more inclusive. Specifically, an inclusive development approach should build on the vitality and multiplicity of Jakarta's urban water services. The diversity of water services is inherent to the fabric of the Southern city, and despite policy announcements and reforms, and models imported from elsewhere, continue to survive and contribute to the functioning of cities (Jaglin, 2014). Policy makers, activists, and academics need to pay more attention to the heterogeneity of urban water services delivered outside and or alongside a centralized piped network in order to make access more equitable and more environmentally sustainable.

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