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Editorial
Improving water governance in Kathmandu: insights from systems thinking and behavioral science

Dale Whittington[a] and Wu Xun[b]

[a]Corresponding author. Departments of Environmental Sciences & Engineering and City & Regional Planning, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA; Global Development Institute, University of Manchester, Manchester, UK; and Institute of Water Policy, Lee Kwan Yew School of Public Policy, National University of Singapore, Singapore
E-mail: Dale_Whittington@unc.edu

[b]Division of Public Policy, Hong Kong University of Science and Technology, Hong Kong

Introduction

At the time this introduction to the special issue is being written (September 2019), the global water and sanitation community is wrestling with the policy implications of two important realizations. The first is that it is quite possible for cities to actually run out of water – for the piped network to run dry. In the spring of 2018, the world watched the unfolding water crisis in Cape Town, South Africa. The Cape Town water utility's website showed a countdown to day zero when the pipes would run dry in a modern global city of 3.7 million people. Cape Town was just weeks away from this calamity when heavy rains arrived to raise the reservoir level in the city's water supply system. While the rains offered a reprieve, the world had been given a glimpse of the challenges of this emerging era of water scarcity (Muller, 2017). Rapid population and economic growth, coupled with rural to urban migration and climate change, is increasing the threat of water scarcity in many cities in the Global South. Cape Town barely avoided having its piped network run dry, but this near miss should not make us overconfident in our ability to manage water scarcity.

The second realization is that in many locations, basic water and sanitation interventions do not result in the large public health improvements that many water and sanitation professionals had hoped (Arnold *et al.*, 2018; Coffey & Spears, 2018; Cumming & Curtis, 2018; Brown *et al.*, 2019; Pickering *et al.*, 2019; Whittington *et al.*, 2020). The evidence comes from a series of recent randomized controlled trials that evaluated water and sanitation interventions in the Global South[1]. However, we do know

[1] These new findings are, in fact, consistent with much older evidence from observational studies (Esrey, 1996)

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the water and sanitation intervention that will result in dramatic public health improvements: modern housing connected to a piped water distribution network with 24/7 supply of potable water and piped sewerage collection (Cutler & Miller, 2005). What is not fully appreciated by water and sanitation professionals is how expensive modern housing and piped water and sewer collection actually is.

Households living in modern housing demand four main water-related services: (1) potable water for drinking, cooking, and dish washing; (2) water for bathing; (3) water for clothes washing; and (4) water for feces and urine disposal. In many locations, they would also like water for outdoor gardening or lawn watering. The costs of plumbing and appliances embedded in the cost of modern housing are roughly twice the cost of the public infrastructure needed to supply potable water and carry away and treat the wastewater[2]. The magnitude of these investments required inside modern housing units in order to carry out these four activities is embedded in the cost of the housing and is often invisible to water and sanitation professionals.

However, many low- and middle-income households in cities in the Global South, such as Kathmandu, simply cannot afford these embedded costs of using water in their homes even if they have access to heavily subsidized piped water and sewer services. Some have housing units with indoor kitchens only, with pit latrines outdoors. Others have kitchens and showers, but continue to defecate outside the housing unit. Some housing units have kitchens, showers, and toilet indoors, but wash clothes at facilities outside the home. As incomes grow, households face a complex set of tradeoffs between spending their limited budget on water and sanitation services inside and outside the house and between improved water and sanitation facilities and other attributes of their housing unit (as well as other budget priorities).

Similarly, in cities like Kathmandu, water utilities face complex choices with respect to what kinds of water and sewer services should be provided to houses in neighborhoods with different types of housing. There is little point in providing sewer networks to neighborhoods where households do not have piped water inside their housing units, although this does happen. Similarly, making large investments in public toilets and public taps is likely ill-advised in neighborhoods where households are rapidly investing in modern housing.

As water and sanitation professionals work out the implications of these two realizations on policy and planning for water and sanitation improvements in the Global South, they will require an in-depth knowledge of local housing, water, and sanitation conditions, as well as a nuanced understanding of how households prioritize improvements in housing, water, and sanitation. The papers in this special issue about Kathmandu illustrate the types of analyses of local conditions that are needed. Like Cape Town, Kathmandu holds many lessons for the global community about households' responses to water scarcity and the management of water and sanitation services in periods of rapid urbanization and climate change.

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[2] For purposes of illustration, if the costs per cubic meter of water and wastewater services are US$5 per cubic meter and a household uses 15 cubic meters per month, the cost per household for the public water and sanitation infrastructure would be US$75 per month. If the costs of water embedded in housing are double the public infrastructure costs, they would be about US$150 per month, resulting in a total cost of using water in a modern housing unit of US$225 per month for these four water-related activities in the home or apartment: (1) potable water for drinking, cooking, and dish washing; (2) water for feces and urine disposal; (3) water for bathing; and (4) water for clothes washing. The costs of public water-related infrastructure are typically heavily subsidized, so households rarely pay the full costs of US$75 per month for the public infrastructure. Subsidies for modern housing, however, are more limited. Many households do pay the full costs of US$150 per month for the plumbing and appliances needed to carry out their desired water-related activities inside the home.

Background: an overview of water and sanitation conditions in Kathmandu

Over the past three decades, Kathmandu has experienced rapid population growth due to massive in-migration that resulted in part from political turmoil and civil war. However, there has been little investment in Kathmandu's municipal water supply system inside the Kathmandu Valley. Thus, the gap between the water supply needs of the population and the ability of the municipal water supply system to meet these needs has been growing. In 2014, about 90% of households interviewed in one study in Kathmandu had a private connection to the public water supply system, but most received little water (Gurung *et al.*, 2017).

Planning for a major infrastructure project to bring new water supplies to Kathmandu – the Melamchi Water Supply Project (MWSP) – started in the 1980s. The project involves an interbasin water transfer of about 170,000 cubic meters per day to be delivered through a 26-km long tunnel through a mountain. The construction of the Melamchi tunnel did not begin until 2009. The project experienced further delays due to problems with multiple foreign contractors. In 2019, residents of Kathmandu have still not received any additional water supplies from outside the Kathmandu Valley. Hopefully, new water supplies will reach Kathmandu soon and alleviate many of Kathmandu's water supply problems (Asian Development Bank, 2013, 2015).

Conditions in Kathmandu offer a unique window on what happens when investments in the piped water supply infrastructure in a large, rapidly growing city in a low-income country are delayed for decades. Households in Kathmandu have responded in two main ways to the increasing urban water scarcity. First, many households have drilled private wells to supplement their water supply from the Kathmandu municipal water utility's (Kathmandu Upatyaka Khanepani Limited – KUKL) piped network and, as a result, groundwater levels are falling in the Kathmandu Valley. Second, households began purchasing increasing quantities of water from a new, rapidly growing private water vending industry. In effect, the private sector investment filled part of the water shortfall that resulted from delays in the public investment in the municipal water supply system.

In 2014, 85% of households in Kathmandu were using two or more water sources. Approximately 30% of household water is supplied from private connections, 29% from private wells, 20% from tankers, 8% from public wells, 6% from public taps, and the rest (7%) from neighbors, bottled water (20-l jars), stone taps, and surface water. On average, households self-supplied or purchased about 85 liters per capita per day (lpcd) in the rainy season and 69 lpcd in the dry season (Gurung *et al.*, 2017). However, such coping strategies have entailed high costs to households (Whittington *et al.*, 2002; Pattanayak *et al.*, 2005). Average household coping costs more than doubled in real terms over the period from 2001 to 2014, from US$5 to US$12 per month, measured in 2014 prices (Gurung *et al.*, 2017), as households struggled to find individual solutions to deal with the problems of Kathmandu's poor quality, unreliable piped water supply system.

Challenges in water governance for water supply augmentation projects

There are high hopes that the MWSP will be a savior for the chronic water source management problems currently facing Kathmandu. However, it should not be assumed that the benefits of the project will be easy to achieve or that they are inevitable. The effectiveness of water supply augmentation projects, such as the MWSP, hinges critically upon the policy framework, institutional arrangements, and management practices (Saleth & Dinar, 1997; Grafton *et al.*, 2015). Water scarcity in many cities in developing countries, such as Kathmandu, is often deeply rooted in deficiencies and misalignments in water governance. Therefore, unless such deficiencies and misalignments are tackled head on, the benefits of water supply augmentation projects, such as the MWSP, may be much smaller than anticipated.

There are several potential routes through which this could happen. First, while water supply augmentation projects increase the amount of water available in the system, the efficiency of the water distribution system will play a key role in determining the size of the ultimate gain from the increased water supply. In many cities in developing countries, the increase in water supply may not be converted to an improvement in the financial situation of the water utility if deficiencies in water tariff systems remain untackled. As a result, limited or no investment may be made to improve the efficiency of the water distribution system by reducing non-revenue water (Sahin *et al.*, 2016).

Second, water scarcity in many cities in developing countries is often accompanied with a high level of inequity in water allocation among households with different social–economic characteristics (Bakker *et al.*, 2008). The existing patterns in water supply provision are dictated by political, institutional, and geographical factors that will not be altered automatically when water supply at the system level is augmented. As a result, the inequity in water allocation may actually increase if some households receive much more improvement in the services they receive after the completion of the water supply augmentation project than others.

Third, the augmentation in water supply through publicly funded infrastructure projects, such as the MWSP, may crowd out informal sector investment in urban water supply. In many cities in developing counties, water vendors play a critical role in water supply and distribution as piped water systems fail to provide adequate services to households (Whittington *et al.*, 1991; Kjellén & McGranahan, 2006). Without appropriate water tariffs in place to signal the real costs of the piped water and sanitation services, an increase in new water supplies may crowd out informal sector actors, such as water vendors, who often provide a critical backstop, reducing system vulnerabilities in water supply delivery.

Fourth, the water supply augmentation may accelerate a transition toward high household water consumption patterns that may not be sustainable in the long run. In the case of Kathmandu, for example, more households can be connected to the piped water system after the Melamchi project becomes fully operational, and households will use more water when the current water rationing is reduced. Fueled by low water tariffs, the water supply augmentation may unleash a significant increase in water use, which may aggravate the future water supply and demand balance and further complicate decisions about capacity expansion investments.

An appropriate policy framework, institutional arrangements, and management practices must be in place to avoid such pitfalls, but in many cities in developing countries, the weakness in water governance is a leading cause for water scarcity in the first place. While political opposition is often regarded as the main obstacle for changes in the policy framework, institutional arrangements, and management practices, the analytical challenge is equally daunting (Kandulu, 2013). Problems in urban water supply can be considered as 'wicked problems' which are subject to complex interdependence relationships among a diverse range of factors, and their resolution typically requires behavioral changes by both households and water utility managers (Lach *et al.*, 2005; Grafton, 2017).

Systems thinking can be critical in dealing with wicked problems. While water utility managers focus their work on piped water systems, their decisions and actions have significant impacts on the entire water system, including groundwater and the informal sector (Kjellén & McGranahan, 2006; Foster & van Steenbergen, 2011). The changes that will result in the whole system from the water augmentation project need to be analyzed; otherwise, achievement or progress made in one area may aggravate problems in other areas, a defining characteristics of wicked problems.

Behavioral science can also make significant contributions to improving water resource management in developing countries (Correia & Roseta-Palma, 2012). While most applications in this area so far have been focused on nudging and water-saving behavior (Merrett, 2002; Brick *et al*., 2018), the behavioral insights may also make a significant contribution to the tariff designs and water allocations (Nauges & Whittington, 2019).

Summary of papers in the special issue

The six papers in this special issue reveal the challenges posed by rising water scarcity and the resulting housing-water tradeoffs in all of their complexity. In the first paper in this special issue, Chinnasamy and Shrestha note that in recent years KUKL, private households, and water vendors have been extracting more groundwater from the groundwater aquifer in the Kathmandu Valley than its sustainable yield. Their results show that the total annual groundwater extraction for the Kathmandu Valley is about 69 million cubic meters annually and that the drawdown of the deep aquifer has been on the order of 15–20 m since the early to mid-1980s.

Chinnasamy and Shrestha conclude that there has been substantial overexploitation of groundwater resources while Kathmandu has been waiting for the arrival of new water supplies from outside the Kathmandu Valley. The authors believe that when the MWSP is finished, it should provide sufficient new water supplies to reverse this decline in groundwater depletion. Their results suggest that the overexploitation of the groundwater resource in the Kathmandu Valley during the several decades spent waiting for out-of-basin supplies to arrive may, in fact, have been a reasonable strategy in the face of water scarcity. But for other cities facing water scarcity, this strategy may not be feasible, because out-of-basin supplies may not be available or affordable.

In the second paper, Thapa and his coauthors also address the groundwater situation in the Kathmandu Valley. They assess the spatial distribution of groundwater availability under five scenarios that represent conditions before and after the implementation of the MWSP. They use a numerical groundwater flow model with available local data and analyze water demand, supply infrastructure, changes in the hydraulic head (i.e. groundwater levels), groundwater pumping rates, and aquifer characteristics.

During the period 2003–2014, Thapa *et al*. find that the average hydraulic head in the wells in the valley declined from 2.57 meters below ground level (bgl) (0.23 meters per year) to 21.58 meters bgl (1.96 meters per year). Their model simulations suggest that changes in the average hydraulic head would range from +2.83 to +5.48 m at various stages of the MWSP implementation and −2.97 m for increased pumping rates if the MWSP was not implemented. The authors argue that the regulation of groundwater pumping is important for achieving the recovery of the valley's groundwater levels. They suggest that appropriate policy options could include groundwater extraction charges. They argue that such extraction charges should differ by location depending on the availability of new and existing public water supply in different areas. Based on their modeling work, the authors believe that the completion of the MWSP is an important positive step on the Kathmandu water development path.

In the third paper, Raina and coauthors paint a detailed picture of the complex water vending industry that has arisen in Kathmandu to provide households and businesses with water supplies to meet growing water demands. Their research shows that at the time of their study (2014), water vendors in the

Kathmandu Valley operated a diverse, heterogeneous group of businesses. There was a supply chain with two main products: bulk water and bottled drinking water. Transactions occurred in four main markets: two upstream markets (between water source owners and tanker trucks and between bottled water vendors and distributing vendors) and two consumer markets (between tanker truck vendors and consumers and between distributing vendors and consumers). Approximately 20 per cent of the water that households and businesses use in the Kathmandu Valley is delivered by this water vending supply chain.

However, Raina and coauthors show that these water vending services are not cheap. In the dry season, end users of vended water (both tanker truck water and bottled water) pay approximately 3.4 times as much for vended water as they pay for water from the public piped water distribution system (which is heavily subsidized). Nevertheless, the authors concluded that the portions of the water vending supply chain that they examined were all quite competitive.

The large amounts of money flowing through the water vending supply chain illustrate the revenue potential associated with improving services offered by the public piped distribution system. When the MWSP is completed, KUKL should be able to improve the quantity and quality of the water supplied through the piped water system. The authors' results suggest that most households in Kathmandu are already paying much more to water vendors than to KUKL, and that the completion of the MWSP offers KUKL a rare opportunity to raise water tariffs simultaneously with the delivery of improved piped services.

In the fourth paper, Chindarkar and her coauthors analyzed the relationship in Kathmandu between household time allocation, the reliability of tap water, and water consumption patterns under the current conditions of intermittent supply from the public piped system. Unsurprisingly, they find that time spent on productive activities is negatively correlated with time spent on water collection for the person most responsible for water collection in the household. Yet surprisingly, they also find that when tap water connections become more reliable, households spend more time for collecting water. As a consequence of this increased time investment, households consume more water both from their private tap and from all sources. Because an increase in reliability leads to an increase in collection time inside the home, the authors argue that when supplies are intermittent, it is important for the public water provider to arrange water delivery schedules to minimize disruptions that can affect work, leisure, and other activities. For cities with intermittent supply, the authors conclude that more research is needed to understand how individuals and households prioritize different activities in order to identify which times of day would be the most conducive to water collection.

In the fifth paper, Leong and Tan use qualitative research methods to explore the narrative structures that residents of Kathmandu use to describe their emotions about the delay in the completion of the MWSP and the consequences for their daily lives. Despite the long delay in the completion of the MWSP and the high cost this delay imposes on the public, economic and social life in Kathmandu continues to be vibrant. Based on 55 interviews conducted in Kathmandu in 2016, Leong and Tan explore people's subjective narratives about the delayed MWSP, in particular the self-reported perceptions of their resilience. Leong and Tan argue that people's ability to cope with adversity engenders the self-perception of resilience. They examine the paradox that the act of coping with water scarcity may *itself* create a false sense of resilience among the population.

Leong and Tan uncover three main themes in people's narratives. First, people in Kathmandu clearly understand that there is a high cost to the current situation. Participants were often acutely aware of the monetary cost of obtaining bottled and tanker water, and that the piped water supply has become more and more intermittent. Their respondents could easily cite figures and compare their coping costs with household income. Respondents also described changes to daily routines to obtain water and heated arguments at public taps. Yet despite the high costs, participants have adapted, accepting these costs as part of their daily lives.

The second theme to emerge from Leong and Tan's analysis is people's feeling that the current situation is unsustainable, and that the problem has (and will) worsen over time. The third theme relates to a perception of incompetence on the part of the government and generates the most emotional responses. Participants expressed anger at the incompetence and corruption within municipal government and KUKL, and bitter resignation at the lack of progress on the issue of water supply. Leong and Tan's research thus emphasizes the interrelationships between self-perceptions of resilience, the incremental worsening nature of the water scarcity problem, people's perceived ability to pay increasing coping costs, and a lack of confidence in government capacity.

In the sixth paper in this special issue, Suwal and coauthors examine the preferences of households in Kathmandu for different attributes of the tariff structure. They note that only rarely do water utility managers have information about what types of tariff structures households prefer. These authors find that many households express a preference for an increasing block tariff when it is described to them. However, when they are asked about what a fair water bill would be for a specified quantity of water, households support a tariff structure that determines household water bills as a linear function of water use, not a tariff structure that results in household water bills increasing as a nonlinear function of water use, such as an increasing block tariff. These results suggest that after the MWSP is finished and new water supplies arrive in Kathmandu, utility managers may have considerable latitude in choosing a tariff structure other than an IBT. A post-Melamchi tariff structure should be able to focus on objectives, such as cost recovery and economic efficiency, and allow affordability concerns to be addressed by customer assistance programs (Cook *et al.*, 2020a, 2020b).

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