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The pain of water: a household perspective of water insecurity and inequity in the Kathmandu Valley

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Abstract

This paper draws on participatory research with 47 household water managers over the dry, pre-monsoon, and monsoon season, alongside expert knowledge of water management in Nepal's Kathmandu Valley. Doing so, it presents the perspectives of water managers to highlight three dimensions of water security that existing approaches often overlook. First, experiences of water security vary greatly between households over the year, even within a relatively small geographic area. Second, social connections and landownership play an important role in mediating these experiences. Third, coping with poor water supply places a burden on certain household members. This paper argues that addressing water inequities and insecurities demands research, development and policy responses to look beyond the main pipe network and engage with the variety of ways in which households secure water.

Keywords: Himalayan towns; Household water security; Kathmandu Valley; Qualitative research; Urban water

Introduction

Uma, a middle-aged woman, dreams of leaving Nepal's Kathmandu Valley to be in a village where there is flowing water. Like many residents, she summarizes the city's situation as '*paani ko dukkha*': a painful struggle for water. After her marriage she moved from the periphery of the Valley to a central urban area, Patan; often also called Lalitpur, Patan is just south of the capital, Kathmandu. Like most

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residents of the Valley, she faces growing water insecurities. Although her neighbours receive tap water, Uma does not have access to the main water grid system. About six times a day she walks to a community-run water source to fetch 15 litres of water each time; for 90 litres of water, she pays 80 Nepali rupees (NPR) (around 1 US dollar). This is a challenging task; as she explains, 'even when it rains, I have to go and get water and get all drenched. I have to carry water and walk. Now I am getting older and weaker.' Uma is worried because groundwater is increasingly scarce and she lacks affordable alternatives.

As stream flows and groundwater levels become more variable, over-tapped and contaminated (Salike & Fee, 2015; Saraswat *et al*., 2017), urban residents like Uma worry about the future habitability of the Kathmandu Valley. Already, many households are not meeting their water needs: a recent study shows that the median total per capita water consumption in Kathmandu's households is below the United Nation's mandate of 50 litres per person per day for personal and domestic use (Raina, 2016). Moreover, a 2017 evaluation of water security in Kathmandu found that the public water company, Kathmandu Upatyaka Khanepani Limited (KUKL), provided much less than the 135 litres per person per day that the study recommends for economic growth (Thapa *et al*., 2018). In the meantime, research continues to show that most water sources contain pathogens, heavy metals, ammonia, nitrates and other contaminants due to poor sewage and waste disposal (Udmale *et al*., 2016). As climatic changes impact rainfall dynamics (Salike & Fee, 2015) and current landcover changes decrease the Valley's recharge potential (Shrestha *et al*., 2012), institutions face serious water management challenges to ensure residents meet their needs now and in the near future.

Peer-review literature, policy documents and institutional reports about the Valley's water situation tend to rely on data from surveys of households and water sources. While this quantitative perspective is critical to understanding overarching patterns of water supply, use and quality, there is a lack of understanding about the variety of ways in which people address water insecurity in their everyday lives. These diverse stories of resource access in everyday life are important for understanding both the drivers of resource insecurity and potentials for transformation at multiple scales (Hulme, 2011; Wutich & Brewis, 2014; Loftus, 2015; Ranganathan & Balazs, 2015; Carey *et al*., 2016; Furlong & Kooy, 2017).

As such, this paper presents household perspectives of water security. It does so by drawing on the experiences of 47 household-level water managers over 2017's dry, pre-monsoon and monsoon seasons. These participants all live relatively close to each other in newer and older areas of Patan. The goal in recruiting participants was to understand everyday life in an urban area across demographics. Once recruited, the lead author created 'story-maps' with participants over the year. Building story-maps requires constant participant feedback as photographs, maps and participant experiences are integrated into one story over time (see Supplementary Material). The paper relates the adaptive strategies and framings of household-level water managers within the broader context of water management and policy in the Valley.

Analysis reveals several commonalities. First, although experiences of water security vary greatly between participants over time, household water options are increasingly limited; see Figure 1 for a schematic of the types of water systems that households access. These constraints appear through either cost and/or time investments in storage, additional water sources and treatment methods to ensure water is available for different tasks each week. Although wealth, household location, social networks and landownership alleviate these burdens to an extent, the burden – and stress – of managing water falls heavily on certain household members. Over time those burdens widen inequities and constrain the capabilities of families, neighbourhoods and communities to build and sustain water security.

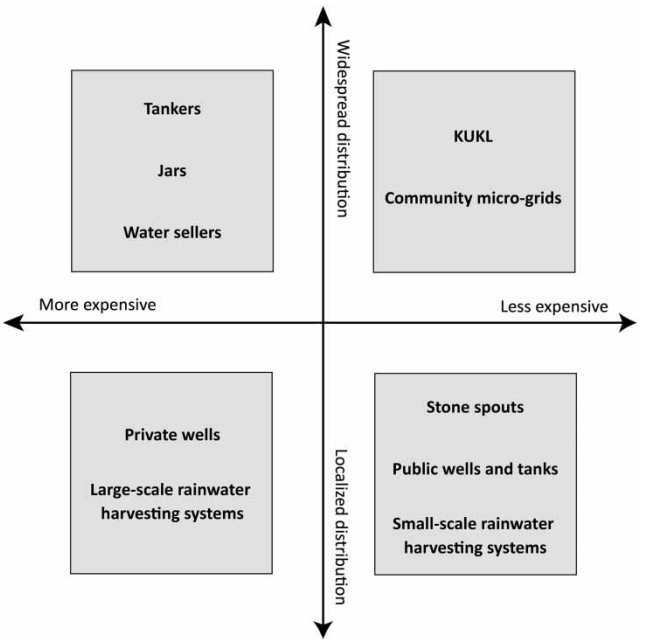

Fig. 1. Schematic of different water sources and systems available to households. © Olivia C Molden.

The following section outlines the research methodologies and approaches that inform this paper. To contextualize the study, the paper provides an overview of historic and contemporary water management issues in the Kathmandu Valley. From this background, empirical findings are presented in three sections. The first illustrates the inequities of water access by detailing the ways in which households in the study secure water over the year, focusing on an example of piped water access. The second highlights the role of social connections and landownership in household water security. The third presents the burdens placed on households and particularly on certain people within households when coping with water access. Between these findings, the growing vulnerabilities and inequities between households, especially as water access becomes more variable and expensive, are emphasized. The paper concludes with policy responses to these insights.

Methods: qualitative research insights

Prior to conducting this research, the lead author reviewed research publications on domestic water issues in the Kathmandu Valley. That review found that literature often describes patterns of water security based on the aggregated findings of large-scale surveys of households and assessments of water sources. However, there is a lack of information on the spatial and temporal variability of water security. Here, knowledge is produced within municipal and sometimes ward boundaries in-between either the dry or wet season. More fundamentally, there is a lack of in-depth research that investigates the drivers and experiences of water security in the Kathmandu Valley. Yet, examining complex environmental issues, such as water security, demands greater communication and integration between

knowledge communities through multiple research approaches (Carey *et al*., 2013; Zwarteveen & Boelens, 2014; Klenk & Meehan, 2015; Loftus, 2015; Jepson *et al*., 2017). In the Kathmandu Valley, there is a need for more discussion based on qualitative research insights, in addition to shared knowledge production between communities, institutions and researchers.

This paper primarily draws upon insights from the lead author's year of ethnographic research in 2017 in the Patan area of Lalitpur Metropolitan City. During this time, over 150 semi-structured and informal interviews were conducted with 47 household-level water managers living in Patan during the dry, pre-monsoon and monsoon seasons. Interviews with these water managers took place over a series of interactions in 2017 in February–March, April–May and between June–August. Through these interactions, the lead author built a spatial and visual database of how water sources and storage practices changed for each household between meetings to create individualized story-maps. These story-maps synthesize visual, textual and spatial information about how participants understand, feel and respond to changes in water quality, quantity and availability. The lead author designed these story-maps to encourage participation and reflection and, moreover, to facilitate comparison, transparency and reflexivity in the research process.

To contextualize these experiences in broader institutional changes, this paper is also informed by insights from interviews with 31 experts and water managers working for governmental, non-governmental, private, community organizations during the lead author's fieldwork in 2017. The second author's expert knowledge of the governance of water and the hydrogeology of the Valley informs the insights and policy directions for this paper.

Using convenience sampling, household managers were recruited from different neighbourhoods in Patan as a case study of water insecurity in the Valley; it is important to recognize that it is likely the dynamics of water insecurity vary greatly across urban areas in the Kathmandu Valley due to the diversity of cultural histories and features in the physical landscape. The study area selected roughly encompasses a 1.5 km radius from the centre of Patan's Durbar Square outwards to Kumaripati, Balkumari, Gwarko and Shankhamul. Some participants in the study are quite wealthy while others are poor; some own their homes ($n = 33$) while others rent ($n = 19$); and some live in temporary housing due to the 2015 earthquake ($n = 4$); most participants are women ($n = 40$). (Five participants who rented provided information only for the dry season as they moved after the first or second round of interviews; consequently, only 47 participants of the 52 remained in the study throughout).

Background: situating water insecurity

Historically, cities in the Kathmandu Valley were built around cascading water distribution networks of canals, ponds (*phuku* or *pokhari*), wells (*inar*) and stone spouts or stepwells (*hiti* or *dhunge dhara*) (Becker-Ritterspach, 1995; Tiwari, 2001; Spodek, 2002; Colopy, 2012). The dynamics of these water systems vary across the landscape but in general the system catches, stores and transfers various sources of water – from rainfed springs in the Valley's surrounding forests to aquifers in the Valley floor. In addition to their cultural heritage value, stone spouts and wells still function today as vital water sources for the urban population (NGO Forum for Urban Water & Sanitation, 2009).

The longevity of these water networks and their diverse engineering techniques constitute knowledge about the natural environment, particularly of the local geology, given the Valley's zones of high and low recharge (Tiwari, 2014). In other words, the ancient water system incorporated the physical

landscape and ecosystem processes. For example, people tell stories of how the worship of frogs, snakes and fish icons at water sites reflect the integration – and celebration – of life cycles in ecosystems. Here, the construction of these water systems both shaped, and were shaped by, the practices and beliefs of surrounding Newar societies (Tiwari, 2001; Shrestha & Shrestha, 2013). (Newar peoples are the historic inhabitants of the Kathmandu Valley or Nepal Mandala civilization; Newar rule over cities such as Patan or Yala in the Kathmandu Valley ended with the Gorkha invasion in 1768).

The maintenance of the ancient system relied (and to some extent still relies) on natural and cultural systems such as the Newar festivals like *sithi nakha*, where people clean their water sources in worship of water deities (Tiwari, 2001, 2002). Many communities are organized around these ancient water sites and revitalizing wells, ponds and stone spouts for both their cultural significance and utility (Regmi, 2005; Welle, 2006; UN-HABITAT, 2008; Molden *et al.*, 2016). As these practices continue today, it is important to recognize that water and water infrastructure in the Valley are more than a resource or means of distributing a resource: they embody cultural histories and changing social relationships (Tamang, 2016; Clark *et al.*, 2017).

The ancient cascading water system was radically transformed during the Rana period of government in the 1900s. Influenced and supported by the British Empire, Rana rulers imported metal pipes for elite households and stand posts for the public. In 1911, Prime Minister Chandra Shamsher Rana built the Pharping Reservoir which continues to feed pipelines supplying the Patan area. To lay down that infrastructure, which today's grid system extends from, the Rana regime set in motion a process of modernization that fragmented the infrastructure and governance of pre-existing Newar water systems (UN-HABITAT, 2008), exerting some degree of authority through the water system: stand posts appear directly adjacent to stone spouts, wells and ponds, and in other places these sites were demolished for new buildings. After the Shah dynasty regained power from the Ranas in 1951, the government expanded the piped water system for more public access (Colopy, 2012). From the 1900s to the present day, efforts to build new pipelines, roads, schools, government buildings and other infrastructure, both government and private actors have demolished and/or damaged many canals, ponds, wells and stone spouts. These developments not only diminish water availability in historic wells and stone spouts but also lead to displacement and the loss of cultural heritage (Molden *et al.*, 2016).

The metal waterpipe system initially laid down by the Ranas quickly degraded due to poor maintenance and management. Moreover, extensions and replacements of that system have been unable to keep up with increasing demands from rapid urban growth and changing lifestyles. Demands for water have increased from 35 million litres a day in 1988 to 155 million litres a day in 2000, and then to 370 million litres a day in 2015 (Thapa *et al.*, 2018). In the meantime, the extent of the built up area increased by 412% from 1989 to 2016 (Ishtiaque *et al.*, 2017). Growth in the Valley has largely been driven by rural to urban migration due to unrest during the civil war period (1996–2006) and a lack of development in rural areas. In 1990 and 2017, migrants accounted for 40% and 36% of population growth, respectively (Ishtiaque *et al.*, 2017).

Currently, the KUKL supplies 19% of demand in the dry season and 31% in the wet season, due to changes in water availability at KUKL's water pumping sites and reservoirs (Thapa *et al.*, 2018). What this means is that few households can rely on piped water. A recent study (Raina, 2016) found that, on average, households in the study area of Kathmandu only receive 1.5 hours of water every 5 days from KUKL pipes; the same study also demonstrated that poor households systematically obtain less piped water than wealthier households.

Plans to improve water supply came into motion in the early 1990s with an internationally funded scheme to privatize the water system and expand infrastructure with the Melamchi Water Supply Project, referred to commonly as 'Melamchi'. Although the Melamchi project now involves many other projects, its key feature is a 27.5 km-long tunnel to transfer water from the Melamchi basin to the Kathmandu Valley. The project promises to bring in an added 170 million litres a day, year round, from the snow-fed Melamchi River until the completion of the second phase of the project which will add 340 million litres a day from the Yangri River. Even so, models predict a 124 million litre daily deficit with the first phase of the Melamchi project, based on growing demands (Udmale *et al*., 2016).

The Asian Development Bank approved a loan for the Melamchi project in 2001; however, it did not materialize and institutionalize until after the civil war ended (1996–2006). Moreover, due to protests at both ends of the pipeline (Domènech *et al*., 2013) tunnel construction in Melamchi did not begin until 2009, missing its first 2007 deadline. Decades later and around US$360 million spent, the project missed its second deadline extension. In April 2018 the contractor finished building the tunnel but kilometres of pipe laying remained incomplete in the city.

In addition to building the tunnel that will divert water from mountain streams into the city's piped water system, the project required the restructuring of infrastructure and management systems within the Valley (Domènech *et al*., 2013). After changes to the scope of the project to expand and improve piped water distribution in the Valley, institutional reform and foreign investment shifts took place in 2007 and 2008, involving the creation of three new water management entities based on a public–private model (Domènech *et al*., 2013). These institutions are the operator of water and wastewater services (KUKL), the asset owner of those services (Kathmandu Valley Water Supply Management Board; KVWSMB) and the economic regulator (Water Supply Tariff Fixation Commission; WSTFC).

The KVWSMB is the sole authority responsible for water supply management within the valley area. It was formed from an ordinance in 2005 that was later accommodated within an Act of Parliament, the Water Supply Management Board Act, 2006 (the Act). The Act led to the formation of the KVWSMB as the authority responsible for regulation and monitoring of water supply business within the whole valley. The KVWSMB is the apex body for water supply management in the municipal areas of the valley and has issued a 30-year lease to KUKL, the main operating company responsible for piped water supply within the valley. Since its establishment, the KVWSMB has worked in the field of water supply management, groundwater regulation, identification of new water sources, artificial recharge, licensing and monitoring of small water vendors (such as tanker vendors), on social awareness campaigns and on the rapid water quality assessment of different water sources. One major goal of the KVWSMB is to ensure equitable drinking water access to all residents of the valley.

Findings

The temporal and spatial variability of insecurity

Within the span of many people's memories, water has become a highly contested and expensive resource to access. As public water sources run dry and become contaminated people must rely more on buying water. Costs include payments to KUKL, to tanker and jar companies, to neighbours, or through the installation of new technology and infrastructure, such as pumps, tanks and filters. Together, these sources and systems form a complex meshwork where boundaries of formal and informal, legal

and illegal, public and private, all become entangled (Schwartz *et al.*, 2015). To help make sense of this meshwork, Figure 1 provides a schematic of these various sources based on household methods of access. As the schematic shows, households have a choice between tapping into water brought in through pipes, tanks, and jars or sources available in their compounds and neighbourhoods. For example, since Uma harvests rainwater from her roof in buckets and goes to a nearby community run stone spout, she accesses sources that are comparatively less expensive and more localized.

Due to unreliable KUKL supplies, households and communities have invested in new water infrastructures for storage, treatment and supply. Small-scale rainwater harvesting is common in households and the government now promotes rainwater harvesting and recharge on a large scale (Pandey *et al.*, 2012). Some neighbours have worked together to create small-scale water supply and distribution systems. On a slightly larger scale, several communities have created water supply systems. Depending on availability and cost, community leaders collect water from deep bores, shallow wells and tankers, and from ancient stone spouts or wells. Then, depending on membership status, people pay to collect water from public tanks and taps, from hose connection points to micro-grids, or from private tap connections to these micro-grids. Some communities also provide free water access to the broader public at certain times in the week.

Households, especially wealthier ones (Raina, 2016), increasingly rely on water brought in from the surrounding hills in tankers and jars; research in 2005 estimated that tanker and jar companies fulfil half of demands (Dixit & Upadhya, 2005). The costs of these non-grid sources are estimated to be around US$12 a month, or around 2–3% of household income (Gurung *et al.*, 2017); however, there are many other hidden costs in time spent and the cost of pumping, storing and treating water that make this a much greater burden (Pattanayak *et al.*, 2005). Cost is an important factor for research participants. Although some would like to pay more for a constant flow of clean water from taps, they do not want to keep paying high prices for water from sources like jars and tankers.

Groundwater from private wells (for homes, schools, hospitals, hotels, industries and tankers), KUKL wells, and historic community wells supply the needs of the Kathmandu Valley (Shrestha *et al.*, 2012). Industries and private groups (including community organizations) with land and capital are tapping deep aquifers through deep boring technology. Overall, 21.56 million m^3 a year are being extracted, exceeding the recharge rate of 9.6 million m^3 (Pandey *et al.*, 2010).

Research into Kathmandu's water use tends to portray households by dimensions of source access and less as a meshwork, or entanglement, of different sources that shift spatially and temporally (Schwartz *et al.*, 2015). This study finds that access to water varies because of the subjective ways people distinguish quantities and qualities of water for certain tasks, for example using jar water only for drinking, and rain water and well water for washing clothes. However, these use and storage dynamics transform, for example, in the rainy season when some people store their well water with tap water. Moreover, the amount of water households access varies greatly: some struggle daily to find enough water for drinking, washing dishes, and using the toilet. Other households worry about calling a tanker every month for their non-consumptive needs. During the dry season one participant had plenty of water in her well but the water in her neighbour's well became yellow and then ran dry.

Similar differences apply in the case of piped water. Two neighbours, Sonika and Shanta who live next to the main KUKL water supply line in Patan experience water insecurity very differently. Sonika rents a room and has access to her neighbour's KUKL connection and to the public well. Once a week she waits in line with other renters in the area and collects 100–150 litres of water from her neighbour, paying her neighbour US$2 a month for that water. Sonika feels like she never has enough water. Across the street, Shanta has two KUKL connections because he expanded his family home into two lots and receives

around 8,000–9,000 litres a week for US$7 a month. Shanta only buys water from tankers after the 2015 earthquake and during the rice planting month when farmers divert water from the Pharping source to their fields. However, Shanta is concerned about the sustainability of the piped water connection as he does not trust the government or the Melamchi scheme. Shanta's experience shows that even with abundance insecurity persists due to a lack of trust and autonomy.

For households further down the piped water line, the water that comes is not as clean or as voluminous. Here, households living upstream of the pipeline and directly along the main line receive the most benefits, which coincides with more central areas such as along the road from Pulchowk to Mangal Bazar. In March, only five participants could rely solely on water from the pipes. Most participants who have KUKL access ($n = 12$) received less than 400 litres a month. However, most lack easy access at all: 11 participants lack a working KUKL connection and 19 lack direct access to a KUKL line.

As Hari explains, 'When it is Saugal's turn to get tap water [Saugal is a community downstream of the pipe], if the force of water is high then we can also get water … But to send water depends on staff of KUKL. Sometimes they do not open the tap key but usually they open the tap keys on time. Then we would use tanker water. But once a week there will be water.' There are also many areas which lack piped water connections because they are in newly developed areas and/or too far from the main line.

As the pipeline pressure is weak, many households invest in pumps and remove KUKL meters to collect more water. As such, people who can afford stronger pumps can effectively suck up more of the water that would extend further through the network. Although such practices are illegal, they are widespread and deregulated. However, for Nanichhori, a poor homeowner who lives adjacent to the main line, these forms of 'cheating' mean that she has to wait all day around the tap: 'It [KUKL water] should come thrice a week but when there is electricity the people use machine and they get water. But we don't get [any].' She says even if she could access the tap water she doesn't have a place to store the water. Overall, even with growing inequities in access between families, as for Nanichhori and Hari, the current pipe network is a source of stress for all families, albeit in different ways.

Between these diverse experiences, feelings of security and insecurity do not necessarily change between seasons of overall water abundance and scarcity. Rather, feelings of insecurity depend upon the ease of access to water sources, which includes perceived financial costs of access and storage, time and physical burdens (e.g. carrying, hand washing, filtering), and social acceptability (e.g. changing gender relations, beliefs, community membership). These costs increase as groundwater levels drop, or as public spouts run dry and taps run black or dry. As a result, families must constantly negotiate with external forces – companies, stores, syndicates, community leaders, neighbours and government officials who control water flows – which in turn reinforces power disparities.

The importance of social networks and homeownership

Homeownership is a powerful dynamic of water security. Registering a home provides residents with the ability to connect to the water mains and, if they have the means, to invest in underground or rooftop storage. Having this storage is particularly critical as it means they can pump well water, tap water or tanker water and store it for future use. Moreover, landownership often provides added income as homeowners rent out spare rooms and space or sell their land. However, not all homeowners have such benefits. Some homeowners cannot afford to move to a better area, repair earthquake damaged homes, or renovate and expand. Conversely, landless residents – such as renters, squatters and people living in informal settlements – have a more challenging time directly accessing, treating and storing water.

Whether homeowners and renters, participants were constantly adapting and changing their strategies: trying out different technologies, investing in new storage tanks, talking to neighbours about their strategies, or watching where other people collect their water. What this shows is that it is not just the ability to attach a hose to a tap or pump water from a pipeline that provides them with water security, but, more fundamentally, social connections. For example, renters like Rupa find friends that watch each other's buckets or children as they wait for water. Homeowners like Dev ask neighbours for the phone number of a more reliable tanker, while Prem invests with friends in revitalizing a community well to create new water possibilities. Or, Shanti, for example, talks about how her life has improved since 'the brothers of the community' asked her to manage the newly installed community tank. Her daily life is different now: instead of buying water and carrying buckets home, she makes a small profit from selling water and spends her time getting to know the renters and homeowners in the area.

Migrants and homeowners who have shifted to a new area explained that they feel more insecure at first because it takes time to learn about water systems. Observing other residents and making social connections improves water security. Doing so, families learn new strategies, such as using a tarp to collect rain; creating or joining a collective water collection and storage system; and acquiring more knowledge about local water sources and their management systems, such as when and where the 'key man' comes to open pipes. However, as some migrants discover, access to certain public water sources are more exclusive, favouring 'locals' or historic homeowners in the area who have membership of community water systems.

Even for household managers who do not have to leave their home to fetch water because they can call a tanker, pump water from their well, or rely more on KUKL tap water, social connections are still vital. For example, Sangita had to talk to neighbours and relatives to find a tanker that would deliver to her home after the earthquake when KUKL stopped working for a month. Gautam's street has a strong KUKL connection because one of his neighbours used to work for the government. Gautam can also drive his scooter to his ancestral home near the main KUKL line to collect water when his tap and well run dry.

Investments in certain sources, technologies and social networks provide many participants with a greater sense of autonomy and security. When asked if they would stop using non-grid sources after Melamchi, many participants said that they will continue to support their neighbourhood well and stone spout water systems and/or maintain their personal wells, but stop purchasing water from tankers, jars and other vendors.

Several participants rely on community leaders to make water management decisions. For these households in community cooperatives, the community system is an extension of their household as they are socially, economically, politically and culturally invested in their local system. For example, Samrat says it is the community's decision to incorporate Melamchi into their neighbourhood water system. Systems like the one Samrat relies on provide inspiration for other participants who lack local connections. Prem and his neighbours are investing in a tank and filter system for his community's well: 'We have to use the source that we have. We have to think how can we use the well effectively. We have a strong well where about 30,000 to 40,000 litres of water is pumped daily. That water is enough for us if we can collect properly. But we don't use it well. People hesitate if they have to spend money. We have to treat it with chemicals, medicines, filter plant and we have to clean it regularly. But in case of tap water we don't have to do all that. We just have to pay 150 [rupees]. But imagine if Melamchi comes and we have to pay 1,000 to 1,200 [rupees] per month then how difficult it will be. If someone gave us the medicines to keep in water I think this water will be okay to drink.'

In some cases, strong cultural ties have enabled community groups or 'clubs' to have a greater degree of autonomy (Molden & Meehan, 2018). As a result, some household water managers have given up on the government attempts to fix the grid. Santa Maya, a resident in a historically low caste neighbourhood, feels betrayed by the government: 'I don't care [what the government does]. We get water from the club. The government won't give you water.' Samrat, similarly expressed, 'the government had said that the Melamchi water was coming years ago. If we were just sitting and waiting for water then people would have died of thirst. But the community people has helped getting water. I don't know much about government. I don't trust in government.'

Nevertheless, most participants complain that people in their area act too individually and selfishly. Participants wish for more local unity – to have meetings to discuss what the problems are, develop strategies, go in mass to the KUKL office to complain and make demands. Participants explained that these strong social ties grant them power but acting as an individual they are powerless, especially when making demands at the KUKL office or local government offices.

Yet, even for participants who are part of strong community systems, only a few groups have been able to successfully negotiate with the KUKL office, and still they complain that the results are short lived. Take the neighbourhood of Chyasal where locals claim the government responded to their demands by building a deep boring plant next to the Bagmati river and installed new pipelines to households in that neighbourhood. Despite this investment, residents do not think water will not flow through the system anytime soon. One resident complained that it would not come until after Melamchi.

These strategies indicate that insecurity persists due to rapid changes and the increasing fragmentation of social ties and physical water flows. All participants expressed worries that water is increasingly scarce and hard to find or more expensive to buy. Here the burden falls heavily on the people who secure water for their families and communities as most lack the ability to fully trust a larger system.

The burdens of coping

Institutions often praise the resourcefulness of residents as they wait for the completion of Melamchi. Here, institutional narratives view the use of multiple sources and water saving techniques as coping mechanisms, or temporary alternatives, until the grid supplies demand (Molden *et al.*, 2016). As Ching (2018) argues through her research on public narratives of piped water supply in Kathmandu, there is a paradox of resilience: the act of coping creates a false sense of resilience. Coping thus becomes part of a cycle of inaction where the public's perceived resilience feeds into bureaucratic incentive towards blame-aversion (Ching, 2018).

However, what does coping look like in everyday life? This study finds that the burden of coping falls heavily on households as families take management into their own hands. More specifically, that burden of managing water falls on certain household members who bear responsibility for gathering, paying, storing, treating and using water. In most cases that burden falls on women, yet, with changing social relations, participants explain that men are more involved in water tasks, to varying degrees.

Take the following two experiences of household water management, from Rupa and Dev. Rupa, a grandmother, who migrated with her children to the Valley 10 years ago, says she spends her entire day 'touching water.' She must walk 10 minutes down the road to a stone spout and then wait in line, sometimes for an hour, to collect one bucket of water. When water comes and the homeowner lets the renters

take water, Rupa and her neighbours take turns collecting buckets from the KUKL line. She stores the tap water in clear jars under her bed and uses it for drinking. Then, when the homeowner has unlocked the well and it is not smelling of sewage, she takes turns pulling buckets with her neighbours. Rupa's children and grandchildren will sometimes help her when they get back from school or work. Rupa says it is always hard work securing water but it is easier when there is more water available through the KUKL tap or well.

Dev, a grandfather who is long retired, has built a new home on the outskirts of Patan. He has two large storage tanks on his roof and on the ground floor, and has built a system to channel rainwater directly into the toilet cistern. Dev orders a tanker twice a month and collects one large bottle or jar of water every three days. He lets his renters use the household well.

While in completely different situations, both Dev and Rupa cannot rely on systems beyond their household to provide them with water. Dev is constantly arguing with tanker suppliers and Rupa is constantly figuring out which sources will be available. While these experiences of insecurity vary between Dev and Rupa and their households, both managers feel stress and frustration. Both wish that water management could be less stressful, just like the old days when Dev's previous household in Patan Dokha received a constant supply of water, or in Rupa's village where clean water was always available from springs.

To build security, household water managers like Rupa and Dev have invested in storage: for Rupa this consists of dozens of 5–20 litre buckets and drums stacked in her small room, while Dev has several 500–1,000 litre tanks and an underground reservoir. Looking out at the water tank-lined skyline of Kathmandu, investment in different water storage units is clearly a key mediator of water security.

Participants long for a working KUKL connection where they can just turn on the tap and not have to worry about filling all their tanks when they have a chance. Both Dev and Rupa are optimistic that they will soon stop buying other water and only use tap water as they see pipelines being laid. However, other participants feel like 'Melamchi will never come' or when it does they are sceptical of how long it will last.

Already the unfolding of Melamchi is amplifying the insecurities of some households more than others and increasing the multiple costs of coping. This is because, for the many households with unused and broken KUKL connections, household managers and community managers made a choice to either continue paying the bills despite not getting water, to ignore the bills and accumulate a large fine, or to 'cut the line.'

However, several other participants, such as Santa Maya and Samrat, opted to cut the line because they transitioned to rely on other systems instead and did not want to keep paying for water that they do not receive. As Muna explains, 'After we built this house we cut the pipelines. So now we don't have [a KUKL line]. We have cut the pipes here, but we haven't gone to the office to inform them. So, I think if they send Melamchi water then we will have to pay a lot of fees. It's been 12–13 years that we build the house … But water hasn't come for 18–19 years.'

After seeing Melamchi finally materializing in the city, these participants have realized that they need to reapply for a connection or pay up all their fines, some of which have accumulated over many years. Sarita owes around US$500 to unlock her connection to Melamchi water. However, Sarita also needs to rebuild her house which was damaged in the 2015 earthquake, so she said she will see what Melamchi looks like before paying. Currently, she collects buckets from the community well and pays the mothers' group that manages it 50 cents a month. While homeowners, like Sarita, grapple with the costs of becoming reconnected to the piped network, renters wonder how much they will have to pay to access the landlord's tap. This is because current policy governing the piped water system systematically

marginalizes residents who lack certain kinds of property in the city, as seen in the disparities of access between Sonika and Shanta or Sarita and Dev.

Discussion

Urban residents are paying for the costs of ineffective and at times absent water management systems. As one participant expressed, 'let people realize that it is the government duty to provide water. Even if people don't pay, the government needs to supply water. It is a basic human right!' This paper argues that meeting these rights demands research, development and policy responses to look beyond the main pipe network and engage with the variety of ways households secure water.

When asked, participants prefer water from KUKL and/or community water sources such as stone spouts and wells. The reasons for these preferences vary but participants often emphasize perceived cleanliness, convenience, reliability and social value, especially around community systems. However, without regulation and enforcement, water sources are vulnerable to contamination and over extraction from upstream or surrounding users. Thus, not addressing the drivers of inequities and vulnerabilities surrounding water access risks perpetuating the disparities or creates new forms of insecurities, as the stories of Sarita, Samrat and Rupa demonstrate. At the very least, addressing water insecurity requires the upholding of existing laws and policies to ensure water resources are available and accessible to the public for domestic needs through better regulation, public outreach and coordination between national, municipal, community and household management systems. Addressing inequities demands a greater understanding of the social, political and economic factors that shape spatial and temporal disparities in water access between families living in a city.

Following local, national and international laws and policies, the State must ensure that water resources are available for public use. Indeed, following Nepal's 1992 Water Resources Act, the State owns all water resources 'for the rational utilization, conservation, management and development of water resources', and prioritizes domestic use above all others. While Article 35, Section 4, of Nepal's Constitution states that 'every citizen shall have the right of access to clean drinking water', those rights can be addressed through sources beyond piped water from Melamchi and KUKL. Yet, so far, the main way in which the State and development efforts have attempted to address that right is through a piped water network. However, as current practices in Kathmandu and other developing cities demonstrate, privileging the grid over other sources risks perpetuating inequities and insecurity (Bakker, 2010; Meehan, 2013; Ranganathan, 2014; Anand, 2015; Furlong & Kooy, 2017).

Policy responses

In its effort to better manage available water resources in the Valley, the KVSWMB is working on new policies and regulations. It has issued a 30-year lease (license) to KUKL with the terms of reference of operation and maintenance of the piped water supply network in the Valley.

Recently, KVWSMB also issued about 500 licenses (to date) to private tanker water vendors. Each water vendor must submit a water quality report from the desired water source. After studying the physical, chemical and microbiological characteristics of the submitted report, KVWSMB classify the water as drinking water, household use water and other water. After the categorization of the water,

KVWSMB issues the license with colour codes, e.g. blue for drinking water meeting all national standard values of physical, chemical and biological parameters, green for household use water meeting the national standard for physical and chemical parameters, and yellow for other water meeting only one of the physical, chemical or biological parameters. All license holders must put a colour sticker on their tanker according to the quality of water being supplied and this colour-coded classification for tankers has helped users to identify the water quality of tanker water they have been using.

Similarly, the licensing of more than 400 deep tube wells (to date) has helped formulate conjunctive water management strategies for incorporating good groundwater sources as a viable alternate water source to piped water.

KVWSMB has issued regulating guidelines with the aim of regulating tanker water business and groundwater abstraction in the Kathmandu Valley. *Licensing Underground Water Extraction and Use Guideline* (*2014*) and *Tanker Water Business Guideline* (*2017*) are two major policy documents that KVWSMB has been following for better management of the water nexus in the valley. KVWSMB issues groundwater abstraction license to all major groundwater users within the valley depending on their water demand on the groundwater potential of the area, water quality and on water consumption per day. Licenses thus issued have to be renewed every year and, for renewal, submission of data regarding water quality, water abstraction/day and rainwater harvesting schemes in the premises of the license holder is mandatory.

KVWSMB has additionally been working on a comprehensive and interactive database with detailed attributes about all available stone spouts, ponds, tube wells, community schemes and spring sources within the Valley. Overlapping this information on one single map will help the public and even policy makers to formulate a plan for equitable water access to all user group within the Valley.

Conclusion

This paper examines the ways in which households address water insecurity in the Patan metropolitan area of the Kathmandu Valley, Nepal. It draws on insights from institutional expertise and participatory research with 47 household water managers over the dry, pre-monsoon and monsoon season in 2017. By presenting the experiences of urban residents like Uma, Rupa, Shanta and Dev over the year as they negotiate different water challenges, this paper questions common assumptions in water security research. As such, this paper calls for greater attention to the diverse experiences of different people living in the city over time.

First, this paper highlights spatial and temporal disparities of water access across household demographics and water sources, for example between the neighbours Shanta and Sonika. These disparities demonstrate that commonly applied spatial and temporal boundaries in discussions of water security, such as the dry season or the municipal border, inadequately reflect lived experiences and conceal inequities. Here, in-depth qualitative research of household experiences helps to reveal systemic forms of marginalization that mediate experiences of water security (Loftus, 2006; Sultana, 2011; Truelove, 2011; Meehan, 2013; Buechler & Hanson, 2015), such as the difference in the ways that renters and homeowners, wealthy and poor, central and peripheral residences struggle to access piped water from KUKL.

Second, this paper highlights the role of landownership and social connections in mediating experiences of water security. Registering a home in the right areas enables access to a KUKL tap connection, and also grants the homeowner extra space for storage, potentials for well-building and a possible means of income from renters. Conversely, migrants who cannot afford to build and register a home, such as

Rupa and Sonika, remain vulnerable and insecure as they lack these options. Nevertheless, as stories like Sarita's and Uma's demonstrate, not all landlords and homeowners are more water secure or privileged. For homeowners like Sarita, Uma, Shanti, Samrat and Sanu Maya, social connections and local membership of community water systems are vital lifelines and support systems. More generally, it is through socializing more than by direct access to infrastructure that people come to build security. As this study and others show, prevailing narratives about water management often overlook these social and cultural drivers of security in favour of metrics of access and basic needs (Molden *et al*., 2016; Tamang, 2016; Jepson *et al*., 2017).

Third, this research emphasizes the burdens of coping with poor water supplies on particular household members. In the Kathmandu Valley, ineffective governance means that households must manage their own water carefully. However, within a household, there are often several families and, within these families, there are particular individuals who bear the responsibility of securing water. The costs of coping are high, not just financially but also in terms of time, labour and stress, as Uma and Rupa explain. Moreover, the prevailing standards of measurement of basic needs, through metrics such as litres per day per person, poorly align with household management strategies by missing critical dynamics of water storage, social networks and belief systems that affect the security or vulnerability of a family (Wutich, 2009; Jepson *et al*., 2017; Molden & Meehan, 2018).

With these three findings, we argue that policy and development efforts must look beyond the piped water grid to fulfil residents' rights to water and build water security. Although residents dream of a functional water grid, current efforts to fix and supplement the existing piped water network will not adequately address water insecurities or inequities in access.

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Supplementary material

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