Shortage in the Mountains of Plenty: Water Supply in Mountain and Hill Cities throughout the Hindu-Kush Himalayan Region

2014 Borlaug-Ruan International Internship

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Introduction

Iowa is nestled in the center of the breadbasket; its soils are rich, and agriculture is abundant. The sky is huge, the people are friendly, and I am proud to call this state my home. It is in this beautiful state—more specifically, its capital—that the World Food Prize Foundation keeps its headquarters. In 2012, I was accepted to one of the World Food Prize's youth programs: the Global Youth Institute (GYI). This event left a lasting impression. Armed only with a small (and, as I know now, incredibly simplistic) report on water issues in Peru, I faced world-renowned scientists, politicians, and leaders. For the first time, I caught a glimpse of what absolute poverty looks like. In the tradition of Norman Borlaug, I knew from that weekend that there were virtually no causes so noble, so purely right, as eliminating food insecurity—and with it, hunger.

With the passion of the GYI still coursing through me, I resolved to do the Borlaug-Ruan International Internship. While I loved my state, I also desperately needed to leave it. There was a huge world, waiting just beyond its borders, and I yearned to experience it. This internship facilitated the two driving factors in my life: *to see the world and to fight hunger.*

Lisa Fleming, Director of Global Education Programs, could not have placed me at a better research institution. The International Centre for Integrated Mountain Development (ICIMOD) is an intergovernmental, knowledge-seeking and knowledge-sharing center which focuses on climate change in the Himalayas and the impact it will have both on the hydrology of the land and the livelihoods of the people. While there, I worked with Dr. Aditi Mukherji and Olivia Molden (see bibliographies) to better understand how people in mountain and hill cities access water. With the Dr. Mukherji, I compiled a literature review on the collection, management, distribution, sustainability, and social aspects of water in nine different cities. With Olivia Molden, I helped survey local users of the traditional water systems in Kathmandu.

Abbreviations

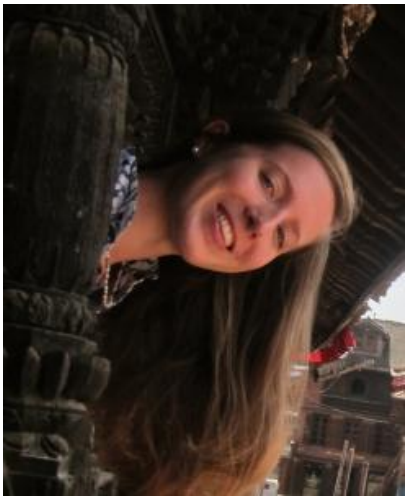
Center for Integrated Urban Development	CIUD
Central Bureau of Statistics	CBS
Glacial lake outburst flood	GLOF
Hindu-Kush Himalayan	HKH
Irrigation and Public Health Department	IPH
Kathmandu Upatyaka Khanepani Unlimited	KUKL
Liters per capita per day	lpcd
Melamchi Water Supply Project	MWSP
Million liters per day	MLD
National Water Supply Committee	NWSC
Non-governmental organization	NGO
Non-revenue water	NRW
Public Health Engineering Department	PHED

Solar Disinfectant System	SODIS
Willingness to pay	WTP

Biographies

Dr. Aditi Mukherji, Water and Air Theme Leader at ICIMOD

"Prior to joining ICIMOD, Dr Aditi was a Senior Researcher at the International Water Management Institute (IWMI), based at Colombo, Sri Lanka and then at New Delhi, India. She has also worked briefly at ICRISAT – another CGIAR center based in Hyderabad, India. She has over 12 years of research experience and her research revolves around institutions and policies of water resources management. She has worked in South Asia, Nile basin and in Central Asia. She has published over 50 peer reviewed research papers…She is currently an executive committee member of the Permanent Consultative Committee on Groundwater set up by the GEF and FAO…In 2012, she was awarded the Inaugural Norman Borlaug award for Field Research and Application, endowed by the Rockefeller Foundation and given by the World Food Prize Foundation for her policy work in West Bengal, India." *-From ICIMOD*



Olivia Molden, Master's Student

Olivia Molden is originally from Sri Lanka. She studied in the U.S. at Whitman College, then went on to pursue her Master's at the University of Oregon in the Department of Geography. Her interests include water infrastructure and urban political ecology in South Asia. Currently, Olivia is researching the use of traditional stone spouts, or *hitis*, in the Kathmandu Valley of Nepal, where a movement to restore the stone spouts has increasingly gained momentum.

Personal Impact

Two months later, my heart still aches for Nepal. Not a day passes when I do not think of Nepal, and so many of my experiences and lessons there are exceedingly relevant to the classes I am taking in college. While I learned a lot about water availability, I also observed my own views of the world, and myself, changing.

Personal Growth

Going into this internship, I was ready. I was ready for the adventure. I was ready for a life-changing experience. I was ready for a new paradigm. But once I got there, I experienced heaps of doubt. It was crippling, at times. I had been thrown into a world of working adults—all of whom had their Master's or Doctoral degrees—and I whole-heartedly believed that I would not succeed by their standards. Not knowing what a literature review was, I had to figure out what I was doing and how I was going to do it. It was a scary time, as at that point, I had not made many friends either. When the power was off at night (and with it, the internet), I had a lot of alone time to mull over my situation. Even more discouraging was the outlook of my two months, as no interviews were set up or mentioned in my first weeks there. I thought I would be stuck behind a desk for the duration of my time in Nepal, and that was wholly frustrating.

The internship was nothing like what I had expected. But that is not entirely bad: because I was out there alone, because I was feeling completely inadequate, I had a chance to grow. It is not in my nature to give up easily, and so I resolved to prove myself and my imagined-doubts-of-others wrong. This is one of the biggest lessons that I will take away from the internship—it wasn't something I had logically concluded as much as something I felt—and that was confidence. After the painstaking attention to detail and the days reading decades old literature, I had produced a report that made my adviser and myself proud. I had given a presentation that met the standards of my significantly more intelligent peers.

It was this self-doubt that we all experience, but that I had to directly face—and ultimately conquer—while I was in Kathmandu.

Poverty

My view of myself had changed, but so had my view of the people around me. Through my whole internship, I did not see much poverty—at least, I thought I hadn't. I realized towards the end that the only criteria I had for poverty was whether or not you owned a home, and the amount of homeless people I had seen was no different than what I would see in Des Moines. Based on that observation alone, I scoffed at the idea that Nepal was so poor. But this perception was entirely inadequate. As I reflected, I realized how incredibly ridiculous it was to use a building as the way to judge whether or not a person could provide for themselves and their families. I had gone to Kathmandu expecting to see homeless people at each turn, but this wasn't the case.

I was once told that Kathmandu is much more open compared to America, because you can see into everyone's houses. You can see their furniture, their families, their livelihoods; but in America, everyone is closed off and fenced in. In Kathmandu, I could see that people had things, had each other, and had a career (whether it be fruit stands, wood carving, or tiny shops), so I thought that they didn't classify as poor. And perhaps they wouldn't have classified themselves as poor either. When I discussed poverty with others, they frequently brought up that subsistence farming has been a way of life for centuries in Nepal. It's still something that I am conflicted on. In the U.S., poverty is defined by making a certain amount of money per year, but in a system where services are exchanged for other goods or services, the monetary exchange isn't counted. Why should we consider it poverty? In the end, I believe a deeper understanding of culture and situation is necessary to evaluate what poverty actually is.

Religion

I wasn't in a culture where the phrase "going to church" was used or where there were debates on the fundamentals of Christianity. Seeing a Christian in Nepal, or anything referencing the Bible, seemed oddly out of place. Instead, religion was treated much differently: it was simply part of everyone's life. Buddhism and Hinduism blurred together, to the point where religious idols and shrines occupied the same places, and where people considered themselves both. Instead of being asked whether or not I was Christian, I was asked whether or not I was spiritual. This experience helped me understand that there are different ways of seeing religion, and there are different ways of seeing spirituality without religion as well.

Support

Finally, and this is in stark contrast to the first lesson, but I also learned to value support. In a culture where family is valued so highly, I learned that it is okay to miss my own family. There were many times that I relied on interactions with other friends and coworkers. I learned that it is not a sign of weakness to ask for help; it is a means of accomplishing things, of learning, and of doing things much better the first time around. Even though I met people who I might not be friends with elsewhere (or perhaps *because* I befriended these people), I was able to learn so much more from the different ways that they viewed the world and the different values that guided their lives. While I did do a lot on my own in Kathmandu, I would be hugely misguided in saying that I did it completely alone. So many things had fallen into place to get me there, and once there, I was so lucky to have the support and guidance that I did.

Looking to the Future

This internship has reaffirmed the path that I am on. I know that I want to work with people in a foreign country, through the study of their culture. This has led me to pursue a degree in anthropology. After being told tale after tale of how aid was misused in Nepal, or how foreign countries influenced and hurt Nepal indirectly, I am convinced that greater cultural understanding will help alleviate some of these issues.

Cultural understanding is especially important in attaining food security. As aforementioned, it is necessary for Westerners to understand the mindset of subsistence farmers. As will be elaborated on in the research portion, it is also necessary to understand the significance of water to Hindus. By working within this frame, a significantly more efficient and effective solution to water insecurity (and, thus, part of food insecurity) can be implemented.

Research Results: Surveys

Iku Hiti

Iku hiti was one of the best managed and pristine hitis we visited. It smelled of fresh water, slightly soapy, and everyone whom we spoke with was happy with the way water was being distributed. Water flows from the main spouts in one pond—which is used for drinking and bathing only—and excess water is drained into a second, larger pool for washing clothes. There is also a reserve tank in place, with numerous pipes running from it. Over 200 households are connected to this water source, and members of the hiti pay 200 rupees (about 2 dollars) a month for water.

There is very little staff (only three people are hired to look after the hiti), and the decisions for the hiti are made by a committee of 5. They don't talk with the leaders of other hitis, nor have they considered rainwater harvesting. Cultural programs, festivals, and stage performances are held at Iku hiti. While there is little management, there is high maintenance from community participation in weekly cleanings.

Most people are concerned about the water at the hiti. The area around the hiti was entirely rice fields just ten years ago; now, there are buildings as far as you can see. With this urbanization comes an increase in bore wells which draw from the same aquifer. Urbanization also means impermeable surfaces, decreasing the recharge area for the aquifer. With climate change compounding the issue, the leaders fear that the hiti may dry up. For now, the water flows normally in the summer and only slightly decreases throughout the winter (interestingly enough, we were told that the water is cold in the summer and warm in the winter).

Nag Bahal Hiti

Nag Bahal hiti was a conundrum. The chairperson of the hiti seemed to have a slightly different account than the two users who were interviewed. While the leader claimed that there was a significant flow and long queue (or line), interviewees and our own observation attested otherwise. The hiti had been contaminated from a broken sewer line, and it was only used sparingly, often by migrants who didn't know about the contamination (although the chairperson

claimed no migrants used the hiti). Unfortunately, foreign aid used to beautify the hiti was mismanaged, as the water remained polluted with sewage.

Nag Bahal hiti was also rich in culture. It partakes in all of the major festivals related to stone spouts, and even has its own unique one (religious idols are brought from across Nepal and lined up around the hiti). There are many committees—including one for women and the elderly—which have a say in how the water is managed. The spout itself received its name from a story of a large snake (or *nag*) that protected the spout. This snake is painted on a wall nearby. The water is also used for purifying a house after someone has passed away, and it is not until the house is purified that other people may enter. Women also go to the hiti for socializing: small arguments and light jests, as well as gossip and information sharing, all occur at the hiti.

With over 250 households, a low rate of only 125 rupees is required for each house. Two large tanks, with a storage capacity of nearly 40,000 liters, are filtered and then distributed to these houses. No private wells are allowed that would detract from the hiti water, and permeable bricks were used to pave the area around it. The water has been constantly flowing since 2008, the chairperson claimed, yet only one of the three spouts was trickling upon inspection. Many in the area also buy from water tankers—although it is usually only the rich who can do so.

Sundhara Hiti

Named after its golden spouts, Sundhara hiti is barely used anymore. For the first time in months, the water had just begun to flow from its spouts again (coinciding with our visit). The management had been inactive for four years, although they used to host festivals and yoga at the hiti. People are not able to use it for daily ceremonies any longer, as it does not flow every day (instead, they often use water from the tap). The decrease in available water is attributed to the increased use of wells, and, after a few were destroyed by an angry crowd, water had once again flowed to the hiti. Still, there is great concern over industries using too much water, and thus depleting the source of Sundhara hiti.

The management wants to see the hiti flowing with clean water, 24 hours a day, yet they are skeptical that this will ever be realized. While people are proud of this hiti—one that was built centuries ago to outcompete another hiti—they also recognize its decline. “Sundhara is dead, is no good,” we were told, yet the management also refused to let the road encroach on the hiti either. While some religious value remains, without water, the hiti has been largely disregarded.

Washa Hiti

Washa hiti is part of a system of four hitis, with water flowing from one to the next: Washa hiti, Amrit hiti, Dathu hiti, Buincha hiti. For 16 hours a day, water is collected and dispersed through tubes to local houses. Over half of the people living in the area are renters, engendering a diverse community. The water is used for drinking only, and it can be stored in a 13,000 liter tank nearby. Washa hiti was mentioned by several NGO leaders for its medicinal qualities, and reminiscent stories of childhood were recalled at the mention of its water.

Washa hiti has also seen aid play a part in development. Not too long ago, a philanthropist donated to have a children's park built nearby, which has left much of the land green and available for recharge. UNESCO also contributed to build Amrit hiti, and funds are being awaited for the others; tools for cleaning up the hitis were donated, as well.

The management of this hiti system repeatedly told us that they were uneducated. They proudly remembered how they decided to stay when everyone else left to get an education. Their reason for staying: they wanted everyone in the community to have clean, free water. Since the project started, those four leaders have successfully implemented a way to make sure no one in the community they care so deeply about goes thirsty.

Washa Hiti

Buicha (Grasshopper) Hiti

Research Results: Literature Review

Abstract

Access to clean water is a human right denied to millions of people worldwide (UN, 2010). In the Hindu-Kush Himalayan (HKH) Region, urban centers and hill cities are experiencing acute water scarcity from an amalgamation of political, ecological, and cultural factors. This literature review assesses the available information on how residents of major cities in the HKH Region obtain their water and the issues they face in doing so. Specific attention is given to the cities of Kathmandu and Pokhara in Nepal; Darjeeling, Kohima, Mussoorie, and Shimla in India; Lhasa, China; Thimphu, Bhutan; and Kabul, Afghanistan. Articles from regional news sources, published research, NGO information, and relevant books were examined and analyzed to collect information on the state of water scarcity in the region and variables affecting it. From this, it has been concluded that water shortages have become increasingly prevalent in each of the aforementioned municipalities. The inefficiency and lethargy of centralized governance and municipal water management are largely blamed for shortcomings in the provision and distribution of clean water: their actions engender the prevalence of coping strategies to bridge unmet water demand. The Himalayas—"the youngest, tallest, and most unstable mountain range in the world" —procure a quagmire of environmental concerns: seismicity, glacial lake outburst floods (GLOFs), melting due to climate change, and the geological composition of aquifers are all threats to the existing and potential sources of water for urban areas. Furthermore, the caste system, urbanization, and social structure of local cultures also influence the ability to collect water from varying sources. After analyzing this nexus of political, ecological, and cultural factors, several proposed solutions will be evaluated to determine what could effectively alleviate water shortages in the HKH Region. This work serves as an exploratory study of research done on urban water supply in the HKH Region, exposing gaps and potential areas of future study for the International Centre for Integrated Mountain Development (ICIMOD) while assaying the quality of available literature and data.

Table 1.1: HKH city statistics

City	Supply (MLD)		Supply (lpcd)		Demand (MLD)	Demand Met		Year
	Wet Season	Dry Season	Wet Season	Dry Season		Wet Season	Dry Season	
Kathmandu Valley	105	86	42	34.3	280	37.5%	30.7%	2012
Pokhara	24	21	80	70	45	53.3%	46.7%	2014
Darjeeling	8.3	2.3	62.9	17.4	8.6	96.5%	26.7%	2002
Kohima	1.8		22.3		--	--		2011
Mussoorie	7.67		255		14.4	53.3%		2014
Shimla	54.5		316		64.7	84.2%		2012
Lhasa	--		--		--	--		--
Thimphu	--		--		9.9	--		2006
Kabul	52.14		15		--	--		2013

Table 1.2: HKH main issues

City	Main Issues
Kathmandu	Water shortage, contaminated water, pipe leakage, inconsistent supply, lethargic government, urbanization
Pokhara	Water shortage, ineffective management, natural disasters
Darjeeling	Water shortage, contaminated water, outdated system, lethargic government, lack of coping mechanisms
Kohima	Water shortage, contaminated water, lethargic government, inadequate groundwater recharge
Mussoorie	Water shortage, contaminated water, lethargic government, electricity shortages, slope instability
Shimla	Water shortage, contaminated water, pipe leakage, lack of new sources, tourism, fragile ecosystem
Lhasa	Water shortage, supply infrastructure, foundational instability, lack of data
Thimphu	Water shortage, contaminated water, lower downstream supply, landscape complications
Kabul	Water shortage, water contamination, electricity shortages, urbanization, unsustainable groundwater extraction

KATHMANDU

Municipal Water System

The municipal water system in Kathmandu, established nearly a century ago, fails in nearly every aspect of water supply. Major water shortages exist throughout the valley, the system itself is defunct, and the quality of water arriving at local taps—if it does at all—is too unsafe to consume directly.

Supply

Kathmandu Upatyaka Khanepani Limited (KUKL) is a public company that oversees the distribution of municipal water. Population growth has kept well ahead of developments in water supply, leaving many with unfulfilled water needs. Jha (2012) reported that water demand in the valley was 280 million liters per day (MLD), but KUKL was only supplying 105 MLD and 86 MLD in the wet and dry seasons, respectively (P. Jha). The problem continues to grow: In 2013, NGO Forum for Urban Water and Sanitation reported that water demand in the Kathmandu Valley was 350 MLD, whereas the supply was less than half of that at 149.2 MLD in the rainy season and only 90.59 MLD in the dry season (*The Water Supply and Sanitation*). Many residents only receive water for half an hour each week at night, making the collection of water inconvenient (Kharel). Nonetheless, fees must be paid for having a connection, even if that connection never delivers water. While a few efforts to provide tankers to areas without water have made progress, many still do not receive any water from the city.

Distribution

Recent reports from the KUKL website blatantly spell out their shortcomings: trucks past service life, no routine monitoring or maintenance, disorderly fixes, minimal repairs (Kathmandu Upatyaka Khanepani Limited). Adding to the water scarcity, a chasm exists between the water KUKL does supply and the water consumed; a 2003 report found that the average water usage was 73 liters per capita per day (lpcd) (Joshi, Shrestha, and Shrestha). The difference between water supplied and water consumed is in part derived from leakage: Rajiv Joshi, chief of KUKL office in Mahankal, claimed that 35-40% of the water is leaking from pipes (The Himalayan Times), while other estimates are twice as high (Dirty Sacred Rivers). KUKL Spokesperson Suresh Acharya explains that leakage is due to construction and vibration from traffic damaging the pipes (although construction standards require the pipes to be buried at least 2 meters underground, presumably to eliminate the hazard of traffic vibration) (The Himalayan Times). Another variable in the gap between supply and consumption is illegal connections, yet no study has been done to evaluate the extent of this issue.

Water Quality

Water that does arrive through the municipal water system is often too contaminated to drink. The main source of water for the city, the Bagmati River, has come to resemble a sewage line (“NEPAL: Kathmandu faces worsening”). High levels of pollution in the river water make it unusable for irrigation, recreation, and drinking (Sharma et al.), yet the treatment plants used by KUKL to filter this water are often defunct or inadequate (Kathmandu Upatyaka Khanepani Limited). Furthermore, KUKL reported that “water is distributed directly to the customer without treatment from many tube wells from which some waters have high content of ammonium, iron and some, arsenic” (Kathmandu Upatyaka Khanepani Limited). Hence, over

half of residents in the valley rely on their own form of treatment (see *Coping*).

Management

Most blame has been placed on the government for inadequate quality and quantity of water (UNEP, 2001). Common belief is that these politicians are greedy and self-serving, not following through on their promises to the public and only doing what is necessary to be elected again. To prepare the sluggish KUKL, a team of experts in water management from Cambodia met with KUKL in June 2014 to improve their framework and mindset (The Online Kathmandu). They will try to prepare the organization for increased amounts of water from the Melamchi project, with goals including 100% metering; however, attaining these goals will also mean raising the tariffs, which were already doubled in 2009 (The Online Kathmandu; Kharel). The raising of these fees will put the poor at an even greater disadvantage (see *Culture*).

Urban vs. Rural: The Melamchi Project

Most of Kathmandu's problems with sharing water are prominent in the Melamchi Water Supply Project (MWSP), an interbasin river diversion scheme that was initiated in 1998. The plan was proposed to alleviate Kathmandu's growing water scarcity by providing 170 MLD to the valley (P. Jha). The total project will cost about $317.3 million, with the Nepali government paying $90.6 and international agencies and banks covering the remainder. While this project has been repeatedly delayed, both the government and aid agencies agree it is still the best option ("NEPAL: Kathmandu faces worsening"); however, with such severely deteriorated and broken infrastructure, questions have been raised as to the viability of transporting such copious amounts of water.

The MWSP has also struggled to serve competing urban and rural interests. With 90% of people in the Melamchi Valley working as farmers or fishermen, concerns have surfaced about the potential disruption that the diversion of the Melamchi River will bring to their livelihoods (Domènech, March, and Saurí). A study by Gurung and Bharati (2011) supports their fears; it concluded that there would be significant impact to the basins in the immediate vicinity of the source, even if there would be minimal flow reduction downstream (Department of Irrigation). Procedural injustices were prevalent, for rural residents were left out of the decision-making process altogether (Katuwal and Bohara). This issue of marginalization is further exacerbated by mitigation payouts, which only go to landowners and not the tenant farmers who will be most impacted. However, members of the Holmo ethnic group have succeeded in having their voices heard: They have established at least one local on the executive's board and received higher reimbursements (Domènech, March, and Saurí).

Another issue with the project is the hiring of foreign companies to oversee it, when it is believed that the process would be cheaper if overseen by a local company (Katuwal and Bohara). As of June 2014, only 7,157.3 m had been completed, leaving 20, 424.7 m to go ("Progress on Tunnel Work") for a project whose completion date is set for 2016 (Thapa).

Population Change

Kathmandu Valley's population has increased by over 150% since 2001. This rise in population is accompanied by "unplanned

and haphazard urbanization." As a result, overcrowding and pollution of riverside areas have become serious problems (Pant and Dongol). Excessive urbanization is also causing a demand stress on many basic infrastructure services, including water. This stress pushes costs higher and higher, putting pressure on central government agencies and municipalities who most often do not have the capacity to expand their networks.

A 2011 report by the Asian Development Bank discovered that "rapid and largely unplanned urban growth, lack of sustainable water sources, and inadequate past investments have resulted in poor availability and quality of drinking water" in Kathmandu ("34304-043: Kathmandu Valley Water"). It also found that this has caused higher health risks and economic burdens that are experienced in large part by the impoverished and vulnerable of Kathmandu Valley.

Coping

Throughout the city, residents receive highly variable amounts of water. Those closest to the main pipe may have constant running water from the tap; those farther away may only see water for half an hour each week; some houses even have completely dried taps, yet still pay for the useless connection. In 2008, about 80% (up from 70% in 2005) had a legal connection, but only 30% report actually receiving water ("Water Movement in Patan"; "Drinking Water Survey Summary"). Nearly two-thirds of houses in urban areas reported that the pipeline was not enough ("Drinking Water Survey Summary"), and of those connected to the pipe, 57% participate in collection activities from public sources (Pattanayak et al.). The resulting costs of coping with water scarcity were about $3 dollars per month, amounting to 6% of per capita income ("Per Capita Income Up"; Pattanayak et al.).

Pattanayak et al. (2005) have identified five main coping strategies: collecting, pumping, treating, storing, purchasing. The study found that over half of homes used a storage tank (with an average capacity of 110 L) and that willingness to pay (WTP) for clean water—$19.50 and $12.82 for connected and unconnected, respectively—was much greater than the reported $3 per month coping cost (Pattanayak et al.). Citizens use numerous other water sources to cope with the shortage of water: stone spouts, tube and dug wells, commercial suppliers, rivers, rainwater, and illegal connections (*The Water Supply and Sanitation*). Stone spouts and wells have been well studied, yet no research has been done on the quality or quantity of commercial suppliers, river-water usage, and illegal connections.

Stone Spouts

Stone spouts, also known as *dhunge dhara* and *hitis*, were the main source of water for centuries in the Kathmandu Valley. Brought about by the Lichchhavi rulers as early as 550 AD, this system placed responsibility in the hands of all who used its revered water ("Traditional Stonespouts"). Most often, these spouts appear at the bottom of a several meter deep excavation lined with brick. The spouts themselves are often intricately carved, showing the artistry, religious value, and longevity of the system. These spouts have a significant context in the course of local life for religious value. The water from these are often used for puja, and many idols of Hindu gods adorn the spouts ("Water Movement in Patan").

When the Ranas usurped the throne, water management became more centralized. The

Ranas began to implement a Western system of water management and distribution, altogether neglecting the stone spouts (Dirty Sacred Rivers). Combining the two systems had worked for a period of time, but increasing construction and unplanned urbanization destroyed many traditional stone spouts and the pipes leading to them. Although this destruction is in violation of the Local Self Governance Act of 1977, the legislation is rarely invoked to stop stone spout destruction. Now, nearly a third of the spouts have gone dry or been demolished altogether (Rawal). In the face of increasing water scarcity, efforts to revive and restore the spouts are gaining momentum ("Water Movement in Patan"). Forty-three stone spouts have been revived by connections with city lines; others have been restored through improved recharge in the area (Dirty Sacred Rivers).

These spouts are an important source of water when the municipal system does not meet water demands ("Water Movement in Patan"); according to Conan (2004), stone spouts were the main alternative to the municipal piped water supply. These spouts collectively discharge nearly 3 million litres per day (mlpd) in the dry season and up to 8 mlpd in the rainy season (Rawal), catering to 10% of Kathmandu's population ("Traditional Stonespouts"). While this only plays a small part in closing the tremendous gap between supply and demand, efforts can be upscaled. A prime example of restoration is the effort to put Alko Hiti back in working order and the creation of community support groups.

Many have argued that just because a system is traditional does not mean it is useless. The system that was in place before modern techniques were implemented had sufficiently provided clean water to residents ("Water Movement in Patan"). Methods of conserving recharge areas, sharing excess water, and using sand beds to filter water were well developed and often superior when compared to the decrepit state of the current municipal water system.

Management problems are also an issue when there isn't a collective group that has taken ownership, resulting in an overuse of resources more commonly known as the tragedy of the commons. Governance often does not understand or care to cater to the dhunge dhara, and the poor do not have enough of a voice to speak up and protect these sources of water. Furthermore, market forces can outweigh their voice, and the centralization of water management has led to corruption rather than pride and careful attention. It has been suggested several times that community management is inadequate since it is often a volunteer or nominally paid position. Furthermore, municipal management is still too centralized and inappropriate for this system ("Water Movement in Patan").

Tube and Dug Wells

The Central Bureau of Statistics (CBS) estimated in 2005 that 21% of households had tube wells/boreholes and 14% had wells/kuwas ("Drinking Water Survey Summary"). Joshi and Shrestha (2008) report over 218 shallow dug wells in Patan alone (Joshi and Shrestha). These wells voraciously extract water from both shallow and deep aquifers. Unfortunately, the groundwater that these wells draw upon is often contaminated and being extracted at an unsustainable rate (see *Groundwater*). A study of drinking water quality in Kathmandu Valley by Warner et al. (2008) found that shallow aquifer tube wells had an average of less than 100 users per well, yet the two

deep aquifer tube wells had an estimated average of 200 and 10,000 users each. The average price for constructing a well is about 8,000-10,000 rupees, but this price may increase as observed groundwater levels are dropping, requiring some wells to be dug to even greater depths of over 100 feet (Kisi; "Water Movement in Patan").

Treatment

Two-thirds of households in Kathmandu treat water before drinking (Pattanayak et al.). Treatment is a coping strategy identified by Katuwal and Bohara (2011) with main treatment options being boiling, filtering, Urogaurd, and a Solar Disinfectant System (SODIS). Most households do treat water: 40.4% (45% from CBS) of citizens filter and 34.2% boil with 19% of households doing both. Under half—47%—of households used no form of treatment (Katuwal and Bohara). Treatment of water in industry and business is completely unaddressed in the literature, but the organization Splash is working to make sure there is a 99.99% effective filter in every school. They were 15% complete in 2013 (Hoeft).

Rainwater Harvesting

NGO Forum reports that nearly all surface and groundwater sources have been exploited—thus leaving rainwater as a potential option ("Traditional Stonespouts"). Rainwater harvest-ing, although an increasingly recognized strategy for coping, has not been academically studied in Kathmandu. Joshi and Shrestha (2008) concluded that rainwater could be used to recharge aquifers in Patan; they compared this method to a natural, underground, rainwater harvesting tank, but did not report on any actual rainwater harvesting. Rainwater may be dangerous, though: rainwater was unsafe as per WHO standards in 84% of tested jars in the Himalayan Region (Sharma et al.).

The Center for Integrated Urban Development (CIUD) opened a rainwater resource center in Kathmandu in June of 2013. They claim that, with an average annual rainfall of 1,365 mm, a house with 100 sq m of rooftop surface has the potential to capture more than 130,000 L per year. They are also trying to dispel the notion that rainwater harvesting systems are only for the wealthy—a view that was perpetuated in an article from My Republica ("Rainwater Resource Center"; "Pipe Dream: Water Scarcity"). They hope that rainwater harvesting will become more widely used, but no official numbers on it have been recorded yet.

Environmental Considerations

Groundwater

Groundwater remains the single largest source of water, making up 50% of the water supply (Warner et al.). Unfortunately, the pollution of rivers, with both solid waste and defecation, has led to the contamination of groundwater. Major causes of groundwater contamination in the Kathmandu Valley are pathogenic bacteria (whose main source is sewage), pesticides, nitrate and industrial effluents (Sharma et al.). Khatiwada et al. (2002) found that shallow sources of groundwater contained both nitrate and mercury. Furthermore, deep groundwaters are mostly anaerobic, making them more vulnerable to iron, manganese, and ammonium (Sharma et al.). In fact, sewage contamination, manganese, iron, silica, dissolved ammonia, carbon dioxide, nitrate, and fecal coliform levels have all been observed at high levels throughout the valley (Khadka 1992, Khadka 1993, Chettri and Smith 1995, Australian Geological Survey Organisation

(AGSO) and Ground Water Resources Development Board (GWRDB) of Nepal). These contaminants were found at levels which, when compared with WHO standards, will have significant and negative health effects (Khatiwada et al.).

Due to the high levels of usage, there is a major strain on groundwater in Kathmandu. Sustainable groundwater withdrawal is 26.3 MLD, yet it is being extracted at a rate of 58.6 MLD (Sharma et al.). Groundwater was reportedly lowering 2.5 m/yr according to the Ground Water Resources Development Board in 2009 ("NEPAL: Kathmandu faces worsening"), but the reported rate decreased to 0.7-1.7 m/yr in 2011 (Bhushal). Nonetheless, this unsustainable withdrawal is having negative effects. Groundwater overuse is actually sinking the Kathmandu Valley which can cause infrastructural instability (Walker).

Urbanization has played a significant role in curtailing groundwater availability. Increasing concretization has reduced the recharge area for aquifers (Bhushal). Rajan Raj Pandey, senior divisional engineer at the Ministry of Physical Planning and Works Water Supply Section, has observed a negative correlation between the construction of houses and groundwater levels (Kisi). This is exacerbated by the construction of wells and 60% of households having an in-home electric pump ("NEPAL: Kathmandu faces worsening").

Cresswall et al. (2001) reported that the current recharge rate is estimated at 5 to 15 mm/yr, contributing 40,000 to 1.2 mil cubic meters/yr to the groundwater system, yet current extraction rates are at 20 times that amount. Projections forecast that the reserves will be used up within 100 years (Sharma et al.). The UN Habitat (2008) reports a lack of acts regulating groundwater use. One route of protecting groundwater is to eliminate pollution. Pathak et al. (2009) clearly connects pollution and contamination of groundwater, positing that groundwater in the Kathmandu Valley is highly susceptible to contamination due to loose and alluvial soils. The study also recognizes the need to manage groundwater for its efficient use.

Social Considerations

The UN reports: "Providing physically accessible clean water is essential for enabling women and girls to devote more time to the pursuit of education, income generation and even the construction and management of water and sanitation facilities." Women are often not a part of management, and UN recognizes a need to use programs to incorporate women (UN Water). Unfortunately, women are often not part of the discussion when it comes to water management, although they are often the ones collecting water.

Social issues arise in the usage of stone spouts; it is seen as necessary to "escape the hiti" for some. The perception is that a higher caste has the ability to afford tankers or other systems of coping, making reliance on the hiti unnecessary. There is also a perceived shame for males to fetch water from these spouts, as it is a chore traditionally completed by women. Intuitively, women take more pride in maintaining these systems as it lessens their strenuous workload in obtaining water. Many of the urban poor use the hitis, leading to tension with those who try to maintain them when there is not mutual understanding of the way hitis work ("Water Movement in Patan").

POKHARA

Pokhara, the second largest city in Nepal, is also experiencing acute water shortages; however, very little information is available on the situation in Pokhara, especially in the realms of water quality and coping methods.

Municipal Water Supply

Established over three decades ago by the Nepal Drinking Water Corporation, water infrastructure in Pokhara has not kept pace with the growing demands from urbanization. Originally intended to support 8,000 households, about 34,000 households now rely on this system (Pokharel). NGO Forum reports that although there are plenty of water sources, scarcity still persists. While urbanization, migration, and population growth have affected the system, ineffective management and natural disasters seem to be the greatest obstacles to water security in Pokhara (Gorkhapatra).

Supply

Pokhara is using several projects for its water supply: Madri Khola Drinking Water Project (16 MLD), Kalimuda Drinking Water Project (6 MLD), Bhote Khola Drinking Water Project (4 MLD) (Gorkhapatra). In 2008, Chitra Prakash Maskey, chief of the NWSC Pokhara branch, reported a 33 MLD demand in Pokhara; at the time, the NWSC had only been able to supply 20 MLD ("Drinking Water Scarcity in Pokhara"). Republica reported a demand of 450 MLD in 2014, but this is most likely an error as NGO Forum noted a 40 MLD demand in 2010 (the number has been adjusted to 45 in "Table 3.1") (Pokharel; Bhusal). In 2010, the supply was about 25 MLD, but a discrepancy again arises as Republica reported a 24 MLD supply in the monsoon season just four years later—the supply during the dry season is even less, at 21 MLD.

While these numbers vary, the trend is the same: slightly over half of the demand is being met by municipal water supply in Pokhara. There is also mention of a .3 MLD supply from one of the three traditional sources remaining, Bal Dhara. Only three of the fifteen dhara remain due to encroachment (Gorkhapatra).

Table 3.1: Pokhara supply and demand

Year	Supply (MLD)		Demand (MLD)
	Wet Season	Dry Season	
2007	26	18	36
2008	20	-	33
2010	25	-	40
2014	24	21	[45]

Distribution

Pokhara's municipal water system is unable to provide water to all citizens. Statistics from the Pokhara Sub-metropolis show that around 1500 new houses are built each year, yet no effort has been made to supply water to all of them. It is not surprising then that complaints of insufficient water are common. Some buildings are equipped with pipes but still do not receive water—tariffs must be paid for the non-existent supply anyways (D. Koirala; "Drinking Water Scarcity in Pokhara").

Water Quality

Exacerbating the issue of water scarcity is leakage from broken pipes, which can lead to deteriorated water quality (Pokharel).While the extent is unknown,

Pokhara has a major problem with uncovered water pipes and water mixing with mud (D. Koirala). The decrepit state of infrastructure will have negative health effects for those drinking from it, but no study has been done on the quality of water in homes to conclude how damaging the supply is.

Management

The language surrounding government action in water supply is overwhelmingly negative. As NGO Forum writes: "The city denizens blame the corporation's negligence for no water supply. Stating that water is supplied in one's area if one can pressurize or allure the NWSC staffs." An internal dispute at NWSC and government apathy are also blamed by the Himalayan Times (B. Koirala). Furthermore, consumers do not know the water supply schedule—another shortcoming in NWSC's responsibilities ("Drinking Water Scarcity in Pokhara"). Upset locals have self-reportedly gone to the managerial office sixteen times to demand better supply, but, with no perceivable changes, it seems their petitioning was to no avail (B. Koirala). On the other hand, government officials report that they simply do not have enough funding to replace defunct pipes (Pokharel).

Urban vs. Rural: The Madri Khola Drinking Water Project

The largest among the drinking water projects, the Madri Khola Drinking Water Project has caused a violent reaction from the people who used it before Pokhara did. In September of 2010, residents from the Mardikhola area overtook the water supply for an hour. This protest aired frustrations over the thousands of ropanis of land the Mardi Khola Drinking Water Project had left dry and barren. Their demands included the construction of embankments in affected areas, 25% annual allocation of the water tariff for development activities, employment for affected residents, conservation in the area, and the elimination of stone, pebble, and sand extraction from the Mardikhola (Bhusal).

Coping

Coping strategies are largely unaddressed in all relevant literature. The writer for Voices of Youth reports that people are using a public tap, leading to the conclusion that public taps are indeed available. The same writer also claims that Pokhara has a lot of rainfall, but residents do not have the proper equipment to capture and retain it (D. Koirala). Finally, the Himalayan Times wrote that tankers are now being used with the help of British Camp of Pokhara, but the quality, quantity, and cost of water is unaddressed. In all, no quantitative data is available in the discussion of coping methods in Pokhara. There is also a surprising omission of any data on wells in the city.

Environmental Considerations

Whereas several groundwater studies could be found for the Kathmandu Valley, none exist to evaluate groundwater in Pokhara. It seems that the greatest threats to water supply come from natural disaster and their destruction of infrastructure. Major floods in the Seti River had destroyed water pipelines in 2012 (Himalayan News Service) and other natural disasters had swept away water pipes just a few months later. These incidences left citizens without water for months even when the village next to Pokhara was receiving water every other day (B. Koirala).

Social Considerations

Gender, caste, and class are left out of the conversation on water accessibility in Pokhara almost altogether. One instance of class observation occurs: "Although, these people are rich when their bank balance is counted but may be the poorest when accessibility to water is considered" (D. Koirala). While the article does not provide a quantitative measurement of income, it is an insight into the way class becomes irrelevant when trying to fulfill basic human needs. Unlike the situation in Kathmandu, the author claims that users of the observed spout do not care to pay for a tanker, signifying that the stigma associated with public taps is not the same throughout the HKH Region (D. Koirala).

Further analysis of another source indicates the potential for increasing class divide. The aforementioned corruption in NWSC staff indicates that only those with resources would be able to persuade the NWSC to supply their area with water ("Drinking Water Scarcity in Pokhara"). This will put the poor at a significant disadvantage, leaving them voiceless to change their situation of water scarcity.

DARJEELING

Municipal Water System

Darjeeling faces the same issues that plague many of the other cities in the HKH Region, yet few studies have been conducted to evaluate the extent of these issues. Similar to other sites, Darjeeling has an outdated water system, created for only 10,000 people, which can no longer sustain the 132,016 people who reside there (Khawas). In general, Darjeeling is severely lacking in available reports and data on water issues. Unfortunately, many of the web pages from the municipality's website are also unavailable, meaning even less information is accessible.

Supply

Springs are the main source of water for the Darjeeling Municipality. Most water is from 30 major springs which are routed into two lakes: Sinchal North (capacity 20 MG) and Sinchal South (capacity 12.5 MG) (Khawas). Water is also used from Sindhap Lake and in the lean season water is taken from Khong Khola (Central Ground Water Board; Khawas). Once completed, the upcoming Balasun water project is estimated to produce 2 million gallons of water a day (V. Chhetri). All local perennial sources have been tapped, yet the gap between supply and demand continues to widen (Khawas). In 2002, the demand was 8.58 MLD and supply was 8.28 MLD in the wet season but dropped to 2.27 MLD in the lean season (Tunyi). A study comparing urban and rural water supply in the Darjeeling district concluded that 75.4% of urban households were connected to the municipal pipe system (Ray et al.), but a case study from 2004 reports that only half of homes are connected to the municipal water supply (Khawas). The former study also found that none of the urban residences had shallow tube wells (Ray et al.).

Table 4.1: Darjeeling water sources

Source	Inside House		Outside House	
	# of 28	%	# of 16	%
Well	4	14.3	0	0.0
Deep Tube Well	8	28.6	3	18.7
Shallow	0	0.0	0	0.0

Tube Well				
Corporation Tap	16	57.1	13	81.3

Distribution

The only current report on distribution is an optimistic claim that officials conduct surveys of pipes to determine where illegal connections exist (Sunam). Other than that, a report based on the Facebook post of Bimal Gurung, chief of the Gorkha Janmukti Morcha party, promises a new project that will overhaul the distribution system of Darjeeling. The plan includes the construction of 30 water tanks and 14 pumping stations with meters. It is set to be completed within 30 months, but based on the trends of the Balasun water project, this seems unlikely. Gurung also claims that it will eliminate the perennial water shortage ("Darjeeling Municipality to Sign").

Water Quality

Water quality has not been tested throughout Darjeeling. In the study that compared urban and rural communities, it was found that 26% of urban consumers did not purify water, and a meager 22% cleaned their storage vessel daily. The study also found that 12.5% of sources in urban areas had Coliform, but that 90% of the water consumed was pathogen free. However, the study only observed 61 households in the urban area—not enough to be used as a representative sample (Ray et al.).

In 2012, Bimal Gurung reportedly went to the site where water will be drawn for the Balasun water project. He is quoted as saying that the water is too filthy and too unhygienic for human consumption. When told about the water purifying system to be set up in Darjeeling, he was "unimpressed" and continued to promote another source of water (Chhetri and Sinha). However, it is doubtful that the site's water was actually tested due a lack of documentation and details regarding the event.

While it is unknown what percentage of the population relies on groundwater, it is important to note that groundwater in the Siliguri subdivision of the Darjeeling district is too contaminated to consume directly. Levels of iron were higher than permissible limits while concentrations of calcium, magnesium, and fluoride ions were too low for drinking water. The combination has major implications for "cardiovascular problems, gastrointestinal irritation, dental caries, respiratory disorders and spinal cord system diseases" (Haque and Jana).

Management

Management is cast in a positive light only when it comes to the monitoring of illegal connections (Sunam). Otherwise, critics admonish the government for its poor decision on the location of a water treatment plant; the originally flawed plan had to be altered, causing another of numerous delays in the Balasun water project (Banerjee). An article from the Darjeeling Times similarly argues that politicians have no follow-through on promises to increase water supply once they have been elected (B. Chhetri). There was also friction between the government and the World Bank over funding, leading to another halt in the Balasun water project (Khawas).

Urban Vs. Rural

Water supply conflicts between urban and rural areas is completely unaddressed.

Population Change

Darjeeling has been experiencing growth due to both urbanization and tourism. Population density had increased by 47.5% from 1991 to 2001 and is still on the rise (Central Ground Water Board). Darjeeling is also a popular tourist destination, leading to an increased stress on water supplies. The industry has been hit hard due to water shortages. Tourists must pay more for hotels that have water, and they are sometimes served buckets of water—an altogether unappealing situation to travelers (Sunam).

Coping

Coping strategies are almost entirely ignored in reports on Darjeeling. No study or news article has a dedicated section to the multiple ways citizens must deal with shortages: Only brief and vague mentions are made of how citizens cope.

Darjeeling produces 30 metric tonnes of waste a day, an amount that the municipality is unable to handle. In total, the equivalent of 500 full trucks are dumped into jhoras (waterways) each month ("Conserve Water Reduce Your"). These are the same waterways that some people must use to meet their water demand. Another system of coping is buying water from tankers, but this has only been addressed with a focus on hotel consumption. It has been briefly stated that fights sometimes break out as people try to buy water from tankers, leading to even more lost water in the process (Sunam).

Finally, rainwater harvesting as a coping technique has significant potential: Annual rainfall estimates range from 2,812 mm to 4,136 mm (Sunam; Central Ground Water Board). The amount of rainwater available is nine times the shortage in supply, meaning it could easily cover the deficit; however, no water harvesting systems exist. Illegal connections to the municipal pipelines are also an issue (Sunam).

Environmental Considerations

The primary environmental complications for Darjeeling are deforestation and a lack of groundwater. These are, naturally, irrevocably intertwined. Deforestation is repeatedly reported as the cause of water sources drying up (Haque and Jana; Central Ground Water Board; B. Chhetri; Khawas): Illegal and indiscriminate deforestation is blamed for reducing the number of working springs from 26 to 14 (B. Chhetri). It is also identified as a probable factor in the decreasing availability of groundwater (Haque and Jana). Soil structure in the area also makes the retention and extraction of groundwater difficult (Central Ground Water Board).

Social Considerations

The only cultural consideration is brought up in the article from Darjeeling Times. The author postulates that water shortages are prolonged to increase the difficulty of access for youth, meaning that they will have less time to dedicate towards education (B. Chhetri). This observation is consistent with class warfare theory.

KOHIMA

Where Darjeeling is lacking in information, Kohima has almost nothing available. No study exists dedicated to water supply, meaning that almost all of the information here is from news sources, which may or may not be reliable. This report is simply bringing these news articles together, not validating them.

Municipal Water System

Supply

The Asian Development Bank (ADB) provides a report on the water supply of Kohima. In 2011, there were two sources that the Kohima Municipal Council drew water from: the Dzuna River (13 km away) and the Phesama stream (8 km away). As the ADB reports, the Public Health Engineering Department supplied 1.8 MLD, with water arriving once every three days. During the lean months, an insufficient 18 lpcd were supplied, less than half of a human's basic need according to the UN (State Investment Program Management and Implementation Unit and Urban Development Department for the Asian Development Bank; "The Human Right to Water").

An ongoing water supply scheme is the Kohima water project. Sixty percent was completed as of 2013 according to the PHED minister Noke Konyak. This project is located 20 km away and was estimated at a cumulative cost of Rs 2,794.40 lakh in 2013 (Chishi). There is hope for another untapped water source—Dzukou Valley. Tokheho Yepthomi, former PHED minister, urges serious evaluation of the Dzukou Valley, where he claims there is enough water to quench Kohima's thirst (Sandham).

Distribution

Kohima uses an internal water distribution network (State Investment Program Management and Implementation Unit and Urban Development Department for the Asian Development Bank). There has been no report on leakage or percentage of the population connected to the municipal supply. A brief reprieve of privatization is administered from a blog: "...in Kohima, the price of water rises according to the whims and fancy of the water tanker boys. It is not equitable…" (Tunyi). The blog also reports that the government uses one or two tankers in the worst hit areas only a few times during the lean months—actions that are insufficient for solving the problem of water scarcity.

Water Quality

The only report on water quality comes from a news article entitled "Water scarcity still haunts Kohima residents" (Sandham). The author, Oken Jeet Sandham, reports that municipal water is safe and tested, but there are problems with private water providers during the lean season. No citations are provided.

Management

In the face of water scarcity, the government has threatened to establish a winter capital and a summer capital to meet their water needs (Chishi; Sandham). Several sources cite frustration with this announcement, as they believe that the cause of water scarcity is from indifference on the part of the government (Chishi; Sandham; Tunyi). It is even claimed that government officials use running water when their neighbors have never experienced it (Tunyi). The government is indeed facing challenges in settling land disputes for their water projects, but there is still pressure for it to continue exerting effort instead of moving away from the issue (Sandham).

Urban Vs. Rural

Land right disputes comprise the largest conflict as Kohima tries to obtain water from outside of the city. Neighbors reportedly refuse to share water with the city, citing

compensation and land disputes as the two main reasons (Chishi). The issue is supposedly not monetary; rather, it stems from a concern about having enough water in the original area (Sandham). Customary laws complicate the matter: "What was meant to protect us from exploitation from outsiders becomes our own bondage when it comes to sharing of water" (Tunyi).

Coping

There is no direct report on how citizens of Kohima cope with such an inadequate supply in the lean months; however, indirect mention is made of systems existing for coping: bottled water, tankers, tube wells (Ministry of Water Resources; Tunyi). The first is dismissed for being too expensive as a sustainable solution (Tunyi). The second is aforementioned. The third is sparingly used, as groundwater is difficult to access (Ministry of Water Resources).

Environmental Considerations

Kohima serpentines along the crest of a mountain, meaning that surface runoff moves too quickly down the steep slopes to adequately recharge groundwater (Ministry of Water Resources). Rivers are noted as being reliable and clean upstream but too polluted for use once it enters the city (State Investment Program Management and Implementation Unit and Urban Development Department for the Asian Development Bank).

Social Considerations

No specific cultural issues surfaced in the readings on Kohima; however, a common theme is expressed in regards to income inequality. The poor are noted as being disadvantaged by privatization when they cannot afford the fluctuating prices of water tankers (Tunyi).

MUSSOORIE

Mussoorie is another town impacted by both the geography of the Himalayas and the tourism which it attracts. Unfortunately, many articles about the water supply in Mussoorie are dated; only the more recent are included. It also seems that the topic of water supply most frequently surfaces when other issues are addressed, and so is often reported on indirectly.

Municipal Water System

Supply

In the summer of 2014, Mussoorie's demand of 14.4 MLD was almost twice that of its supply at 7.67 MLD (Ramola). Currently, water is drawn from 19 different brooks and streams (up from 17 in 2011) (Ramachandran and Ramachandran; Ramola). Mussoorie defines the minimum amount of water necessary for bathing and washing at 120 lpcd, with a goal of 175 lpcd, but has failed to meet these standards due to such high and growing demand (Ramachandran and Ramachandran). To increase the storage capacity of the municipal water system, the construction of a lake at Kandi Ghat was proposed. This proposal came largely in response to the increasing water demands from tourism (Sandeep). Other proposals include replacing water pumps with more efficient versions and implementing a new water scheme at the Yamuna Bridge (Ramola).

Distribution

The only allusion to distribution in Mussoorie is through energy. Energy supply is a

limiting factor in water distribution since energy is needed to pump water from most sources up to the city. In the summer, electricity shortages are more frequent, exacerbating the water shortage (Ramachandran and Ramachandran).

Water Quality

A study of groundwater samples in Uttarkhand provides the closest quantitative estimate of what citizens may be receiving in their taps or otherwise. None of the physicochemical characteristics tested exceeded the Bureau of Indian Standards (BIS) permissible levels (Table 6.1); however, the heavy metals of cadmium, chromium, and lead exceeded the permissible levels (Table 6.2) (Gaur et al.). While use of groundwater is not very high, it should perhaps be increased due to pollution in other streams. Hugh Gantzer, a member of the Supreme Court Monitoring Committee, claims that one of the most used streams near Dhobi Ghat is polluted with chemical, and that everyone knows that it is a health hazard (Ramola).

Table 6.1: Physicochemical characteristics

Parameter	BIS Standards*	Mussoorie
pH	6.5-9.2	7.4
Alkalinity	200-600	336
Total Hardness (TH)	300-600	329
T H(As Ca++)	-	249
T H(As Mg++)	-	80
Total Dissolved Solid (TDS)	500-2000	551
Suspended Solid (SS)	-	18
Chloride	250-1000	121.0
Sulphate	200-400	139

*All except pH are given in a range from desirable amount in mg/l to permissible amount in mg/L. (Gaur et al.)

There are plans to improve the quality of water: In 2013, the Rotary Club had announced a 5.5 million rupee project which would provide potable water to schools throughout Mussoorie (Dietvorst).

Table 6.2: Heavy metal concentrations

Heavy Metals	BIS Desirable Level (mg/l)	BIS Permissible Level (mg/l)	Mussoorie
Mn	0.1	0.3	0.054
Al	-	0.2	0.056
Ba	-	-	0.079
Cd	0.003	0.01	0.130
Cr	0.05	0.05	0.094
Co	-	-	0.064
Cu	0.05	1.5	0.021
Fe	1.0	1.0	0.062
Pb	0.05	0.05	0.088

Management

A local news company, News 18 Uttarkhand, reported that six families had written to the President demanding steps to be

taken to improve the water supply within three days. If not, they wrote, they would seek euthanasia. While a dramatic threat, the letters represent the frustration with the government and its role in water supply. According to the article, the government had not moved since February of 2013—a few months earlier—after receiving both verbal and written complaints ("Mussoorie: Water Crisis-Hit People").

Urban Vs. Rural

The only cited struggle with Mussoorie encroaching on the surrounding landscape does not include conflict with humans, but rather, butterflies. The ignorance of the government is scolded in an article that testifies to a pump built in a hot spot for blue butterflies (Sidhu).

Population Change

In 2001, with a permanent population of about 40,000, the city was able to supply adequate water; however, with tourists pushing the peak population to one lakh, the city was not able to consistently supply its set minimum of 120 lpcd (Ramachandran and Ramachandran). Tourists expressed their frustration with water unavailability by blaming the administration (Sandeep). Such discontent among tourists are expected to have long-lasting negative impacts on the economy if water cannot be sufficiently supplied soon.

Coping

While the municipality cannot use groundwater due to its distribution (Ramachandran and Ramachandran; Government of Uttarakhand, Department), citizens have tapped into aquifers as a way to cope. The Indian Bureau of Statistics provides a glimpse of where water is obtained from, yet no other source addresses this issue.

Environmental Considerations

A major issue with the area surrounding Mussoorie is slope instability. The hasty construction of buildings and water supply infrastructure are at risk due to active landslide areas and rock falls (Government of Uttarakhand, Department). Furthermore, the streams that Mussoorie solely relies on have reduced discharge in the summer, intensifying the issue of water shortage (Ramola). Since 1970, six of the springs used as a water source had experienced a 37% flow decrease. As of 2014, Vipin Gupta, a noted environmentalist, remarked that the heavy snowfall in Mussoorie should be enough to recharge the aquifers; whereas rainfall runoff moves quickly, snow accumulates and slowly recharges these aquifers. Gupta claims that this will "supply enough water to the rivers and springs here during the summer" (Jain). Previously, it had been recognized by the Mussoorie Municipal Council and the Centre for Ecology Development and Research that recharge areas are needed to ensure the longevity and full flow of these streams (Ramola).

Social Considerations

Although possible tension may exist between residents and tourists, their relationship is not reported on. In all, social issues are overlooked in reports on Mussoorie.

SHIMLA

Shimla is another city with an outdated water supply system. Constructed in 1875, the system was originally intended for a popula-

tion of 16,000 (Sharma, Kansal, and Tyagi). Shimla had a population of 1.7 lakh in 2011—a figure that swells three fold in the tourist season (Walker).

Municipal Water System

Supply

Shimla draws from seven water schemes: Dhalli Catchment, Cherot Nallah, Chair Nallah, Nauti Khad-I, Ashwani Khad, Nauti Khad-II, and Giri River (Sharma, Kansal, and Tyagi). The demand in Shimla is inconsistently reported, but estimates have a grim forecast for the widening gap between supply and demand: The deficit of 10.12 MLD in 2012 is expected to double by 2021 and quadruple by 2031 (Sharma, Kansal, and Tyagi).

Table 7.1: Shimla demand and supply

Year	Demand (MLD)	Supply (MLD)
2012	35.17 (Domestic)	NA
2012	64.66 (Total)	54.54
2013	37-38	12-15
2013	38-40	NA
2014	42	35-37

In 2013, Shimla was only receiving a supply of 12-15 MLD—less than half the demand—due to siltation and leakage in pipes ("Shimla faces water shortage"). Previously, however, the Irrigation and Public Health Department (IPH) reported that the city was able to maintain an average of 120 lpcd in Shimla (Government of Himachal Pradesh).

A report from the municipality in 2009 claims that water sources are being extracted at their maximum and that new sources must be found ("Water Supply"). In June 2014, the Pabbar River Project was being proposed; however, it seems unlikely to be a success as cost estimates are three times greater than the previous project that had just been shut down ("Heading to Shimla? Get Ready").

Distribution

Distribution of water in Shimla is often inconsistent. Water is reported to run for very little time and at odd hours (Dhaleta; "Water Supply"); some consumers receive water for only 45 minutes a day (Sharma, Kansal, and Tyagi). Frequent electricity shortages play a role in water scarcity; a high cost of 35 Rps per liter is in place to account for the energy cost of raising water ("Heading to Shimla? Get Ready"; "Water Supply"). Leakage is an issue, with losses of about 26% reported by the IPH Minister Vidya Stokes ("Heading to Shimla? Get Ready"). The municipality also reports that leakage accounts for up to 35% of revenue loss. Instances of leakage also increase towards the end of the pipelines ("Water Supply").

Water Quality

No comprehensive study of water quality in Shimla exists; however, one specific case study offers a glimpse into the quality of water. An investigation of a Hepatitis A outbreak found that two thirds of those infected had received their water from the Ashwani Khud system, one of the main sources of water for Shimla. The sewage deposited 4 km upstream must not have been properly treated before being distributed to consumers (Chobe and Arankalle).

Management

In 2012, city officials claimed that enough water was being supplied (Dhaleta). By 2014, many locals were blaming the government for insufficient water ("Heading to Shimla? Get Ready"). A heavy water subsidy of 90% or more for urban water is provided by the Shimla government ("Water Supply"). Overall, there is very little reported on the management of the Shimla municipal water system.

Urban Vs. Rural

There are no reports on conflict between Shimla and surrounding rural areas.

Population Change

Tourism places a significant strain on the city: Shimla swells to three times its size in peak tourism season and existing infrastructure cannot support it (Walker). The gap in supply and demand mimics the three fold growth, expanding from 5-7 MLD to 17 MLD. Extra costs are being pushed onto tourists: As one tourist reports, they had to pay 50 Rps for an extra bucket of water at a hotel ("Heading to Shimla? Get Ready"). These instances are hurting the tourism industry and hence the local economy.

Coping

While 84.9% of families in a recent survey depended on the municipal water supply system and tankers, the reliability of the system was insufficient to meet basic needs. With a norm of 135 lpcd, the study found that families with more than two people in the household had a deficit; families of six only had half of the norm (Autade and Sonia).

Table 7.2: Shimla water sources

Source	**No. of Households**	**Percentage**
Municipal	60	56.6
Well	-	-
Bore-Well	4	3.78
Water Tanker	30	28.30
Hand Pump	8	7.55
Pond	-	-
Spring	4	3.77
Total	**106**	**100**

The Shimla municipal corporation reported that over half of households have a private water supply. Rainwater harvesting shows potential: If 30% of rainfall was captured in built-up areas, it would meet over half of the domestic water demand (Sharma, Kansal, and Tyagi; Singh and Kandari). Sixty-three percent of respondents claimed they were aware of rainwater harvesting, but only 3 of 30 families surveyed had installed a rainwater harvesting system (Autade and Sonia). Another possible source is packaged water. Potable water vending machines are popping up around the city to cater to tourists, although not exclusively. At 20 Rps a package, locals may also use this alternative water source (Thakur).

Environmental Considerations

Shimla receives heavy snowfall and rain—both a blessing and a curse for the city (Dhaleta; "Shimla faces water shortage"). The same snow that attracts tourists brings frigid temperatures which have caused pipes to freeze and meters to break (Dhaleta). The outlook on rainfall is not positive either. Effects of climate change forebode a decrease

in rainfall, making it inversely related to population growth. Furthermore, the surface runoff moves too quickly down the steep slopes surrounding the city to make groundwater extraction a viable option for many (Autade and Sonia). Due to the fragile ecosystem, any widespread use of wells is discouraged (Ministry of Water Resources).

Social Considerations

No cultural influences are noted in the findings on Shimla.

LHASA

Information on Lhasa's water conditions is severely limited. The information that is available comes from several sources of questionable reliability. News reports are one such source. There is also slight mention of Lhasa's condition in literature on religious figures. Unfortunately, this is the extent of accessible data.

Municipal Water System

Supply

In 1977, it was reported that 70% of people in Lhasa had access to a tap (Barnett). More recently, in 1999, a report on the old city of Lhasa found that water supply was inadequate: Supply was intermittent and some houses had only hand pumps or no supply at all. Exact numbers were not included. At the time, the city was pumping water up from a depth of 60 meters (Alexander and De Azevedo).

A 2008 news article reports the water supply being brought back after a riot, but does not explain why it had shut off, who had shut it off, or for how long it had been shut off ("Power, Water Supply Assured"). This instance, however, contributes to the theme that conflict has a significant and negative effect on the water supply.

Distribution

Distribution in Lhasa is not directly spoken of. Mention of electric pumps being used for the water supply may lead to the problem of power shortages affecting supply. While low pressure is an issue, neither the cause nor effect is given; thus, it could be posited that, at Lhasa's high elevation, low pressure is a result of pumping from water sources at lower elevations (Alexander and De Azevedo).

Water Quality

One alarming report details allegations against officials on water quality. As the news article explains, officials were accused of poisoning the water supply. This accusation was dismissed by the officials, who said that the water had been tested by experts and was found to be clean. No report from the accusers or the experts is given ("Power, Water Supply Assured").

Another major concern with water quality was the proximity of supply pipelines to sewerage lines. Once new water supply infrastructure was laid in the old city, contamination from broken sewage pipelines was addressed to ensure that the supplied water was not degraded (Alexander and De Azevedo).

It is included in the report from 1999 that the Official Health Regulations of China require chlorine to be added to the water supply once a month—whether it actually is or not is unspecified (Alexander and De Azevedo).

Management

Management in Lhasa was celebrated for its renovations to water supply in the old city of Lhasa. All places in the old city that previously had no supply became connected to the pipelines; the city was able to supply water to more places while maintaining a low cost ("Power, Water Supply Assured"). However, management has also been criticized for allegedly poisoning water and disregarding environmental damage.

Urban Vs. Rural

There is no mention of conflict between Lhasa and rural areas.

Population Change

Population change is not identified as an issue with water supply.

Coping

Slight mention of hand pumps is made, but no other identification of coping methods in Lhasa exists (Alexander and De Azevedo).

Environmental Considerations

Lhasa was reputedly built on a marsh, which has led to issues with laying foundation. For over a year, water was pumped from what used to be a lake in order to make an underground parking garage for a new building. Concerned citizens voiced their fears about the groundwater extraction to authorities, who supposedly only replied that construction should continue at an even faster pace so as to reduce the impact on the surrounding environment. This immense extraction of groundwater was followed by subsidence: Roads have begun to crack as the ground sinks (Woeser).

A brief and anecdotal recount of an email suggests that hydroelectric dams are contributing to Lhasa's water shortage. No details are given, only a warning that they are negatively affecting the supply (Woeser). While this is not sufficient grounds to draw conclusions from, it does suggest a potential area of study in Lhasa.

Social Considerations

A social survey carried out in 1999 revealed that "water and sanitation was the field where most local residents wanted immediate improvement" (Alexander and De Azevedo). However, it should be noted that this study was conducted parallel to a project working to fix both water and sanitation.

In the case of the aforementioned unsustainable groundwater extraction, fears arise over the possible harm to ancient relics. Potala Palace, Jokhang Temple, and Ramoche Monastery, among others, are all found in close proximity to the site of extraction (Woeser). Just as the roads have cracked, there is speculation that subsidence may destroy these culturally valued places.

THIMPHU

Even though Thimphu does not have the largest population of the nine cities, it is one of the best researched. In particular, a comprehensive study was done on the water supply system—something not done or readily available for most other cities. It is especially unique in that most information comes from research or reports, not news articles (although news articles are more recent from

Thimphu than any other city). Other interesting points also arise with Thimphu which are not as frequently addressed in other cities, such as the tariff system and water policy.

Municipal Water System

Supply

The four decade old system has been expanded upon time and time again to account for the growing population, yet it has not quite kept pace with Thimphu's water demand (Babel, Gupta, and Pradhan). All water sources for the city are currently from surface water and gravity fed, but this is insufficient. Only 60% of the population was connected to the municipal water supply in 2004, and of that, less than a third had continuous supply. The antiquated system was running at 50% above capacity—causing water quality issues—to maintain these inadequate standards (Babel, Gupta, and Pradhan). There were also public taps in 2004, but the report only mentions that ten existed at the time and nothing further. Additionally, two potential freshwater sources have been located between 10-20 km away, but no specifics on location or capacity were given (Siwakoti).

The average per capita consumption as of July 2014 was 130-135 liters (Dorji). Just seven years earlier, the demand was estimated at 125 lpcd (Siwakoti), but this is from the same study that expected the demand in 2025 to be 300 million lpcd. The targeted population for water supply in 2013 was 30,000 (a third of the population), and the targeted population for 2027 is 60,000 (again, about a third of the expected population) (Wangmo; "44240-013: Urban Infrastructure Project"). This means that the current and forecasted situation will leave thousands high and dry in this Himalayan city. A different news report has an even gloomier outlook: "City officials said the water at the two treatment plants is not enough to meet the needs of the population of 124,000. The 11,000 cubic meters of water distributed by...treatment plants is sufficient for 85,000 people, if each person uses 135 liters of water per day" ("Thimphu Faces Water Crisis").

Distribution

The trend of less water down the pipe repeats itself in Thimphu, but this time there is a study to show exactly how bad it is. Babel et al. (2004) evaluated case studies of upstream versus downstream usage for both intermittent and continuous supply. In the continuous supply section, upstream consumed an average of 242 lpcd and downstream users consumer 143 lpcd. In the intermittent section, upstream users consumed 133 lpcd while downstream users consumed a meager 66 lpcd. Both demonstrate that downstream users used about half as much water—a phenomenon attributed to both leakage and excessive consumption upstream (Babel, Gupta, and Pradhan).

Water Quality

Giri and Singh (2013) show how the city is polluting itself: "The water temperature, pH, conductivity, total dissolved solids, turbidity, nitrate, phosphate, chloride, total coliform, and biological oxygen demand were lower at upstream and higher in urban area." The benthic macroinvertebrates in the study also point toward an alarming trend. Pollution intolerant species are abundant upstream of the city, yet only pollution tolerant species occur in habitats just downstream of Thimphu (Ghiri and Singh). This is probably

due in part to the open dumping that occurs in the city (Wangchuk).

Another issue in water contamination arose with the interim water project. When drilling first began, the Thimphu Thromden reported that the tested water was clean and nearly ready for direct distribution. However, the National Environment Commission (NEC) conducted tests of the Wang Chhu and found the water to be highly contaminated after the project had started ("Thimphu Thromde Fined for Violating Water Act").

Finally, the city itself has troubles treating the water. Running over capacity has led to sandiness in the water during the rainy season. Even worse, dead animals have been found in the tank at the water source. The frequency in testing this water varies depending on the test being run: bacteriological testing occurs every six months; E. coli and fecal matter testing occurs each month; turbidity and hardness testing occurs daily. The Thimphu District Municipality (TDC) reports that water generally has normal pH. TDC Executive Secretary Minjur Dorji claims that—with two treatment plants established, one nearly complete, and another to be funded by the World Bank—there won't be drinking problems in the city for another 13-15 years (Dorji).

Management

In April of 2012, a subdivision of government, the Thromden, was charged 100,000 Nus after not complying with a bill passed almost exactly a year before: the Water Act of 2011. The National Environment Commission took action after the environmental clearance certificate was not obtained ("Thimphu Thromde Fined for Violating Water Act").

Several suggestions have been made specifically for Thimphu's management of the water supply; the Global Water Operators' Partnerships Alliance through the UN aims to improve on both non-revenue water supplied (NRW) and obtain the ideal continuous supply ("Thimphu City Corporation"). Babel et al. (2004) also evaluated the financial feasibility of how the water supply was managed. Furthermore, they found that the rate of NRW distributed was too high at 38%. The study suggests raising the tariff, especially considering that water was significantly lower than 5% of the monthly income on average—the standard for water pricing in Bhutan (Babel, Gupta, and Pradhan). This suggestion came about ten years before the Thromden reported that they had no budget for water supply projects (an announcement that came only eight days before the report that the World Bank would be funding a new project) (Babel, Gupta, and Pradhan; Dorji).

In contrast to the missteps of governance, two citizens' anecdotal tales asserted that the city is in fact doing good work—granted, this was after the news of progress on water supply projects (Wangmo). Another positive aspect of management is the passage of the Water Act 2011, a positive and inspiring step towards more comprehensive water management.

"The Bhutan Water Policy (2003) recognizes that water is a precious natural resource that is basic to all social, economic and environmental well-being and, as such, the water resources need to be conserved and managed efficiently, while ensuring sustainability and without damaging the integrity of the environment. The Policy adopts an integrated approach that recognizes natural linkages and covers all forms of resources including snow, glaciers, rivers, lakes, streams,

> springs, wetlands, rainwater, soil moisture and groundwater, to achieve poverty alleviation and increase Gross National Happiness (GNH)."
>
> – ("Bhutan")

Urban Vs. Rural

No conflicts are reported, only the pollution of rural areas (see Environmental Considerations).

Population Change

There are several different estimations on the population of Thimphu in coming years, but they all show the same trend—significant growth. Estimates begin with the provided fact that in 2005, there was a population of 79,185 and a growth rate of 7%. Each estimation also agrees that, naturally, the demand for water will also rise with urbanization. The exact prediction, however, ranges. An ADB report puts the population of 2025 at about 184,000 while another report posits a significant growth towards almost three million ("44240-013: Urban Infrastructure Project;" Siwakoti). An evaluation of Thimphu's water demand up to 2020, from a declining growth rate to a constant growth rate, is about 23.43-40.313 MLD (Babel, Gupta, and Pradhan).

Coping

Even though houses have gone four days a week without water, there is no information in the reviewed literature on how citizens of Thimphu cope with the shortage (Dietvorst).

Environmental Considerations

The landscape of Bhutan contributes to Thimphu's problems. With many inclines at a 30% or greater slope, landslides are quite frequent. Heavy rainfall and sudden cloud outbursts are expected to increase with climate change; this alteration in precipitation patterns will exacerbate the issue of landslides. Furthermore, with wetlands paved over in the process of urbanization, the increased amounts of runoff will be unable to infiltrate the already steep landscape (Wangchuk).

Social Considerations

At this time, there are no documented social issues relating to water supply.

KABUL

Kabul is a city plagued by war torn people, buildings, and water supply. Decades of conflict have both destroyed parts of the system and reduced the available data in the region. The issue of water availability has grown with the population and is exacerbated by a four-year drought. NGOs and other aid organizations are playing a large role in bringing Kabul out of its vast water crisis. Generally, reports on Kabul are quite thorough and reputable, making it one of the most well analyzed cities in this report.

Municipal Water System

Supply

The supply situation in Kabul is dire: An average of only 15 lpcd of drinking water was distributed in 2013. The Afghanistan Urban Water Supply and Sewerage Company (AUWSSC) is only able to cover the water needs of less than 20% of Kabul ("Kabul Urban Water Supply"), although the esti-

mate from the government is higher at 35% connected (Integrity Watch Afghanistan). In 2007, residents received water 2-3 hours a day (Lashkaripour and Hussaini), but this had marginally improved to about 12 hours every other day in 2013 ("Kabul Urban Water Supply").

Distribution

Once again, distribution is limited by energy. Lashkaripour and Hussaini (2007) report that water supply is limited by the amount of energy available to pump water to Kabul. There is enough water in the basin for over 7,900 lpcd, but the system does not capture and equally distribute enough of this water (Integrity Watch Afghanistan). A joint report from the U.S. and Afghani governments, titled *The Forgotten Front: Water Security and the Crisis in Sanitation*, spells out the inequalities in distribution. Often, upstream consumers overuse and pollute the water for downstream users, reminiscent of a local proverb: "Better to be a servant in the upstream area than a king in the downstream area" (Integrity Watch Afghanistan).

Water Quality

The inadequate state of waste management in Kabul has led to contamination of what clean water there is. Only 3% of houses connected to the sewage system, and over 86% have a cesspit, which are often in poor condition and overflow (Himmelsbach et al.). This poses a significant threat to the well-being of the city since the mixing of sewage and dirt with water contributes to the spread of waterborne diseases (Eng. Habib Rahimi). Furthermore, about 400 tons of solid waste is produced each day—an amount that the municipality cannot handle. The incredible amount of untreated waste has led to high amounts of nitrate, boron, sulfate, dissolved solids, and fecal bacteria in the water (Himmelsbach et al.; Lashkaripour and Hussaini). This has major implications for human health; the high infant mortality is partially attributed to unhygienic water. From a positive standpoint, redox and high pH buffering capacity have mostly precluded the movement of heavy metals (ie. arsenic) through the water (Himmelsbach et al.).

Management

NGOs have been prominent in Kabul's water supply due to the horrid conditions brought about by war (Pinera and Reed). More recently, though, the German Development Bank agreed to lead a project which would significantly improve the supply system ("Kabul Urban Water Supply").

Program Objectives:

- Increase piped water coverage to a total of at least 1.4 million people (or about 29 percent of the Kabul population of 4.5 million in 2010);
- Increase production from 60,000 to 120,000 cubic meters(m3)/day, (approximately 44 million m3/annually);
- Increase the distribution network from approximately 500 to 1,300 kilometers; and,
- Increase house connections from 30,000 to 90,000."

Community management has sprung up in times of need. These local schemes can provide immediate relief, but there is no guarantee of the quality of water being distributed. There are also gang-related issues when groups within the same community have had their trust eroded by years of conflict, making cooperation in managing water sources extremely difficult (Pinera and Reed).

The complexities of management continue with the Afghani government. In the literature reviewed, their words are more prominent than their actions. It took Kabul three years just to fully conceptualize a plan for the development of water utility (Pinera and Reed), let alone begin work on it. President Karzai was reported as condemning illegal wells and assuring that the government would take action against it. Finally, Latif Muzzaffar Khail, head of the Directorate of Irrigation and Water Supplying System, has also said that the government is coordinating and has plans in place but is awaiting approval from the Council of Ministers (Stanikzai).

Urban Vs. Rural

Information on conflict between Kabul and the surrounding areas is not available.

Population Change

Kabul has experienced recent and rapid population growth, nearly doubling from a population of 1.8 million in 2002, to 3 million in 2004 (Himmelsbach et al.). In 2010, that number had again doubled to about 6 million (Vidal). It is estimated that six times as much water will be needed to support the population of 9 million in 2050 (Integrity Watch Afghanistan; Vidal).

Coping

Coping methods are widely used in Kabul due to the small percentage of citizens supplied with municipal water. Pinera and Reed (2009) found that there was widespread reliance on wells since the water supply scheme had not been adapted for the unplanned settlements. In fact, open wells and hand pumps are the main source of water for the majority of the population ("Kabul Urban Water Supply"). As with other places, the cost of coping is often a significant financial burden for the residents. Anecdotal testimonies put the price of a gallon at 20 AFN ($0.36 USD) and barrels at 150 AFN ($2.67) (Stanikzai). These prices may have contributed to the proliferation of illegal bore wells in Kabul. Khail confirmed the abundance of illegal wells, which not only contribute to the unsustainable depletion of groundwater, but also cause legal wells to dry up.

Environmental Considerations

Groundwater is a limited commodity in Kabul, and, based on past and current trends, it may be even more difficult to obtain in the future. Thousands of wells are now extracting groundwater throughout the city (Himmelsbach et al.). The unsustainable rate of extraction is due to the persistent water scarcity, and as urbanization increases, cementation of recharge areas will limit the amount of water available even further. A drought from 2000-2004, naturally, reduced the available rain, surface, and groundwater for residents of Kabul (Himmelsbach et al.; Lashkaripour and Hussaini).

From 1965-2005, the Kabul aquifer water level had dropped 6-7 m (Lashkaripour and Hussaini). From 2004-2012, there was a slight increase in the water table (which is to be expected after a drought) (Domènech, March, and Saurí); however this was in the whole Kabul Basin. Looking to only the Kabul subbasin, where most of the city is, the water table dropped 15 m from 2008-2012 (Domènech, March, and Saurí). Several wet years would be needed to restore the aquifers (Himmelsbach et al.), but this seems highly unlikely given current climate change predictions which forecast prolonged droughts in the future ("Kabul Urban Water

Supply"). Yet, even if precipitation were to increase, the high rate of evaporation and high concentrations of salt have left the groundwater unfit for human consumption (Himmelsbach et al.). Mack et al (2013) reports that potential mining sites in the area could further contaminate the groundwater for Kabul.

Social Considerations

War has played a major role in shaping the scene of water supply in Kabul. Two and a half decades of conflict have destroyed parts of the municipal water system as well as prohibited geologic surveys from being conducted (Himmelsbach et al.; Lashkaripour and Hussaini). This means that not only was the system damaged, but there wasn't adequate research available to determine the most efficient way to repair and build upon it, exacerbating the issue of water scarcity. The demise of the Taliban has also had an inadvertent effect on water availability, as it is partially responsible for the boom in population from 2002-2004 (Himmelsbach et al.). After the war, many migrated back to the city but did not have access to the tap (Pinera and Reed). Large unplanned settlements are now without water and sanitation; thus, the water flowing from these settlements is often highly polluted once it reaches users downstream (Integrity Watch Afghanistan).

Solutions

It is essential to understand that the issue in water supply is not due to a lack of water. Time and time again, it has been shown that there is plenty of water in the Himalayas to quench the thirst for millions of people.

The real issue lies in distribution. Illegal connections, slow government action, leakage, and inefficient systems have degraded and reduced the available water. Yet this is good news—it is not a physical water shortage that must be dealt with, it is economic water scarcity.

Several studies have shown that water from the municipality is *too* affordable. The water has often been so subsidized that the division in charge of water distribution does not have the funds to maintain or increase the quality and quantity of water. Suggestions so simple as raising the tariff to internationally accepted rates of paying for water could have monumental positive impact on the quality of water supplied.

It is also recommended that NGOs play a larger part in the water supply schemes. Specifically, they are often identified as the ones most appropriate for distributing information and generally educating citizens on health and sanitation with water.

Finally, it is undeniable that these cities are growing. The amount of water may only be enough in these cities if it is used wisely.

Rainwater harvesting is a technique that has been gaining momentum. Both NGOs and private corporations have sponsored the widespread use of collection tanks and pipes to capture and use precipitation.

Reducing the amount of water used—while not a new idea—is also prevalent in suggested solutions. Flush toilets are identified as one of the greatest detriments to sustainable water usage in cities, and the eradication of the western sewage system for something more water efficient is a highly plausible solution. It may even become a necessity as the situation worsens.

Conclusion

Several themes occur with the literature available on urban water supply in the HKH Region. As is obvious from length, there is not sufficient data nor news sources for each of the cities. Kathmandu, Kabul, and Bhutan stand out as having the most research done on them, while the Indian cities of Darjeeling, Shimla, and Mussoorie have many news reports. Furthermore, these reports often have little focus on what happens downstream of the city itself; instead, any reference to pollution downstream usually refers to downstream within the city itself.

In contrast to this, while the literature report is not on rural areas, it seems that there is a much larger base for reports on rural areas in the Himalayas than the urban ones. Similarly, the focus of this literature is almost entirely on households—very few sources even mention industries using municipal water. No study was found that focuses solely on the industrial use of water in these cities.

When it comes to perception of the people using the water, it is frequently noted that the impoverished suffer from water shortages disproportionately. Along these lines, there is not enough data on how citizens cope with the lack of water from the municipality. Instead, reports are more likely to contain the source of water for the

municipality itself. When blame for the insufficiencies in water are placed, it is most commonly on the government. Only a few times are fingers pointed at other users (although this is especially the case in unequal distribution—something that is ultimately linked back to the government's failure to properly plan the pipe system). The government is often portrayed as apathetic towards the situation, unaware of the details, and unmotivated to change it.

Groundwater is very well considered throughout many of the cities; however, not as much attention is given to climate change. The condition of a river in the city or other water sources can usually be found anecdotally, but tests of these sources are more difficult to come by. It must also be noted that scarcity is almost never from a physical lack of water; economic water scarcity is the true problem. In every city, there is enough precipitation, surface runoff, and groundwater to sustain the citizens, but the issue lies in the unequal distribution of this water to each person.

Tourism is another, perhaps unexpected, connector of these cities. The same beauty that attracted settlers thousands to millions of years ago also draws large numbers of foreigners to these cities. This puts a major strain on some of the municipalities, especially in India, as they attempt to keep pace with the rapid population change. Electricity also plays a central role in water supply, limiting the amount of water that can be pumped up to these high-elevation cities.

Finally, there is no connecting language for urban centers in the Himalayas. No comprehensive coverage of these issues occurs when so many of the hill and mountain cities are facing similar issues. Oftentimes, report of water issues are tucked under other issues or are not directly reported on. It is essential to under-stand the extent of these water problems and the plausible solutions for mountain cities, so that the water supply situation might be improved in other cities throughout the Himalayas.

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