Climate Adaptive Water Management Practices in Small and Midsized Cities of Nepal: Case Studies of Dharan and Dhulikhel

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Abstract

Nepal, one of the fastest urbanizing and most disaster-prone countries in the world, faces a looming urban water crisis due to rising temperatures, changing climate, and a rapidly growing population in its cities. Changes in rainfall patterns, growing industrial activity, changing lifestyle of the emerging middle class, unplanned urban development, and rapidly increasing urban populations are all contributing factors to the Himalayan cities becoming more water stressed. Limited water access, poor infrastructure development, inequitable distribution, inefficient water resource management, supply-demand mismatch, and institutional inefficiency are the key issues surrounding water insecurity. Multiple, fragmented, top-down institutional arrangements in water governance pose a challenge for effective, equitable, and decentralized water planning and management. This article presents a case study of the struggles over water scarcity and water management in one small and one midsized city in Nepal—Dhulikhel and Dharan. It examines the research, collaborative strategies, and policies for the codevelopment of innovative approaches to meet the rapidly increasing water demands.

Keywords: climate; Nepal; urbanization; water

Introduction

The International Panel on Climate Change[1] has determined that since 1870, the global mean temperature has been rising approximately proportional to the cumulative total anthropogenic CO_2 emissions. The average global annual temperature rise for 2016 was 0.99°C, making it the warmest year on record.[2] Changes in weather patterns and increased frequency of extreme weather events such as heavy precipitation, longer drought periods, and intense tropical cyclones have all been observed since about 1950.[1]

In addition, climate change has multiplier effects, which have increased the frequency of droughts, extreme precipitation, floods, and other water-induced disasters affecting agriculture, human health, hydro-energy systems, infrastructure, human settlement, potable water supply, and overall human well-being.[3] Furthermore, these climate-induced impacts are not limited to specific sectors or geographic areas: the impacts can also be observed in local overdevelopment, crumbling infrastructure, threat to livelihood opportunities, health problems, loss of topsoil, degradation of environmental resources, and lack of clean water. Changing climate is playing havoc on an already scarce lifeline resource—water.

Research indicates that temperature rise will have direct impacts on the availability of water resources because of changing flow regimes in snow-dominant or glacier-effluent river basins.[1,4] The glacial and snowmelt water yields will increase in many regions during the next few decades, and thereafter, the water yields will gradually decline. Higher air temperatures will increase the temperature of surface water, resulting in negative impacts on freshwater ecosystems and

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reducing raw water quality, thus posing risks to drinking water quality, even with conventional treatment.[4] Changing climate, rising temperatures, rapid demographic concentrations, and weak institutions in the urbanizing world will have adverse impacts on the supply and demand of water resources.

An urban water crisis is looming large in many parts of the world as a result of demographic and environmental changes.[5] The scarcity of freshwater is particularly severe in South Asia due to the melting of Himalayan glaciers, changes in rainfall patterns,[6–8] growing industrial activity, changing lifestyle of an emerging middle class, unplanned urban development, and a rapidly increasing urban population. Limited access and inequitable distribution of portable water, poor infrastructure development, inefficient water resource management, supply-demand mismatch, and institutional inefficiency are key issues surrounding water insecurity. Multiple, fragmented, top down institutional arrangements in water governance in Nepal are posing a major challenge for effective, equitable, decentralized water planning and management. The impacts of climate change and water insecurity are distributed disproportionately among the urban population.[9] The poor are the most vulnerable to climate change stresses and water extremes, especially women, children, the elderly, and the disabled, who bear disproportionately higher costs.

Background

Nepal, one of the top-ten fastest urbanizing countries in the world, has a projected annual urbanization rate of 1.9 percent for the period 2014–2050.[10,11] Rapid urbanization has led to a water crisis encompassing conflicts between urban and rural demands,[12] inequities in financing the mega-water infrastructure,[13] and maintaining the health of the water ecosystem.[14] Nepal's cities, however, are often too slow to respond to a water crisis given the physical unavailability of water and complicated social dynamics that include an inadequate understanding of impacts of climate change, a haphazard quick-fix development approach, and weak political, economic, and governmental institutions.

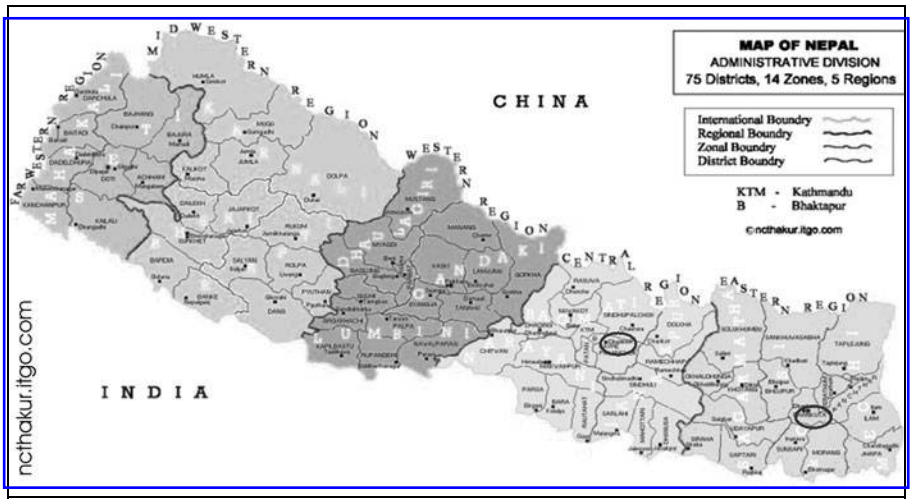

Figure 1. Location of case study cities in Nepal

This article presents case studies of the water scarcity and management issues in one small and one midsized Nepali city, Dhulikhel and Dharan, respectively, and describes their struggles in meeting the increasing water demands due to climate change, rapid urbanization, and population growth. The objective of this research initiative in Dhulikhel and Dharan was to analyze existing water management systems of these cities and identify water conflicts, challenges, and management problems in order to initiate large-scale positive change. Pilot-testing determined that the scarcity of water resources was a result of a decline in water discharge (a notable impact of climate change), and the distribution mechanism for available water is a critical issue for water security. Further, equitable distribution is hampered by associated political, economic, and institutional arrangements.

The nonexistence of local government—democratically elected people's representatives—for almost two decades in Nepal has also played a crucial role in the inadequate management of water at the local level. The case study described in this article presents a unique collaborative model that was used to address the issue of local governance and its scattered, redundant, and disconnected practices of water management, and to implement plans to make the hilltop city of Dhulikhel and foothill city of Dharan water secure.

Overview of Dharan and Dhulikhel

Dharan

Dharan is one of three major cities in eastern Nepal, located in Sunsari District, and situated at the foothills of the Mahabharata Range to the north, with its southern tip touching the edge

of the Tarai region at an altitude of 1,148 feet (349m). Dharan serves as a gateway trading post between the hills and plains of the Tarai region. It hosts numerous hotels, production industries, retail businesses, agriculture tracts, religious places, and both a state and local user-managed drinking water system, all of which are integral parts of the city's economy. It is also a major educational hub that includes a variety of educational institutions.

The city's resident population of over 200,000, along with the increasing number of immigrants, is reeling under an acute shortage of drinking water. Many have been forced to walk long distances, queuing for hours to fetch water, or use untreated water from local rivulets. The Nepal Drinking Water Corporation, Dharan* has only been able to supply 15 million liters per day of water although the demand is twice that amount. This acute water scarcity is mainly because of the city's location at the foot of a low hill with limited surface runoff from the catchment areas.[15] With a growing population, the city is struggling with the management of water from its multiple sources—mainly upstream catchment flows and ground water bore wells.[15] Though about 98 percent of Dharan households have access to piped water, this water supply is largely confined to the rainy season, with the supply being intermittent, untreated, and unsafe.[16]

Although Dharan receives about 70 inches (1,800 mm) of rainfall annually, mostly between June and September, the heavy rainfall turns into storm water, causing flooding downstream. This rainfall is not effectively captured to enhance the water management practices of Dharan. There is one water treatment plant, which gets its water from the main local stream (Shardu Khola), but it does not run properly because it cannot handle the volume of water, particularly in the rainy season. In addition, Dharan does not treat the pumped groundwater, which augments the stream water supply. A study conducted by Panta et al.[17] concluded that most of the water sources and reservoirs in Dharan are heavily contaminated with microorganisms, an alarming situation. The city has not yet initiated quality control for its water supply and is struggling even to meet the requisite quantity needed for its current population; it remains without a plan for future growth.

*The Nepal Drinking Water Corporation, Dharan (NDWCD) is a state-sponsored initiative established many years ago for managing the demands of water in many cities of Nepal.

Dhulikhel

Unlike Dharan, Dhulikhel is a hilltop city located in the mid-hill region of east-central Nepal, 30 kilometers east of Kathmandu, the capital city of Nepal. Dhulikhel is one of the three major urban centers in the Kavre Valley, with a population of 66,405.[18] Dhulikhel is a rapidly emerging satellite city of Kathmandu and it bears prime importance from a commercial point of view, with a trade link to Tibet, the autonomous region of China. Integral components of the local economy include Kathmandu University, Dhulikhel Community Hospital, hotels/restaurants/lodges, businesses, and local farms.

Dhulikhel gets its drinking water from a community-managed drinking water supply organization known as Dhulikhel Drinking Water User Committee (DDWUC). The system has been operational since 1991 and provides a best practice example of water management in Nepal. Yet several issues and challenges related to climate adaptive equitable water management strategies and practices remain in the face of rapid urbanization, expansion of infrastructure development, tourism services, changing climate, and farming practices.

The city has struggled to obtain a reliable water supply for over three decades as it experiences variable rainfall patterns and escalating water demand. The Nepali government's decision to annex the surrounding areas into the Dhulikhel Municipality in 2014/2015 expanded the city's geographic size, which resulted in an increased demographic and added water demand. The city has water pipes that connect to 48 percent of households, but even these households do not receive the amount of water they need.[16] All told, the DDWUC supplies 13.8 million liters of water per day; however, the demand is 23 million liters per day.

In Dhulikhel, there is a wide gap in water access between the urban poor and residents with their own houses, hotel owners, and the wealthy. DDWUC has divided Dhulikhel into three categories for water supply. For the first category, it provides seven-hour water service to the core—downtown—of Dhulikhel every day, and five hours of daily service to the second category in the semi-periphery—an adjoining area of downtown.[19] The third category is a water-poor zone—newly annexed areas—which consists of three blocks: block A gets service for three hours a day, block B for 30 minutes a day, and, block C for 15 minutes every 24 hours. This rationing of water illustrates the water distribution inequality of Dhulikhel.

The Study

Both Dhulikhel and Dharan have been facing increasing water demands

as they struggle to supply water amid variable and unpredictable rainfall due to the changing climate, fast urbanization with high population influx, and expanding territorial areas. The Climate Adaptive Water Management Plans for Cities in South Asia (CAMPS) project implementation process completed its first year in March 2017. It identified the following fundamental water issues in the two cities: changing climate impacts on critical urban water zones; mismatch between supply and demand water management; and conflicting interests in determining water distribution as demand increases due to expansion of the city, industries, households, and farming practices. The idea of a critical urban water zone has never been incorporated in the planning and management process for Nepal's cities, whose local governmental bodies were comprised of unelected officials. There have been no elected local councils since 2002, leaving a public accountability and transparency vacuum, and a challenge in tackling the fundamental drivers of water insecurity.

With this backdrop, the researchers set out to fill the gap of local stakeholders' engagement in various research and action activities through collaborative and deliberative approaches. They proposed to formulate water forums in each of the cities to co-create knowledge by blending empirical science produced by researchers and local knowledge and experiences of local stakeholders, avoid duplication of research and development projects, and build local ownership of the project, expanding and improving the pilots while maintaining sustainability. Participatory, collaborative, and collective interdisciplinary engagement between the researchers and local stakeholders for sharing, co-learning, and cocreation of knowledge bridges the gap between different fields of knowledge, values, experiences, and the friction between bottom-up and top-down approaches.[20–22] Evidence from development studies have stimulated collaborative and participatory learning approaches in natural resource management and adaptation efforts, particularly in the less developed countries. These methodologies encourage co-learning and coproduction of knowledge between local social actors (i.e., relevant stakeholders, marginalized and vulnerable groups), scholars, and practitioners, which can challenge uneven power structures.[20,22–24]

Research Methods

This article describes a case study of water insecurity in two Nepali sites in an effort to develop climate-adaptive and equitable water management practices and strategies (CAEWMPS). The study was piloted in Dhulikhel and Dharan, two cities facing water shortages. The researchers conceptualized CAEWMPS as a holistic, innovative, and integrated approach that sets up a new framework to address both institutional and practical issues. The practical framework includes taking actions on the ground—better capturing of natural water, increasing groundwater recharge, rainwater harvesting, better use and reuse of water, enhancing technological efficiency, reliability in supply, equitable allocation, and equitable cost and benefit sharing—and addressing institutional and systemic issues as applied to the specific locales. These institutional aspects include: increasing awareness of local efforts so as to allow for the emergence of local water champions; keeping monitoring mechanisms in place; developing new incentive arrangements; disseminating new and transformative knowledge for the management of water conflicts; and developing partnerships, new collaborations, and social enterprises. Both parts of the framework involve research and pilot components.

To avoid redundancy and promote long-term sustainability of the research and pilot impacts, the study adopted a participatory and collaborative approach from the very beginning, from design to implementation. Review of literature shows that a few adaptation studies have adopted a participatory research design that explicitly embraces processes of joint decision making between vulnerable populations, researchers, knowledge brokers, and key stakeholders.[25] The research was based on predominantly qualitative, demand driven, collaborative, and participatory inquiry between the primary stakeholders (those affected and city stakeholders) and secondary stakeholders (the researchers and other organizations working in the area of water security); the objective was to implement sustainable water management at the case study sites.

To initiate the study, the researchers organized one-day city-scale stakeholder launch meetings in each city in order to identify the key water stakeholders/leaders/champions, water issues and challenges, climate change knowledge, and local understanding and knowledge about making the cities' water secure. The researchers created the City Water Forum (CWF) to act as a platform for sharing and coproduction of knowledge, and highlighted its role at the initial meetings. The city-stakeholders recognized the importance of CWF and established one in each of the study cities to enable a participatory and collaborative research approach to develop, design, and implement CAEWMPS, as well as to mainstream CAEWMPS

planning and policies at the city and national levels by engaging key stakeholders, including the municipal government, water user committees, and water managing institutions such as DDWUC and NDWCD in each city. The CWF holds meetings on a regular basis as required for research sharing, consultations, and pilot development.

The study included both field research and a study of the relevant research literature. The field research included four water forum meetings, two focus group discussions, and twelve key-informant interviews. The scope of the research included relevant scientific and policy literature on the crosscutting themes of climate change, urbanization, and water security.

Water Forums for Collaborative Research

The researchers envisioned the City Water Forum as a platform for all water institutions and city stakeholders, who often remained scattered, disconnected, and redundant, to discuss the water issues and challenges that they confront in the city. The lack of an elected local government in Nepal made the founding of CWF even more urgent and necessary. The bureaucratic approach, including the ad hoc government decision to nominate a local body without elections that included local level politicians from all the key local political parties (known as All Party Mechanism, or APM) to assist in the decision-making process, received severe and wide criticism, charging that it would be unable to remain pro-people, transparent, and accountable.

As directed by APM, the national political parties self-picked and nominated local politicians who had not been elected by the constituents but were involved in facilitating the local government activities of development, adaptation, and resilience building. These politicians were found to be encouraging corrupt practices and degeneration of development. In the absence of a strong and accountable local government, development research and development activities are either only theoretical and never take place or mired in bureaucracy that results in redundancy. This conclusion can be drawn by analyzing the disaster management roles assumed by the government bodies, INGO, and local NGOs after the April 2015 Nepal earthquake (the Gorkha earthquake), which killed nearly 9,000 people and injured 22,000.[26]

The lack of locally elected officials and ad hoc scattered deliberations about local challenges make any research and the implementation of developmental activities a herculean task. Public dissemination of scientific knowledge about global climate change and its impacts at the local level, along with public understanding of population growth trends and its relationship to the increase in current and potential future water demands, is a necessary, albeit daunting, challenge. Conflict between upstream and downstream communities and different water-user groups in the cities are also obstacles of sustainable water management.

Avoiding duplication of research and implementing and tracking pilot studies are essential to saving resources, finding local solutions, and achieving local ownership of long-term sustainability. To address these issues and achieve smooth implementation of remediation at local levels, the CWF has become critical for the success of the water-related programs. The CWF was conceived as 1.) a knowledge hub for sharing various water-related findings from researchers and scientists, incorporating the local knowledge from water champions and local citizens;[20,21] 2.) as a platform to share ongoing project activities and avoid duplication; and 3.) as a forum to actively engage the local population in the design of the project, pilot, and implementation, thus establishing local ownership for sustainability. The CWF provides a very active and participatory role to all the stakeholders in order to arrive at a consensus through deep discussions on the water-related issues and its challenges.

The researchers facilitated the establishment of one CWF at each case study site: Dhulikhel Water Forum and Dharan Water forum. More than 16 institutions are represented in the Dhulikhel Water Forum, including the municipality, the Dhulikhel Drinking-Water-User Committee, the Department of Soil Conservation, the Department of Forest, the Hotel Association Dhulikhel, water-user committees, women's networks, upstream and downstream water-user communities, among others. Dhulikhel Municipality and DDWUC have now assumed a leadership role and have organized CWF meetings in close coordination with the research team. The first meeting focused on issues of representation, design, legal issues, governing structures, and scope.

The second meeting formalized the Dhulikhel CWF, finalized leadership roles, and defined the scope of work. It was decided that Dhulikhel Municipality would provide the leadership role and DDWUC would act as secretariat for coordination among multiple institutions. The municipality explicitly articulated its interest and willingness to adopt the water security policy recommended by the researchers in collaboration

with DWF in its yearly planning and programming book.[27] At this meeting, a prioritized list of possible pilots was developed, considering the practice aspects of CAEWMPS, for example groundwater extraction, recharge ponds and contours development, and watershed conservation. Discussion also included the institutional aspects of CAEWMPS. The municipality and DDWUC agreed to work to amend existing institutional policies that favor house/landowners, often males, so that the decision-making process can become gender balanced and inclusive.

The two-day residential water and gender training was organized by the research team. Officials from municipalities and the water boards participated in the training, which became an important eye-opener for the participants as they embraced the change and became champions of gender equality.[28]

In Dharan, the first CWF meeting formally established the Dharan Water Forum, which participants agreed would be an extremely useful forum for public deliberation, knowledge sharing, planning, and policy development for making Dharan a water-secure city.[29] This sub-metropolitan city became interested in providing leadership to the Dharan Water Forum in close coordination with the research team. At their second CWF meeting, the Dharan Water Forum narrowed down the highly prioritized pilot options suggested by stakeholders at the first meeting.

Rainwater harvesting at individual households through the development of pits at each house, with government subsidies for the practice, and Shardu watershed conservation were identified as the improvement projects for CAEWMPS in Dharan. The researchers were able to convince the stakeholders that climate change and water scarcity would affect Dharan's businesses. This information prompted the Hotel Association of Dharan to commit to printing "Save Water" stickers to share with all hotels, and large water-use retailers to encourage water-conserving practices through public awareness.[30] The retail industries are also being convinced to develop and sell more water-efficient products, such as low-flow valves for toilets and showers. The key stakeholders at the Dharan CWF agreed to develop an incentivizing mechanism, such as PES (Payment of Ecosystem Services), to be folded into sub-metropolitan policy, as a means of contributing to the quality and quantity of surface water and groundwater harvest.[31] Mechanisms to support diversifying livelihood activities in the upstream areas were also discussed as an option for watershed conservation.

The second meeting also showed the Dharan CWF as a useful platform through which sub-metropolitan cities can access scientific and local knowledge, better understand local needs, and provide locally owned solutions while also institutionalizing CWF.

According to DDWUC officials, Dhulikhel Municipality, Dharan Municipality, and the CWFs have been a very useful platform through which to share scientific research and local knowledge, to build the capacity of scattered, redundant, and disconnected water institutions, and to enhance the institutional capacity for efficient water management. This model may be scaled for use in other similar-sized cities to make them water secure.[32]

Conclusion

The small and midsized cities are growing rapidly in the Himalayan Federal Republic of Nepal. Cities like Dhulikhel and Dharan are already water scarce due to climate change, rising population, water-intensive industries, and changing lifestyles. Cities are slow to respond to increasing water scarcity. To achieve sustainable water security for these Nepali cities, locally owned, scientifically proven interventions are required. The lack of an elected local government has been an obstacle for sustainable local development for the last 20 years. However, elections were held on May 14 and June 14, 2017, casting some hopes and aspirations, though they are yet to be realized. The third phase of local government elections in Province No. 2 of Nepal [as of press time] is expected to take place on 18 September 2017.

The case studies of Dharan and Dhulikhel illustrate the success of CWFs in these cities. By providing a platform for all the water stakeholders, who had been disconnected and scattered, the CWF enabled interested parties to come together and engage in dialogue to address water scarcity in their city and existing upstream-downstream conflicts. CWF continues to foster sharing knowledge among scientists, local government officials, and local residents to cocreate local solutions, thus avoiding external imposition and encouraging lasting local ownership. In addition, the CWF serves as a repository of data collection that helps avoid duplication of program/research development and implementation.

Through these CWFs, some important milestones have already been achieved in Dhulikhel and Dharan. For example, the CWF, through its leadership of DDWUC, has made significant progress in augmenting the water supply system of Dhulikhel, enabling it to provide water service to 70 water-poor

households. Programs for groundwater extraction and water-recharge ponds are being implemented as pilots in the watershed area of Dhulikhel after completing necessary research into climate change impacts and geo-hydrological, social, and water governance.[32] Ten recharge ponds and four contours have been piloted so far. The extraction rate and springs' water discharge are being monitored to investigate and confirm whether the recharge ponds and contours pilots will increase water yields in the future. Local stakeholders have owned the decision making, the selection of projects, and the implementation with a goal of long-term sustainability.

Local innovations and initiatives are ultimately the key to sustainable water management for cities as water stress becomes an ever-greater problem. In the case study cities, the CWF has proved to be an important platform for cocreating and co-implementing knowledge. Participatory cocreation and co-learning of stakeholders' knowledge has empowered an inclusive, integrated, and adaptive decision-making process. It has brought together scattered and disconnected actors and agencies from multiple institutions, and has served as a unique and innovative deliberative model to address the social, political, economic, and institutional obstacles to making cities water secure. This is a novel and powerful method that can be used to infuse participatory and collaborative research and pilot and implement plans for making cities water secure and sustainable.

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