Traditional Water Resource Use and Adaptation Efforts in Nepal

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Abstract

Rapid population growth, unplanned urbanization and the drying up of traditional water resources have caused water scarcity in the Kathmandu Valley of Nepal. The impact of climate change has further exacerbated the increasing problem of water scarcity. Traditional water resources such as stone spouts and wells play an important role in meeting the increasing water demand in the Kathmandu Valley. This paper examines water use and conservation efforts of traditional water resources, especially stone spouts, which have been practiced over many centuries in the Kathmandu Valley. This study used qualitative inquiry to inductively generate data from fieldwork through interviews with stakeholders and the observation of 64 stone spouts in Kathmandu, Bhaktapur and Lalitpur districts. The study reveals that there is not adequate attention given by the state and non-state authorities to the conservation of traditional water resources, despite their high potential to contribute to climate change adaptation practices, and suggests ways of allocating resources to implement conservation activities; more specifically, the implementation of the Declaration of the National Convention on Stone Spouts of 2007. Local conservation efforts are useful climate change adaptation practices that can be used to improve water management.

Key words: *traditional water resources, stone spouts, water scarcity, climate change, local conservation efforts*

1. Introduction

A stone spout(1) is a type of traditional Nepali water resource. It consists of a stone, through which water is channeled to serve as a tap. Stone spouts are usually attached to a shrine and arranged symmetrically on a vertical wall (Pradhan, 1990). An uninterrupted stream of water flows from the channel in the carved stone utilizing rain, surface, and ground water resources to maintain the flow. Stone spouts are found extensively in the Kathmandu Valley. There exists a record of 400 traditional stone spouts in the Kathmandu Valley (UN Habitat, 2008). Pradhan (1990) mentions that 95% of Nepal's stone spouts can be found in the Kathmandu Valley and most of stone spouts have been widely used in Nepal since the 15th century, while evidence shows that the oldest stone spout dates back to 550 A. D. There are also claims that stone spouts were constructed before Licchavi period (400-750 A. D.) by the various ruling dynasties of the Kathmandu Valley. Shrestha (2009) mentions that stone spouts have been in existence since time immemorial, and states that the Licchavi kings constructed and connected these water supply systems to the rain-fed ponds and springs constructed by Kirat rulers. Later on, these historical water supply systems were expanded by the Malla kings to provide an adequate, high quality supply of water to valley residents. Stone spouts are still in use and continue to help to meet the water supply demands of the Kathmandu Valley.

The perennial water shortage in the Kathmandu Valley highlights the mismatch between available supply and ever increasing demand. Currently, valley residents rely heavily on water tanker deliveries and bottled water to meet their water needs; these

supplies are taken from groundwater and other water resources. Although the Government of Nepal has implemented Local Adaptation Plans for Action (LAPA) under the Nepal Climate Change Support Programme (NCCSP) in 14 districts, a LAPA is yet to be prepared for the water supply in the Kathmandu Valley (Jha, 2013). The Global Climate Change Alliance (GCCA) of the European Union and the DFID fund the NCCSP. The GCCA aims to help developing countries, in particular Least Developed Countries (LDCs) and Small Island Developing States (SIDS) improving their knowledge about the effects of climate change, and developing and implementing appropriate adaptation strategies (GCCA, 2012).

Unfortunately, as a result of the lack of timely attention given to the conservation of these traditional resources, many of them have already dried up, while others have a greatly reduced flow of water. UN Habitat (2008) highlights that the destruction of traditional water resources in the Kathmandu Valley actually started after 1950 when piped[(2)] water supply systems began to be introduced. Pradhan (1990) highlights that stone spouts used to be main source of drinking water for the people in the Kathmandu Valley before the introduction of the piped water systems in the valley. Shrestha (2009) also stresses that the management of traditional water systems has been neglected following the introduction of a piped water supply.

There are evidences of conflicts over use of natural resources in Nepal. Currently, water uses, equitable access and allocation, managing water sources, distribution network, dispute among water users' and association, maintenance of water supply systems etc. have emerged as a source of water conflicts in Nepal (WaterAid, 2012). The increasing water scarcity problem in the Kathmandu Valley has also given rise to the water conflicts. Therefore, there is a need to take immediate action, as climate change impacts are likely to negatively affect the valley's water resources, which are already overburdened due to rapid population growth and unplanned urbanization.

1.1 Statement of the Problem

1.1.1 Population Growth, Water Demand, and Supply Situation

Nepal is characterized by rapid population growth, unplanned urbanization, and a high rate of rural out-migration to urban centers. The urban population has increased from 1 million (6.5%) in 1981 to 4.52 million (17%) in 2011, and as a result, water demand has been identified as a major challenge for the rapidly increasing urban population (IUCN, 2013; Jha & Shrestha, 2013). The total population of the Kathmandu Valley is more than 2.38 million (CBS, 2014). The annual population growth rate of the Kathmandu Valley is about 4.63% (KVDA, 2015). Over the last few decades, water security has emerged as a major issue in the Kathmandu Valley due to the increasing population. Natural springs and traditional stone spouts are drying up, and, as a result, obtaining sufficient clean water has become a daily struggle (ICIMOD, 2014). The impact of climate change on water supply is crucial to many rapidly urbanizing countries and cities around the world today (Jha & Shrestha, 2013).

Figure 1 shows the average water demand and supply in the Kathmandu Valley between 2010 and 2014. The average water demand increased from 320 to 360 million litres per day (mld) whereas the supply only increased from 111 to 124 mld. The average water deficit remains more than 200 mld (KUKL, 2014). The average demand for water is 360 mld, and Kathmandu Upatyaka Khanepani Limited (KUKL) is able to supply only an average of 125 mld, which is 35% of the total demand (KUKL, 2014). The supply and demand situation demonstrates that there is a huge shortage of water in the valley.

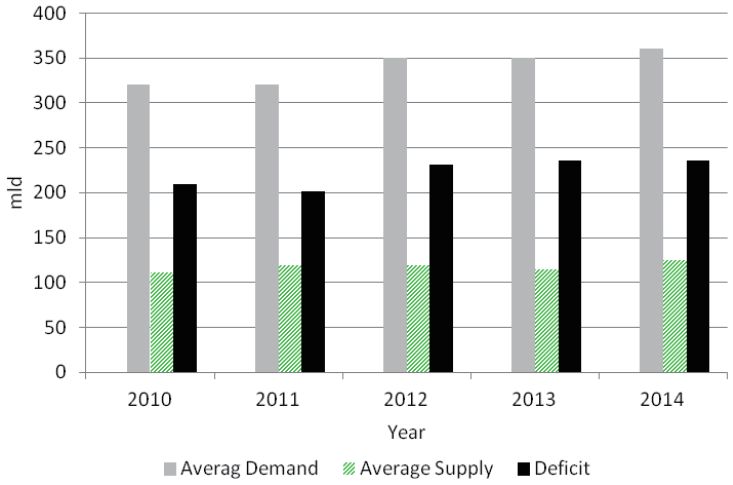

Figure 1. Average Water Supply and Demand Scenario (2010-2014)
Source: KUKL, 2014

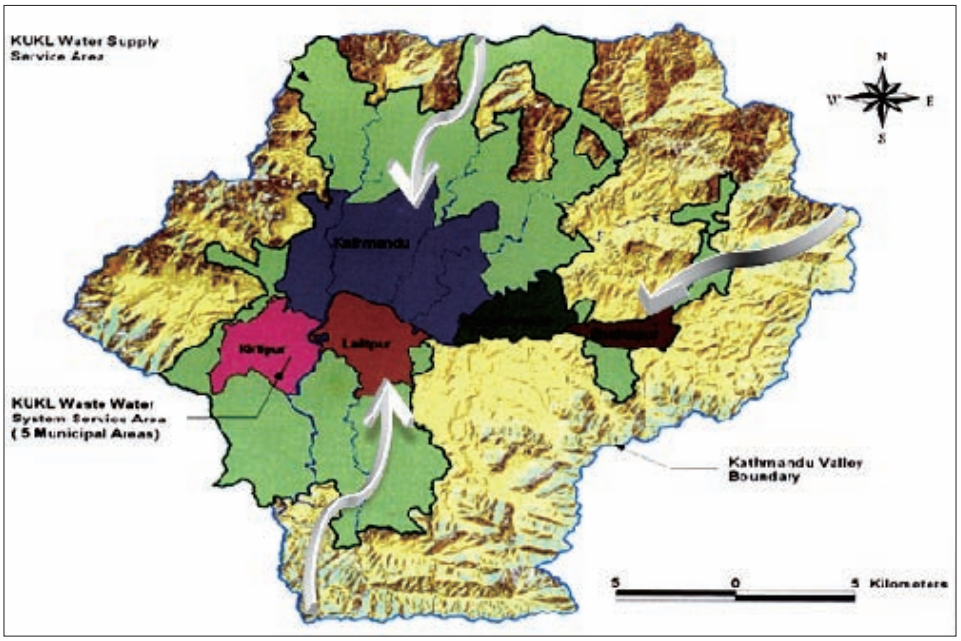

Figure 2. Service Area covered by KUKL and Direction of Water Flowing (white lines) in the Kathmandu Valley
Source: Base Map KUKL, 2014

Figure 2 shows KUKL water supply areas. KUKL was established in 2008 by the Government of Nepal to manage drinking water and sanitation services in the Kathmandu Valley. KUKL is capable of supplying only 33% of total water demand while the remaining 67% comes from traditional water resources such as stone spouts, wells, private boreholes, and private water tankers, which deliver household water from rivers and springs (Jha, 2013; Khadka, Shriya; Shrestha, & Shivana, 2013). A lack of water has become a common problem for households and businesses in the Kathmandu Valley turning water security into a burning issue.

1.2 Climate Change Impact on Water Resources

Jha & Shrestha's analysis of the Kathmandu Valley water supply (2013) highlights the fact that the urban population relies heavily on water tankers and bottled water for its water needs. The authors also emphasize the impact of climate change on water resources, and investigate the adaptive capacity of local authorities to cope with such impacts on drinking water supply.

Climate variability and the climate change trend remain highly uncertain (Jha & Shrestha, 2013). IPCC (2007) states that water supply is expected to decrease due to the increase in the variability of precipitation, the decrease in snowfall, and the rapid melting of glaciers leading to reduced groundwater recharge over time. The situation is expected to worsen worldwide, as a result of climate change, which ultimately will reduce water supply and increase water demand.

Nepal is considered as one of the most vulnerable countries to the impacts of climate change although it produces only 0.025% of total global emissions (IUCN, 2013). In contrast to Nepal's low level of emissions, it ranks 4th out of 170 countries in terms of vulnerability to extreme impacts of climate change over the next 30 years (Maplecroft, 2011). The impacts of climate change are evident in various sectors affecting livelihoods, water resources being one of them. Jha (2013) stresses that climate change has already been observed in Nepal, and its impact could affect water supply. Shrestha, Maharjan, and Joshi (2012) state that climate change will affect water resources. The water demand of millions of people is met from rivers, which originate from mountains but climate change has caused reduced water flows in the rivers, resulting in water scarcity in both urban and rural areas (IUCN, 2013).

1.3 Research Objective

The main objective of this paper is to study traditional water resource use and conservation in the context of sustainable water resource management.

2. Research Methodology

The study used the qualitative inquiry method to inductively generate data from fieldwork through interviews and observations. Qualitative inquiry is oriented towards exploration, discovery and inductive logic, and the analysis builds towards

social construction of knowledge through inductive analysis. This study targeted mainly citizens and key informant households in communities that have been living in the Kathmandu Valley for long time. Respondents and locations were selected following purposive sampling (the snowballing technique). As a result, the selection of respondents and locations varied during the data collection.

The study used semi-structured questionnaires to form the basis of interviews and the collection of qualitative and quantitative data. Interviews were conducted in each stone spout location. Most of the information was gathered by recollection method. Researchers used the general interview guide approach which involves outlining a set of issues to explore with each respondent prior to the start of the interview. The guide also served as a basic checklist during the interview to ensure that all the relevant data was collected. This approach was very helpful for elucidating ways in which stone spouts contribute to fulfilling water demand in the valley. The semi-structured questionnaires were tested before actual field work started, in order to avoid redundancy, and to eliminate elements causing uneasiness to the respondents during the interview. In some cases, while dealing with senior citizens, an informal conversational interview approach was followed. The interviews were complemented by direct observation in order to understand and capture the context within which people interacted.

Data was also gathered by the direct observation of stone spout use, quantity and quality of water, water use, and management and conservation practices. The study also examined water conflicts in the study area, in particular to access to water and management of stone spouts. Observation was useful for triangulating data with the interviews, and for better understanding conservation practices with reference to water resources and climate change adaptation. The information gathered was triangulated between the interviews, between interviews and observations, and between primary data and secondary data.

Altogether, there were 160 interviews (Kathmandu, Lalitpur, and Bhaktapur) conducted from Jan-March and July-August 2014.

2.1 Study Area

The Kathmandu Valley was selected for the study because traditional water resources, particularly stone spouts, wells, and ponds are confined to this part of the country. Figure 3 shows a map of the Kathmandu Valley along with direction of water flow, major rivers and roads. The valley consists of 3 administrative districts, namely Kathmandu, Lalitpur and Bhaktapur, which are Nepal's main centers for political, administrative, economic, education, tourism, trade and other social activities and play an important role in the national economy. The Kathmandu Valley covers an area of 722 square kilometers, covering entire Kathmandu and Bhaktapur districts and approximately 50% land area of Lalitpur district, is located between latitude 27° 49' 4" and 27° 31' 42" N and longitude of 85° 11' 19" and 85° 33' 57" E (KVDA, 2015). It is a low, flat, oval plain situated at about 1,337 meter above sea level (Nepali, 1988).

Table 1 shows the total number of stone spouts in the Kathmandu Valley. Kathmandu district has the highest number (47%) of stone spouts, followed by Bhaktapur (38%) and Lalitpur (15%). Around 20 stone spouts in each district, amounting to about 15% of the total stone spouts in the valley were considered for this study.

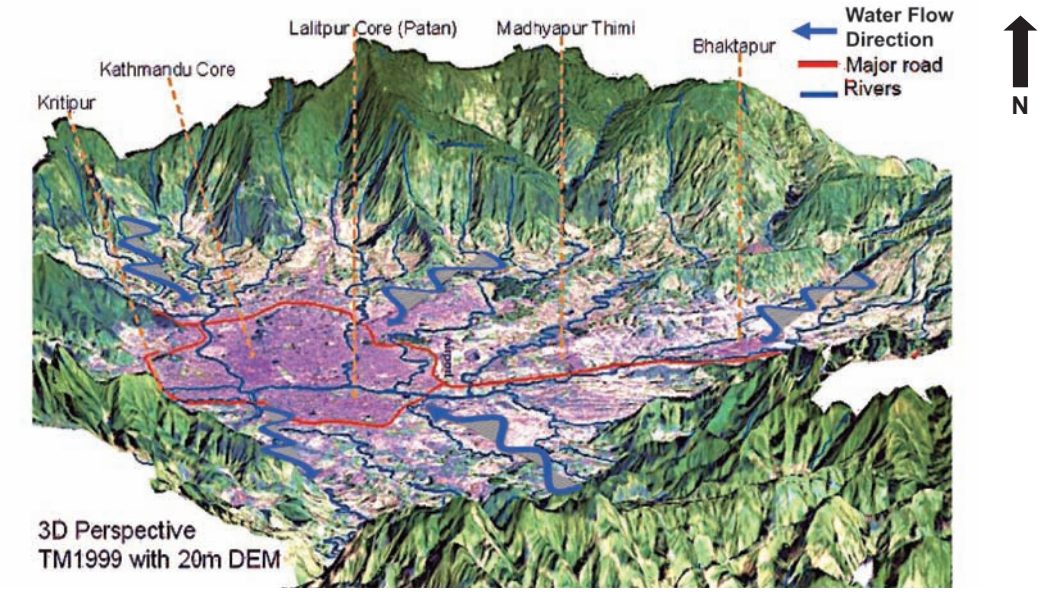

Figure 3. The Kathmandu Valley with Direction of Water Flow, Major Rivers and Roads
Source: Base Map Thapa and Murayama, 2009

Table 1. Number of Stone Spouts in the Kathmandu Valley

Districts	Total	Studies
Kathmandu	189	20
Lalitpur	58	23
Bhaktapur	153	21
Total	400	64

Source: UN Habitat, 2008

3. Data Collection and Analysis

The primary data were collected from 64 stone spout sites in the Kathmandu Valley with 2-3 interviews per stone spout. Among the total number of respondents, 68 were male and 92 were female.

The data were collected from diary entries, audio/video recordings and from photography and sketches. The data were tabulated, and grouped in line with the research questions. Primary data were collected in wards (administrative areas) of the Kathmandu Valley listed in 3.1-3.3 below:

3.1 Kathmandu: Banja hiti[3] (ward 19), Barnganga hiti (ward 34), Bhindyo hiti (ward 20), Chhwasapakha hiti (ward 20), Dhobidhara hiti (ward 17), Gairidhara hiti (ward 1), Paknajol hiti (ward 16), Kaldhara hiti (ward 16), Kapurdhara hiti (ward no 29), Kenta hiti (ward 18), Kon hiti (ward 20), Dusmukhi hiti (ward 4), Maru hiti (ward 19), Mechayon hiti (ward 15), Narayan hiti (ward 1), Naxaldhara hiti (ward 1), Sakhwa hiti (ward 18), Sundhara hiti (ward 22), Tamsipakha hiti, (ward 18), Thapatole hiti (ward 6).

3.2 Lalitpur: Alko hiti (ward 22), Amrit (Kune) hiti (ward 7), Bhandarkhal hiti (ward 11), Bhindhyolachhi hiti (ward 11), Bhola hiti (ward 9), Bholakhel hiti (ward 9), Byan hiti (ward 9), Chhyabahal hiti (ward 21), Chyasa hiti (ward 11), Dhola hiti (ward 14), Dathu hiti (ward 22), Sundhara (loon) hiti (ward 6), Kanibaha hiti (ward 6), Tanga hiti (ward 12), Kumbheshwor hiti (ward 22), Shova hiti (ward 14), Natwa hiti (ward 21), Sauga hiti (ward 6), Shanti hiti (ward 7), Subaha hiti (ward 8), Thapa hiti (ward Ward 7), Tyaga hiti (ward 7), Wasa hiti (ward 22).

3.3 Bhaktapur: Bageshwori hiti (ward 2), Bharbacho hiti (ward 14), Bramhayani hiti (ward 1), Byasi hiti (ward 10), Dattatraya hiti (ward 3), Dekwocha hiti (ward 4), Gaa hiti (ward 1), Gupu hiti (ward 1), Hakufo hiti (ward 17), Lhauda hiti (ward 9), Kishi hiti (ward 7), Mahadev (Maadyo) hiti (ward 7), Mufujo hiti (ward 17), Nara hiti (ward 3), Sworaah hiti (ward 17), Sukupau hiti (ward 15), Suryabinayak hiti (ward 1), Tulu hiti (ward 1), Taraah hiti (ward 7), Twa hiti (ward 6), Wocha hiti (ward 1).

Figure 4 shows the percentage of genderwise ancestral and migrated respondents. The number of ancestral (local residents) female respondents is higher as collecting water from stone spouts for the household is traditionally a female role. The total ancestral female respondents are around 45% against migrated female respondents which are around 14%.

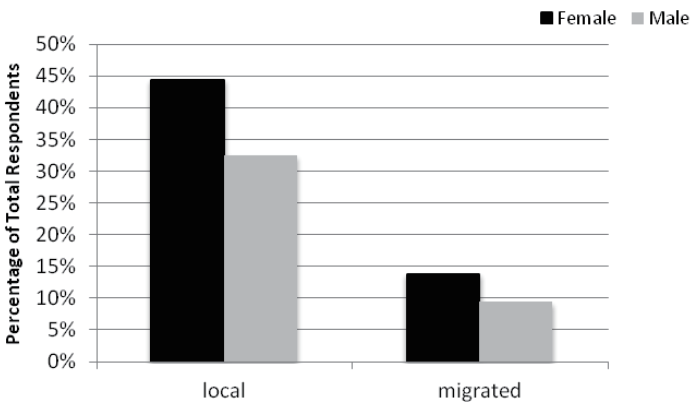

Figure 4. Genderwise Ancestral and Migrated Respondents

Figure 5 presents the percentage of genderwise education level of respondents. Out of 160 respondents, 10% female and around 6% of male respondents had undergone some sort of formal education. Those educated respondents have completed above intermediate (+2) level of education. Similarly, 30% of female and around 23% of the male respondents are literate. The literate respondents have also received a formal education from primary to grade 10 level. In principle, literate respondents can read and write. In all three cases, the percentage of female respondents is higher which is because of higher number of participation of female respondents considered in this study.

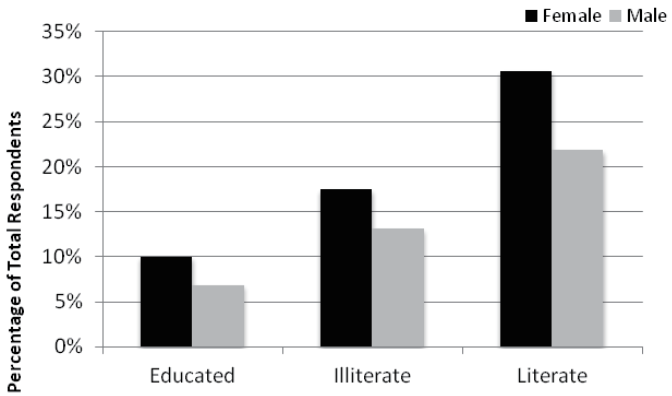

Figure 5. Genderwise Education Level

Figure 6 demonstrates the respondents by genderwise age cohort. The majority of the respondents were between 50 and 60 years old (female around 17% and male around 14%). The second largest age group included people of between 40 and 50 years (around 12% female and around 9% male). Although efforts were made during the research to select respondents with historical memory of stone spouts, those aged between 70 and 80 years represent only 6% and 4% of female and male respondents respectively.

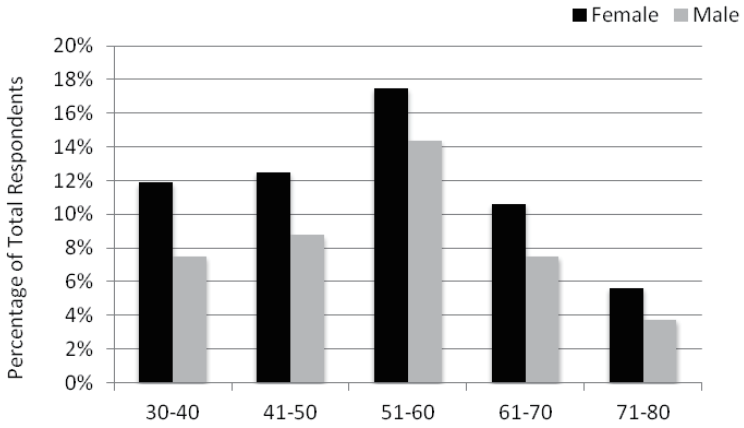

Figure 6. Genderwise Age Cohort

4. Key Findings / Discussions

4.1 Water Use and Conservation Efforts

4.1.1 Water Use

The study shows that there is a severe water scarcity in the Kathmandu Valley. Respondents spoke of the difficulties they face as a result of water being supplied by KUKL only once per week or even once every 15 days, and then for only a few hours. Often, the supply begins to flow during the night or in the early morning, necessitating people to be present to manage water storage. Those that get a water supply daily or on alternate days are regarded as fortunate - regardless of their economic status and walk of life. Those, who can afford to buy tankers full of water from private operators or construct boreholes to harvest underground water on their properties. Others have to rely on traditional water resources, mainly stone spouts and wells.

The study found that water from stone spouts is used for multiple purposes - drinking, cooking, washing, cleaning, animal feeding, irrigation for farming (through the proper channeling of the water draining from one stone spout to other stone spouts and out to the fields). Historic infrastructure of stone spouts exists to ensure that potable water is supplied to households, and drained water to farm fields and other farm water needs. Figure 7 shows that the water from stone spouts can be used for different purposes.

In Bhaktapur and Lalitpur districts, stone spouts were once the major water resource. Farmers would use the water supply for farm, cleaning tasks and for washing their vegetables. The water from those stone spouts located near to temples was used for ablutions before entering the temple and use as a holy water to wash idols of gods and goddesses. Many senior citizens in the Kathmandu Valley still prefer to use the water from stone spouts for their early morning face wash. Although the use of water from stone spouts declined following easy access to piped water, many valley residents still rely on stone spouts during periods of water scarcity and to supplement the irregular and limited supply from the pipes.

Water from stone spouts is used extensively by people who do not have access to a piped water supply. Most importantly, water from stone spouts is supplied free of cost and therefore mainly used by people living in rented accommodation, those with low incomes, and migrants to the valley. The percentage of water users is already presented in Figure 4 in the previous section. Although, the water from stone spout is largely used by ancestral, significant number of migrated people also use it. Although, most of the respondents are local, who were born and brought up in the study areas, there are a significant number of respondents who have been migrated to the Kathmandu Valley. In the winter season when there is little or no water flowing from stone spouts, people are forced to travel long distances to find a water source (other stone spouts, wells, ponds, public taps, public tanks etc.). The study found that hotels, restaurants, factories, and tanker operators also use water from stone spouts to meet their needs.

Figure 7. Different Uses of Water from Stone Spout
Source: Authors Field Survey, 2014

4.1.2 Water Quantity and Quality

Based on the findings of this research, stone spouts in the Kathmandu Valley can be categorized into three major groups: 1) stone spouts with a continuous flow of water during the monsoon and winter seasons; 2) stone spouts with a flow of water in monsoon, but are dry in winter; and 3) stone spouts with a high flow of water in monsoon, but a low flow of water in winter. In general, the majority of stone spouts have a higher flow of water in the monsoon season and a much lower flow in the winter, although there are a few exceptions. One such exception is the Tulu hiti situated at Suryamati in ward no. 1 of Bhaktapur municipality which has had a steady and continuous flow of water for many years and very little change in the volume of water throughout the year.

The majority of respondents (88%) said that they have noticed reduction in the volume of water flowing from stone spout in the last 12-15 years, and that this continues to reduce year by year. The degradation of water quantity is variously attributed to the passage of time, the drying up of land, decrease of open spaces, population growth, the using up of natural resources, the construction of big buildings, the digging of deep boreholes, the construction of private wells near water resources, deforestation, and earthquakes. Earthquakes can change the land structure, causing water blockage or to flow differently. Water flow can also be affected by major construction projects. For example, the Sundhara hiti ran dry following the destruction of its main water resource (*muhan*) which was located in the area where the Kathmandu Mall was built in the heart of Kathmandu metropolitan.

Bajracharya (2014) conducted water quality tests on samples collected from 10 stone spouts (Alko hiti, Chhyabaha hiti, Konti hiti, Manga hiti, Nagba hiti, Nuga hiti, Sincha hiti, Thapa hiti, Tyaga hiti, and Wasa hiti in Lalitpur district. He found that the water quality was within the values stipulated by the World Health Organization (WHO) and the National Drinking Water Quality Standard Guidelines - i.e. the water was fit for human consumption following minor treatment (such as simple disinfection). However, this study found that in the last 15-20 years, the majority of people have stopped drinking water from stone spouts. The study also found that 78% of respondents have stopped drinking water from stone spouts as they do not like the taste. One of the reasons for not using stone spout water for drinking purposes is due to the availability of water piped into the home which has a better smell and is more palatable. Respondents mention that the quality of stone spout water has significantly deteriorated over the years in terms of smell, color and an increasingly high iron content. Nowadays, water from many stone spouts is used mainly for washing, cleaning and bathing. Stone spouts on the way to farms are especially used by farmers to clean their vegetable and muddy hands and legs while returning from their fields, especially in Bhaktapur and Lalitpur districts. Despite this deterioration in quality, respondents also conceded that water from stone spouts can be used for drinking if it is boiled, filtered and disinfected. Indeed, 37% of respondents drink water from stone spouts after filtering, out of 22% of respondents who still drink water from stone spouts. More than 60% of respondents (out of 22% who still drink water from stone spouts) stated that they drink water from stone spouts without using any kind of filtration. These respondents reported no ill effects from consuming the untreated water. Similarly, respondents stated that water from these sources caused no damage or discoloration when used for washing clothes. At an institutional level, the Bhaktapur municipality office is actively addressing the potential health hazards presented by stone spout water by providing potassium, free of cost, to treat water from these sources.

4.1.3 Water Conflict

The study found that several conflicts regarding the management of stone spouts exist in the Kathmandu Valley. In Chhaunni, Swoyambhu, ward no. 15 of Kathmandu, respondents said that although there is encroachment of land belonging to the Mechayon Hiti Guthi, this has been overlooked by the local authority. Respondents accuse the political parties for supporting and encouraging this encroachment. In other cases, sewage, garbage and other effluent produced by nearby hotels and industries has blocked the drainage systems of several stone spouts; this has also caused conflict between householders and hotel owners/industrialists.

In Bhaktapur, there were 3 cases of conflict reported during data collection. The flow of water from Wochu hiti, in ward no. 1, stopped due to the construction of a building close to the spout. The blockage preventing water flow between resource and outlet was subsequently removed by people from the local community. Since then, no additional problems have occurred. Similarly, the flow of water from Dekwocha hiti was blocked during the construction of Khopa Engineering College. In this instance, the problem was solved upon diverting the discharge channel. About 3-4 years ago, the flow of water in Hakufo hiti was blocked during the construction of a *pati*[4] situated just next to the stone spout.

The research also reveals instances of conflict among water users. Users unwilling to queue to collect water often get into fights and arguments with those users who queue patiently. In addition, conflicts arise when business users (private tanker operators, hotel and restaurant owners, factories etc.) and domestic users from other areas trying to collect water from a given spout. Conflicts have also arisen over actions taken to divert water away from irrigation channels to meet domestic drinking water needs and the water needs of industries in urban areas (IUCN, 2013).

4.2 Conservation Efforts

The government's efforts to conserve traditional stone spouts have not been effective, despite the Declaration of the National Convention on Stone Spouts of 2007. Key elements of the Declaration underscore the need for the formulation and adoption of policies governing stone spouts; programmes; the promulgation of Acts regarding stone spouts; annual budget allocations; the formation of formal users' groups; the clarification of ownership issues; and the need to conduct research and studies and so on. More specifically, the Declaration calls for the promotion and celebration of Sithi Nakha as a national festival to promote the conservation of traditional water resources (UN Habitat, 2008). The primary data also suggest that the participation of non-governmental organizations (NGOs) and civil society organizations in stone spout conservation is also weak despite the Call in the 2007 Declaration. As part of their conservation efforts, water users groups give their stone spout a basic clean as and when necessary. To a large extent, the Sithi Nakha festival is still celebrated in the valley, giving continuity to the historical practice of thoroughly cleaning traditional water supply systems such as stone spouts and wells. In the past, local *guthis* (socio-economic institutions of Newar ethnic community) were formed to clean and manage stone spouts and traditional wells. The different auspicious days were selected to clean and conduct maintenance activities of stone spouts by those *guthis* (Nepali, 1988; UN Habitat, 2008) but as of now, no formal committees exist, at least in the study sites, to manage the preservation and conservation of these valuable, historical water sources.

4.2.1 Some Recent Developments

Although the 2007 Declaration specifically mentions that the ownership of traditional water resources including stone spouts should be given to the local authorities, the study found that no municipal office has taken any concrete steps towards improving conservation efforts. While municipal offices are yet to allocate any budget for stone spout conservation (despite provisions in the 2007 Declaration) they have provided varying degrees of financial support on an ad hoc, case by case basis. This financial support is not governed by any specific set of guidelines. In addition, municipality offices provide support to stone spouts of historical value and those that are situated in heritage sites such as Narayan hiti and Sundhara hiti and so on.

Of the 3 municipalities, Bhaktapur is the most active in the conservation of its traditional water resources. This is due in part to the long established tradition of conservation practiced by local communities, particularly the Newars. UN Habitat (2008) mentions that the Newars, an indigenous people of the valley have very good skills of managing historical water supply systems. Both Kathmandu and Lalitpur have larger migrant communities - a factor that has impacted on conservation efforts. Newars make up about 45%, 33% and 22% of the total population in Bhaktapur, Lalitpur and Kathmandu districts respectively (CBS, 2014). The Bhaktapur municipality city office was involved in the conservation and protection of Sukupau hiti. In addition to financial support provided to change the spout's main water resource, the municipality office has also agreed to provide funds to renovate the spout. Work is expected to start in 2015. The municipality office was also involved in the cleaning of Mufujo hiti, and Tulu hiti. (Tulu hiti is situated on the way to Bhaktapur Durbar Square - a major tourist attraction.) Furthermore, Bhaktapur municipality office has provided a number of storage tanks and a network of piping to collect water from stone spouts in Changunarayan VDC during the monsoon season. Similarly in Lalitpur district, during the monsoon season, water from Alko hiti is stored in a 10,000 litre capacity tank. Water flows to the tank through pipes directly connected to the stone spout. This water is distributed to people in the local community who are facing acute water scarcity. In addition, Lalitpur municipality has initiated upstream recharge systems for Alko hiti and Sincha hiti. There are also reports that local communities are recharging their traditional water resources with harvested rainwater using in-filtration techniques. Shrestha (2009) mentions that rainwater harvesting and artificial recharge offer a promising approach for sustaining traditional water resources.

Some secondary data indicates that UNESCO, UN Habitat, the US embassy, the Indian embassy, WaterAid, World Vision International, and local NGOs such as the NGO Forum, Guthi, etc. are involved in a number of conservation related activities. These include raising awareness at the community level; training on water conservation and management; providing water storage facilities; purifying water for drinking purposes; overseeing the operation and maintenance of stone spouts; and others. Some NGOs have tried to promote the conservation of stone spouts through study and research in line with the 2007 Declaration. For example; renovation of stone spouts, rainwater harvesting for artificial groundwater recharge, constructing water treatment and distribution systems, bottled water distribution etc. (UN Habitat, 2008). However, research initiatives have not proven effective in promoting conservation activity so far.

Despite the lack of initiative from government, civil society, water users groups, youth clubs, local residents and Tole Sudhar Samitis (Locality Improvement Committees) have been actively involved in the conservation and preservation of stone spouts. Tole Sudhar Samitis collect funds from municipality offices, private companies and local users to maintain or renovate traditional water resources. In a few, exceptional cases, water users have made additional efforts to conserve traditional water resources. For example, Lhauda hiti in ward no. 9 of Bhaktapur district is cleaned 2-3 times a year by local users. Similarly, Changunarayan Brihat Khanepani Tatha Sarsafai Upabhokta Samiti has been formed, to ensure the conservation of the stone spout in Changunarayan Village Development Committee (VDC) in Bhaktapur district.

4.3 Perception of Climate Change and its Impact on Water Resources

Educated respondents (18%) had heard about the term climate change. They mentioned of changes in temperature and rainfall patterns, thinking climate change as the reason for less rainfall in recent years. They were also aware of how natural disasters such as earthquakes have the potential to destroy traditional water resources. These respondents heard about climate change and its impact from television and printed material.

88% of respondents reported that the scarcity of water was an everyday problem. Piped water supplied by the state authority is both limited and irregular. Sometimes there is no supply of water at all. As a result, local residents must rely on traditional water resources such as stone spouts and wells for their daily needs. To make matters worse, the volume of water available from spouts and wells is decreasing and many traditional resources are drying up due to anthropogenic hydrological changes.

Around 63% of respondents reflected that changes in rainfall and temperature may be due to urbanization, population growth, and construction of tall buildings (which stops the flow of cool air). Monsoon rains in the past would continue for 5 or 6 consecutive days at a time but this is not the case today. Not only has the amount of rainfall decreased, there have been huge changes in rainfall patterns in the last 10-15 years. Whereas rainfall used to follow a regular pattern, it is now unpredictable, even during the monsoon

season. Less rain leads to lower volumes of water flowing in the rivers which in turn leads to a scarcity of water for drinking and irrigation. Rainwater is the main water resource for rivers and farms. When there is not enough rain, water is pumped from traditional wells. Water scarcity has led to a decline in the production of crops such as paddy, wheat, potatoes and chilies which require large and consistent supplies of water to grow.

In the past, high levels of rainfall ensured that the water sources for the spouts and wells in the Kathmandu Valley remained saturated. This is no longer the case. Monsoon rains have started late for the last 8-10 years which has had an impact on the time it takes to grow a crop - particularly paddy. When the monsoon is delayed, cultivation shifts accordingly. Productivity is directly affected by the availability of water. If there is plenty of water, productivity increases, while if there is water scarcity, productivity decreases, leading to economic loss.

The majority of respondents who are illiterate did not know about or had not heard of the term climate change. Respondents who had heard the term used by those working in the development sector did not fully understand what it means. The general perception of ordinary people is that climate change is an environmental problem. Despite this lack of knowledge, many respondents stated that winters are not as cold as they were in the past and summers are hotter. Respondents did not link these changes to increasing temperatures as an indicator of global warming.

Kishore Awale, a 61-year-old male member is a literate respondent. He is a user of Chyasa hiti situated at ward no. 11, Koyelachi Chyasa of Lalitpur. He said that the volume of water flowing from this stone spout has completely changed. Nowadays, the water does not flow in this spout during the dry season and flows only in the monsoon season. He uses the water from Chyasa hiti when there is water in this stone spout. The water is used for all purposes except drinking. However, there are people, who use this water for drinking after treatment. Although he has not heard about the term climate change and does not fully understand changing precipitation and temperatures, he mentioned that summer is very hot, and that winters are mild as well as becomes shorter. He said that he has also observed the changing rainfall pattern compared to the past years.

Krishna Prasad Prajapati, a 69-year-old farmer by profession, who left school after year 10, lives with his 15-member family in Bhramhayani in ward no. 1 of Bhaktapur Municipality is using Bramhayani hiti. Krishna stated that "*The time that a plant flowers and fruits is directly proportional to the amount of water supplied to the plant. Plants grow well and productivity is high when we have enough water - but the opposite is the case when there's not enough water.*" Krishna does not have a proper irrigation system for his farm and depends completely on rainwater which has been decreasing steadily for the last 10-15 years. He uses the water from Bramhayani hiti for his early morning face wash and ablutions before entering the Bramhayani temple, and also uses to clean his muddy hands and legs while returning from his farm. He is extremely concerned about the changing temperature and rainfall patterns due to his dependency on rainwater crop irrigation.

24% of respondents were of the opinion that the quantity of rainfall today is same as in the past; it is only that the timing has changed and rainfall patterns have shifted. These respondents also sensed moderate to high temperature changes in both summer and winter.

Sharmila Awal, a 31-year-old, an illiterate housewife and water user of Bharbacho hiti from Bharbacho in ward no. 17 of Bhaktapur Municipality, told us that the volume of water flowing from stone spouts has decreased slightly when compared to the past, but there is still a high volume of flow in the rainy season. She uses the water from Bharbacho hiti for all purposes except drinking. Although she does not fully understand the term climate change, and changing precipitation and temperatures, she states that there is less rainfall than in the past, that summers are hotter, and that winters are milder.

56% of respondents felt that the temperature has increased in the last few years and that winters are milder. Some mentioned that they had noticed Rudraksha[5] trees flowering a few months earlier than usual.

A 32-year-old Bishal Lama, works in the housing sector and lives in ward no. 6 of Changunarayan VDC in Bhaktapur and uses the water from Twa hiti for all purpose - drinking, cooking, washing, bathing, cleaning, etc. He has had no formal education. He told us "*I don't know about climate change - it is the power of the Gods that makes rain fall and water flow in the rivers, wells and stone spouts.*"

The term climate change, knowledge of climate change impacts among respondents is very limited. Many, however, have an opinion about what has caused the decrease in water levels and the drying up of water resources. These include: temperature increase; population increase; urbanization; the proliferation of boreholes; the construction of sewage systems; a lack of government attention; a lack of maintenance; more concrete structures blocking water recharge systems; increased construction; and a lack of rain; None of the illiterate respondents had heard of the term climate change.

5. Conclusion

A significant share of the increasing water demand in the Kathmandu Valley has been met by traditional water resources such as stone spouts and wells, which also have historical and cultural value. However, these traditional water resources have been

overloaded or overburdened by an increasing population, unplanned urbanization, and the impacts of climate change, which will result in the change of the hydrological system of these resources. They are at risk of vanishing forever.

The residents of the Kathmandu Valley are facing acute water scarcity. The impacts of climate change, alters the hydrological system of these resources, further worsening the water scarcity problem in the valley. The increasing water scarcity in the Kathmandu Valley has led the conflicts in the study area. The conflicts were mainly due to water sharing between households and business purposes, dispute among water users, destruction of water resources due to building constructions, encroachment of land that belongs to stone spout *guthi*, wastes disposal to water sources. Water conflict will be aggravated due to growing water scarcity problem in the Kathmandu Valley.

State and non-state actors do not give adequate attention to the use and conservation of traditional water resources, in particular stone spouts and their management. Although, no formal committees exist in the study area for the preservation and conservation of these traditional water resources, local water users groups, youth clubs and Tole Sudhar Samitis are active in the conservation and preservation. The celebration of Sithi Nakha festival is the sole effort to clean traditional water resources in the Kathmandu Valley. This historical practice of cleaning stone spouts and wells has been continued by celebrating as Sithi Nakha as a national festival to promote the conservation of traditional water resources as per the Declaration of the National Convention on Stone Spouts of 2007.

The effective use and conservation of stone spouts in Bhaktapur district is significantly better than in Lalitpur and Kathmandu districts, because of the Newar community, who has been cleaning and managing stone spouts through the local *guthis* since the past. The local conservation efforts to date have been made largely by local communities, who can play a key role in raising issues and influencing local authorities to develop mechanisms for conservation. These traditional water resources have a high potential to significantly contribute to climate change adaptation practices. Therefore, action points arising from the Declaration of the National Convention on Stone Spouts of 2007 must be implemented, along with the local conservation efforts for effective climate change adaptation and improved water management in the Kathmandu Valley.

Endnotes

(1) A stone spout is commonly known as "*loan hiti*" in the Newar language and "*dhunge dhara*" in the Nepali language. In this study, "*hiti*" is used to denote stone spouts.
(2) Piped water refers to the water supply system established by the local authority.
(3) A tap is commonly called as "*hiti*" in the Newar language.
(4) A traditional roadside shelter for travelers.
(5) A seed from Elaeocarpus ganitrus tree is locally known as Rudraksha, which is used for prayer beads.

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