Adapting to Peri-urban Water Insecurity Induced by Urbanization and Climate Change

Anushiya Shrestha, Rajesh Sada and Lieke Melsen



Anushiya Shrestha Rajesh Sada Lieke Melsen

Abstract : This paper describes the implications of growing urbanization in combination with climatic variability on water security and adaptation strategies of people in the peri-urban landscape of Kathmandu valley. Through a series of focus group discussions and key informant interviews, we found that entire households at Lubhu, Nepal depend on public stand posts with water supplied for few hours a day. Hydro-meteorological data analysis for the area showed an increasing trend of temperature, but a clear pattern in precipitation was not found. However, people perceived the changes in both precipitation and temperature and impacts on their livelihoods. People have envisioned development of a filtration system to treat water from another source. However currently, they have been fetching water from dug wells and spring sources in neighbouring VDCs during the days without water supply in stand posts. Farmers have been adapting to water scarcity by switching to less water demanding crops, by leaving land fallow, and by taking on off-farm activities. The concern for sustainable water management is growing among the community, however. Strong dedication and unity among the communities is essential to ensure the water security in the village.

Key Words: Urbanization, climatic variability, water, impacts, adaptation, Nepal

Introduction

Urbanization and climate change are two major phenomena that have received special attention around the world. In Nepal,the urban population of the country has increased from 0.4 million to 4.5 million between the period 1971 to 2011 (CBS 2012), with an intense increase arriving shortly after 1980. Climate change in Nepal is ahead of the global average (Chaulagain 2006). The impacts of changing climate are observed in several sectors of Nepal among which water resources is one of the most strongly influence (WECS 2011). A National Adaptation Programme Plan (NAPA) reports that Kathmandu is the most vulnerable place to climate change in Nepal.

Kathmandu valley is the most urbanized area in the country. The process of urbanization in the valley began in 1960s and accelerated after 1970s extending towards adjacent rural areas (ICIMOD 2007). Over the last decade the population of the valley increased from 1.6 million in 2001 to 2.51 million in 2011 (CBS 2012) showing a decadal increment of 61.23 percent. The rapid growth in the population in the valley has brought dramatic changes in the land use pattern in Kathmandu valley. The built area in the valley expanded from 3,330 hectares (ha) in 1955 to 16,472 ha in 2000 (Pradhan and Parera 2005). The process of urbanization and subsequent expansion of the built area to the peripheral former rural landscape has resulted inareas with a mix of rural and urban livelihoods, thus called peri-urban areas (Narain and Nischal 2007). These characteristics of peri-urban areas include poor integration into the city with regard to social and institutional issues, and infrastructure services. Unplanned urbanization in Kathmandu has created several physical, social, and environmental problems and placed immense pressure on land and water services in the peri-urban landscape of the valley,further been exacerbated by climatic variability.

Lubhu Village Development Committee (VDC) is a historical peri-urban village in Kathmandu valley, situated 10 kilometers southeast of Kathmandu, Nepal. Prior to 1980s, the main sources of water to Lubhu were rivers, springs, dug wells, stone spouts and ponds. Community water supply services began in 1981. In absence of reliable natural sources of water within the VDC, the operational community water schemes are primarily based on spring sources from neighbouring VDCs. However, until this writing, Lubhu has no system of private water supply connection. Thus the entire households at Lubhu depend on public stand posts. The consistent increase in population and changing life style with increasing urbanization has been increasing the water demand in the area. The increased demand has become a true challenge for the people of Lubhu where the available water sources are limited.This paper tries to explore the implications of growing urbanization in combination with climatic variability on water security and adaptation strategies for the people of Lubhu, a peri-urban area of Kathmandu valley.

Methodology and Materials

Study area

The study was carried out in Lubhu Village Development Committee (VDC), one of the peri-urban areas of Kathmandu Valley in Nepal. It is a 700 year old traditional Newar settlement located in south-eastern part of Kathmandu Valley and lies at 850 24" East and 270 39" North. Its area is approximately 4.76 square kilometers and the population size is 10,585 people distributed among 1,871 households. The location map of the study area is given in figure 1.

Research approach

Our study involved a series of focus group discussions with local people belonging to different age groups

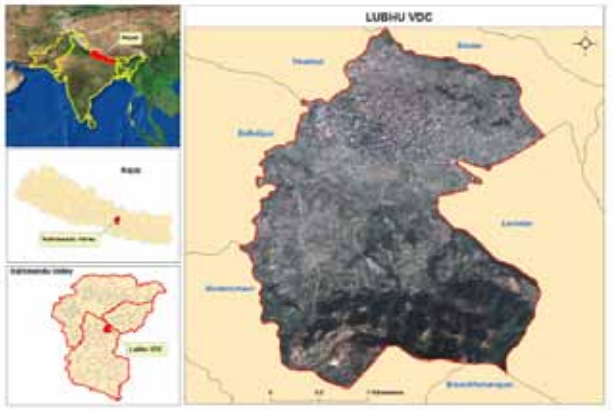

Figure 1. Study Area

and occupations. We wanted to understand water management practices at the household as well as community level and to capture the perception of the local people on climate change and its implications for water resources and agriculture. The information collected was validated through discussions with key informants, who included local leaders, key functionaries of water users committees, personnel in local development organizations, and relevant government agencies. Similarly, key informant interviews were conducted to understand the institutional role and strategies employed to reduce the water stress in the area.

Climatic data

Rainfall data for seven stations (Godawari, Tribhuwan International Airport, Changu Narayan, Naikap, Sankhu, Panipokhari and Khumaltar) and temperature data for four stations (Khumaltar, Tribhuwan International Airport, Panipokhari and Godawari) within Kathmandu valley were analyzed to understand the long-term climatic trend in Kathmandu valley. All the stations except Naikap had data for 30 years and more. We qualified the meteorological data analysis criteria as defined by World Meteorological Organization (WMO 1996). Table 1 gives an overview of the analysed climatic data. As Lubhu is part of Kathmandu valley, the climatic trend in Kathmandu has been used to interpret the long term climatic trend in Lubhu. Thus obtained climatic data were analysed using statistical software "R".

Station	Period of Meteorological Records	
	Rainfall	Temperature
Khumaltar	1967 - 2009	1967 - 2009
TIA	1968 - 2009	1968 - 2009
Godawari	1953 - 2009	1972 - 2009
Panipokhari	1971 - 2009	1971 - 2009
Changunarayan	1971 - 2009	
Sankhu	1971 - 2009	
Naikap	1997 - 2009	

Table 1. Available climate variables and covered period per station

Land cover change data

To model the land cover change and urbanization for Lubhu, we used historical images and data such as aerial photographs obtained from Department of Survey and recent data from Google Earth image. Aerial photographs from the year 1979 and 1992 were collected. The Google Earth image was geo-referenced using ArcGIS and used as the base map for the preparation of historical data. The geo-referenced map was digitized into five major classes: agriculture, built up, forest, river and road.The major challenge was identifying the exact location of the built area in the aerial photograph. To minimize the error, local people who knew the exact location of various building in the recent past were consulted. The open area and agricultural land within the VDC boundary were considered a single class as the area covered by open area was considerably low in comparison to other classes.The future urbanization modeling was done using Cellular Automata and Markov Chain analysis method.

Results and Discussion

The total population of Lubhu was 3,741 in 1971. It increased to 7,481 in 1991and 10,374 in 2011 with 2,365 households (CBS 2012) with an average annual growth rate of 3.63 percent (Figure 2).This population growth rate at Lubhu is three and half times higher than the average growth rate of rural population of the country (1.03 percent) and almost two times higher than the national annual average growth rate of 1.35 percent. Surprisingly, it is even higher than the growth rate of urban population of the country (3.38 percent). These clearly show the rapid growth of population in Lubhu.

A land pooling project was implemented in Lubhu from 1993 to 1996 which increased the selling of the arable land resulting in increasing number of households reaching 2,365 households in 2011, up from 1,439 in 2001.The result from the future urbanization modelling showed that if the current trend of urbanization in Lubhu continues, the built area will grow by approximately146 percent by 2030.

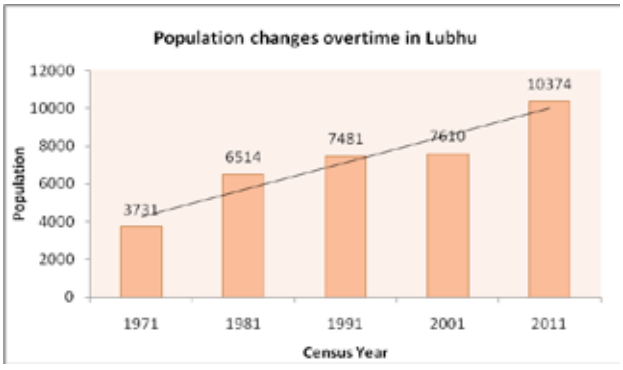

Figure 2. Increasing population trend in Lubhu

Climatic variations in Kathmandu valley

The hydro-meteorological data analysis of Kathmandu Valley showed was a decrease in the number of days with temperature < 0°C and increase in the number of hot days

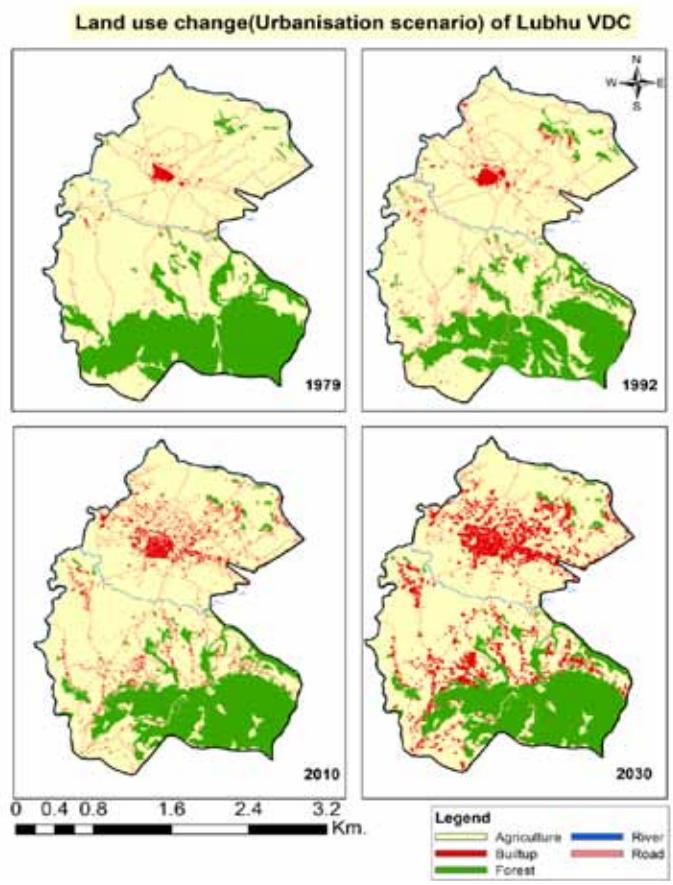

Figure 3. Urbanization trend in Lubhu VDC

(> 30°C) (Figure 4). Both the maximum and minimum of the Tmax as well as Tmin of the year had increased, which might imply that the warmest day of the year had become warmer, and the coldest day of the year, too. It also showed a distinct increasing trend in temperature with an average increase 0.05˚C/year in daily maximum temperature and 0.04˚C/year in daily minimum temperature. In their study, Baidya et al. (2008) showed comparable results for stations all over Nepal: an increase in warm nights and warm days and a decrease in cold nights and cold days. Similarly, a study made by Practical Action Nepal (2009), based on the observed meteorological data for the period 1976- 2005, shows an increasing trend in the maximum temperature (0.05°C/year) and the minimum temperature (0.03°C/year).

Analysis of rainfall data showed that there was no clear visible increase in the number and length of dry spells, the number of rainy days and the daily intensity index. There was much spatial variation. An increase of events with > 50mm of rainfall was found for most stations. There were no significant increasing or decreasing trends in total annual rainfall. A study by Practical Action also found no significant trend of rainfall. A time-series analysis of the effect of climate variables during 1978-2008 by Joshi, Maharjan and Piya (2011) also found trend of rainfall is neither increasing nor decreasing significantly during the same time period.

Besides scientific analysis of hydro-meteorological data, the perception of the local people on climate change was also studied and showed that the daily temperature was an increasing trend while the precipiation in general was perceived to be declining. More precisely, they perceived the precipitation was erratic and thus no more dependable for their agricultural water needs.

Implications of combined effect of urbanization and climate change

Impacts on traditional water infrastructures

People in Lubhu were traditionally dependent on dug wells, stone spouts, water tanks, ponds and rivers to meet their domestic and irrigation water needs. These traditional water infrastructures were also closely linked to their culture and religious rituals. However, many of these traditional water systems have vanished over time due to urbanization and rampant construction of physical infrastructure. Prior to 1980s, nine traditional ponds existed in the VDC for irrigation, bathing, and groundwater recharge, but by the 2000s, most of them had disappeared or been reduced in size to make room for new public infrastructures.Similarly, traditional stone spouts are also deteriorated. At present, there are five stone spouts: Sankhadevi Dhara, Amrit Dhara, Bhagbati Lachi Dhara, Gaphal Dhara and Jharu Dhara.

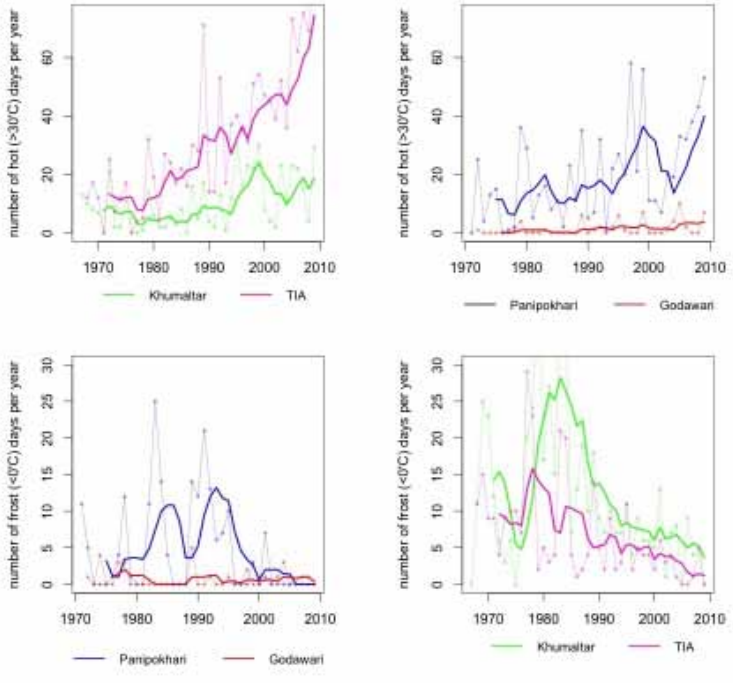

Figure 4. Temperature trend in Kathmandu

But most of these spouts are either completely dry or only in partial use.

Impacts on water supply systems

The Chapakharka community managed drinking water supply system of Lubhu begun in 1981 by tapping a source from neighbouring Bishankhu Narayan VDC. This system has been supplying water through 67 public stand posts with each stand post designated for approximately 30 households around it. According to the local people, the system supplied water twice on a daily basis: a few hours in the mornings and evenings in the initial phase. Being located close to an expanding metropolitan area, Lubhu's growing population has increased the number of people to be served by the existing water supply system while the supply from the source has been limited, due especially to the combined effects of climatic variables and urbanization. Today water is supplied only once a day, and often is irregular in flow and lasts for only a few hours in the morning. This lack forcess women to spend most of their morning time at the public stand posts to fetch a single bucket of water. Mothers of school-going children have an even more difficult challenge. Over the decade, five other community managed water supply have been in operation. However, with the massive increase in population, the improvements in water availability for the inhabitants in Lubhu has not kept pace.

The negative impacts of urbanization and growing population are visible in irrigation systems as well.There are seven community-based irrigation canals in the VDC. Dovan River Rajkulo (the state sponsored irrigation system) has degenerated since being damaged by a flood in 1996. Ultimately, this historical canal was covered for the expansion of a road network passing through Lubhu. Furthermore, local residents have been illegally draining their household sewage into this underground canal. The lack of maintenance for the irrigation systems in Lubhu can be attributed to the vastly increased building construction in the area. While Dovan Rajkulo is now defunct, other smaller irrigation systems in Lubhu have increasingly been dependent on rainfall due to decreased water supply at the source. With reduced capacity of the irrigation system in Lubhu, the agriculture is primarily rain-fed. Local communities visited government authorities for the maintenance of these canals but have been unable to negotiate for significant response. The support has been extremely limited and irrigation service in Lubhu still remains poor.

As per local people, groundwater availaibility and groundwater quality is poor in Lubhu. They perceive the discharge of sewer into the underground irrigation canal is a major cause of depleting groundwater quality. Furthermore degradation of the traditional ponds and increasing buil-up area has reduced the groundwater recharge in the VDC. Though depletion of groundwater table has not been an issue in the VDC, local people anticipate decline groundwater availability. Increasing groundwater extraction, reducing recharge sources and increasing rainfall uncertainty are combined causes of such perception. Likewise rivers in Lubhu are getting polluted. Godawari River flowing along the administrative border of Lubhu also faces pollution problems due to the discharge of sewage into the river. Effluents from an increasing number of textile factories in this area add more pollution into the river. This river is a major alternative water source for sanitary uses and for irrigation. Pollution of the river has been not only reducing water availability at Lubhu but simultaneously increasing health risks. The situation is exacerbated by increasing irregularity in rainfall pattern that compels local people to depend on this polluted river.

Impacts on spring sources

In the Nepal Chaur area of Lubhu, there were two natural spring sources prior to 2000s. One of those springs, Karangeko Padhero, was tapped for the Ban dhara water supply scheme. However, a rainfall patterns changed, trees in the area were down, and a road constructed, the yield from these springs progressively declined. As per the observation of the local people at Lubhu, spring sources have been declining in volume for years, thus the existing water management practices were being less reliable to meet their increasing water needs.

Impacts on agriculture

The local people in Lubhu perceived that rainfall was declining trend and unpredictably variable. The combined effect of urbanization and climatic variables in Lubhu has increased crop damage due to increased pest attacks. As a result of increasing water scarcity the incidences of pest damages is increasing. The farmers also reported the emergence of new pests in crops and believed this to be a result of increasing temperatures along with a disturbance in the natural pest predator system, a condition further affected by soil degradation from unbalanced use of chemical fertilizers and pesticides. Consequently, the cost of production has been increasing while crop production is declining. As per the recent estimate made by local government, only eight percent of the total households in the village have been able to sustain the family for a whole year from agricultural productivity alone whereas forty-eight percent have agricultural production sufficient for three months or less. This has been a major factor in residents moving from agriculture to non-agricultural occupations.

Adaptive Strategies for Water Security

Adaptive practices varied with the nature of the stresses faced by people at the local level, The practices observed encompassed a spectrum of alternatives in the use and management of water at the domestic level and for agricultural.

Community Initiatives in Water Management

There are six different community managed water

supply schemes in Lubhu that supply to people through public stand posts. Chapakharka water supply scheme is the most commonly used. The Dovan Drinking Water Supply System was initiated in 1998 with water diverted from Dovan River with the aim of reducing the pressure on the Chapakharka water supply system. However, the poor quality of water from Chapakharka is compelling Lubhu residents to still depend upon the earlier supply for drinking water. Local people formed the Lubhu Water Resource Committee and defined two phases of achieving water security in Lubhu.

1) Improve of the intake at Dovan River and construct reservoir tanks (250,000 litres of total volume) and
2) Install a filtration system to treat the collected water.

The committee has also proposed a gradual shift from public stand posts to household based piped water supply.Similarly, other water supply schemes have also been exploring alternative water sources, and developing technical and financial support to improve their water service.

Household Water Hoarding: Security for Increased Future Demand

Female residents, especially those who do not have private water taps or water source at the household level, spend a disproportionately large part of their time in the morning and evening in fetching water. The schedule of water fetching in the morning and evening often conflicts with their other household responsibilities, such as preparing children to go to school. Given the unpredictability of water supply, women collect as much water as they can when the supply is strong so that they can build a reserve. These reserves help meet extra water needs during festivals and when supply is scarce. For instance, for a local festival celebrated in April/May, water is collected and stored during the winter months when household water demand is less.

Sequential Queue for Water Fetching: Dealing with Scarce Supply

Women groups in Lubhu have evolved informal but innovative systems of fetching water in a queue, with the sequence decided by lottery from among the women fetching water from a community tap. This is a consented arrangement among the women members and guarantees that each member gets due share of water from the tap and avoids the situation of 'might is right'. The decision for water fetching sequence is made daily, weekly, monthly or annual basis and once decided the same sequence applies for the stated period. At some of the public taps, this sequence of queue was found to be in practice for past 30 years or even more. The advantage of this arrangement has been a social guarantee of the turn for water fetching and a discipline of turn, thus avoiding conflict in water fetching. With the addition of Dovan Water Supply scheme in the recent past, which has led to easing the water supply in the area and reducing the pressure on the public stand posts, the traditional practice of fetching water on queue is getting discontinued at many of the public stand posts.

Contingency Plan: Collective Ferrying of Water and Reliance on the Market Solutions

In the event of extreme scarcity of water, fetching water from spring sources in the neighboring VDCs and depending upon tanker supply are the only alternatives for water. Ferrying water in containers loaded on the bicycle is common sight at Lubhu. Often a number of households rent a vehicle together to transport water in larger vessels. Since large quantity of water can transported in a single trip of the rented vehicle, this becomes an easy and cost effective alternative to them.

Depending on tanker water supplyis another alternative for households to deal with scarcity in the dry season and in the event of unforseen disruption of water supply as in the Chapakhrka Water Supply Scheme, which often is rendered inoperable during monsoon due in the area. Those who cannot buy water in bulk may buy water in small quantities from the tanker operators; the usual rate charged by tanker operators for small quantity of water is Rs. 5 (US$0.05) per *gagri* of approximately 15 liters.

Capturing Roof Top Runoff: Innovation of Low Cost Options

Some households at Lubhu have started the innovative practice of capturing roof top rainwater and storing the harvested water for cleaning, washing and other sanitation needs. This is done by digging a pit in the homestead for storing water for non drinking-uses and livestock watering. Some households have also developed roof top and underground water storage tanks to store enough water to meet their needs in periods of water scarcity. These households use electric pumps to lift water from dug wells or depend on tanker supply.

Changes in Cropping Practices and Occupational Diversification

The agricultural land in the area has been undergoing rapid transformation in the recent time due to urbanization. There has been two important shifts in the area as a result of this transformation. One is shift from traditional cereal base farming to vegetable based farming in smaller area, which has been found to be economically more rewarding. The other is a shift from farming to non-farm occupations. The area was traditionally known for rice and wheat production but the farmers in the area have stopped cultivating wheat due to the high water requirement for the crop, the lower economic return, and the higher input use and drudgery required for crop cultivation. People in the area are shifting to other occupations, such as textiles, government jobs, the private sector, industry, and non-farm wage earning. The usual farming practice at present is keeping small piece of land for cultivation for economically more rewarding cash crops such as vegetables, and selling the additional

land and shifting to non-farm occupations for additional earning.

Increasing Dependence on Groundwater

Groundwater extraction has been increasing in Lubhu. While community dugwells used to be major water source in this traditional Newar settlement, in the recent decade there has been wide increase in the extraction of groundwater in the homestead. These private dugwells supplement water needs for domestic uses, mainly non-drinking. But with increasing water supply constraints at the public stand posts, households have started depending on these for drinking as well. At the same time these are used for irrigating homegardens. Degrading irrigation services and increasing rainfall variablity has attracted farmers towards practice of keeping home gardens that can be irrigated through dugwells available at homestead.

Changes in the Practice of Water Use

On account of the hardship of water fetching, female members go to the river to wash clothes despite the poor water quality. Male residents take baths in the stone spouts and wells in neighbouring VDCs and rivers passing by Lubhu. Since Saturday is a public holiday in Nepal and the washing and cleaning day for service holders, women try to escape from water demanding activities on Saturdays.

Shift of Settlements from the Upland to Low Land

The availability of water is always a constraint in the upland areas due to the unavailability of dependable spring and groundwater sources as well as topographic limitations to developing piped water supply system. In order to avoid this difficulty, there is increasing preference and tendency among the people to shift the location of their houses from the upland to lowland. This shift in the settlement pattern was noted in Ward number 8 of Lubhu.

Technological Support and New Institutional Setup for Improved Irrigation

Increasing variability in rainfall and increased constraints faced by the farmers for irrigation water has encouraged the farmers to invest in rehabilitating their old irrigation canals which were degraded in past due to poor management and long period deferred maintenance. Provision under the micro irrigation support initiated at Lubhu in 2008 provided technological support for pumping river water and operation of drip irrigation. Farmers using these rehabilitated irrigation canals have initated new institutional mechanism of collecting irrigation service fee for improving the operation and management of irrigation services to maintain self-sustained irrigation service. The support however has been serving only a limited farmers and the irrigation still remains a constraint in major part of this peri-urban VDC.

Conclusions

The increasing water demand with increasing urbanization and declining water sources due to compounded effect of urbanization and changing climatic pattern have resulted in increasing water stress in Lubhu. Considering the rapid urbanization trend and increasing variability in climate, the concern for sustainable water management is growing among the local community however, strong dedication and unity among the communities is likely to be critical to improve their adaptive capacity and ensure the water security in the village.

– –

Acknowledgements

The paper is based on findings of an action research project on Water Security in Peri-urban South Asia implemented in peri-urban areas of Kathmandu Valley by Nepal Engineering College in coordination with the South Asia Consortium for Interdisciplinary Water Resource Studies (SaciWATERs) and with financial support from the International Development Research Centre (IDRC), Canada.

Anushiya Shrestha *is a M.Sc. post graduate in Environmental Science with her Bsc and MSc degrees from Tribhuvan University. She was a research grantee of CREEW (Center of Research for Environment, Energy and Water) in 2008. She also participated as a Researcher in the research program of Physio-chemical analysis of Water quality of Bagmati River from Sundarijal to Chovar performed by Tri- Chandra Campus affiliated to Tribhuvan University in 2006. Currently, she is working as Research Assistant in Peri-urban water security Action research project underway at Nepal Engineering College in support of IDRC, Canada.*
Corresponding address: anushiya.shr18@yahoo.com

Rajesh Sada *is currently pursuing Erasmus Mundus M.Sc in Ecohydrology. He obtained his 1st M.Sc in Interdisciplinary Water Resources Management in 2009. He was engaged as Assistant Professor in Nepal Engineering College and Research Coordinator in Peri-urban Water Security Project for more than three years. He was involved in Melamchi Water Supply Project as Interdisciplinary Science Associate based in Melamchi. He also worked as Research Assistant for two years in an IWRM program of Nepal Engineering College. Prior to this, he worked as Research officer in Socio-economic, Agro forestry and Environment (SAFE) Concern, Kathmandu, Nepal and as a Ranger in Nepal Swiss Community Forestry Project, Ramechhap. His special interest lies in water resources management, climate change and biodiversity conservation.*

Continued in page 35