Adapting to Peri-urban Water insecurity induced by Urbanization and Climate Change

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Abstract

This paper describes the implication of growing urbanization in combination with climatic variabilities on water security and adaptation strategies of the people in peri-urban landscape of Kathmandu valley. Through multiple series of focus group discussions and key informant's interviews, the study found that the entire households at Lubhu depend on public stand posts with water supplied for few hours a day. The hydro-meteorological data analysis showed the increasing trend of temperature but clear pattern in precipitation was not found. However, people perceived the changes in both precipitation and temperature and impacts on their livelihood. People have envisioned development of filtration system to treat water from another source. However currently, they have been fetching water from spring sources in neighbouring VDCs and dug wells during the days with no water supply in stand posts. Farmers have been adapting to water scarcity for cultivating agricultural crops by switching to less water demanding crops, leaving land fallow and even by deviating towards off-farm activities to be more resilient to increasing water scarcity. 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

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Introduction

Urbanization and climate change are two major phenomena that have received special attention all over the world. In Nepal, the processes of rapid urbanization started in the period after 1980. The urban population of the country has increased from 0.4 million to 4.5 million between the period 1971 to 2011(CBS 2012). Climate change in Nepal is going even faster than 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 hardest hit sectors (WECS 2011). National Adaptation Programme Plan (NAPA) to climate change has ranked Kathmandu as the most vulnerable place in Nepal.

Kathmandu valley is the most urbanized area in the country. The process of urbanization in the valley got began in 1960s which accelerated after 1970s (ICIMOD 2007) extending towards adjacent rural areas. 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 by 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-up area in the valley expanded from 3,330 ha in 1955 to 16,472 ha in 2000 (Pradhan and Parera 2005). The process of urbanization and subsequent expansion of the built-up area to the peripheral former rural landscape has resulted into forming of areas with mix of rural and urban livelihood; called peri-urban area (Narain and Nischal 2007). These peri-urban areas have the characteristics of being inadequately integrated into the city with regard to social and institutional issues as well as for infrastructure services. This continued process of unplanned urbanization has created several physical, social, and environmental problems and created immense pressure on land and water services in the peri-urban landscape of the valley which has further been accentuated by climatic variability.

Lubhu Village Development Committee (VDC) is historical peri-urban village in Kathmandu valley, situated around 10 km southeast of Kathmandu. Prior to 1980s, main sources of water for Lubhu were rivers, springs, dug wells, stone spouts and ponds. The community water supply services started in 1981. In absence of reliable natural sources of water within the VDC, the operational community water schemes are primarily based on spring sources in the neighbouring VDCs. However till date, Lubhu has no system of private water supply connection. Thus the entire households at Lubhu depend on public stand

posts. The continuous increase in population and changing life style with increasing urbanization has been increasing the water demand in the area. This has become a real challenge for the people of Lubhu where the available water sources are limited. It is in these realities, this paper tries to explore the implication of growing urbanization in combination with climatic variability on water security and adaptation strategies of the people in 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. It is 700 years old traditional Newar settlement located at south-eastern part of Kathmandu Valley and lies at 85^0 24" East and 27^0 39" North. Its area is approximately 4.76 square kilometers and the population size is 10,585, distributed in 1,871 households (CBS 2012). The location map of the study area is given in Figure 1.
Figure 1.

Research approach

The study involved series of focus group discussions with local people belonging to different age groups and occupations to understand water management practices at household as well as community level and to capture the perception of the local people on climate change and its implications on water resources and agriculture. The information collected were validated through discussions with key informant's which included the local leaders, key functionaries of water users committees, personnel in the development organizations and relevant government agencies. Similarly, key informant's interviews were conducted to understand the institutional role and strategies employed to reduce the water stresses in the area.

Climatic data

Rainfall data for seven (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 over 30 years and qualified the meteorological data analysis criteria as defined by World Meteorological Organization (WMO 1966). Table 1 gives an overview of the analysed climatic data. Lubhu being a 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".
Table 1. Available climate variables and covered period per station

Land cover change data

The land cover change and urbanization modeling for Lubhu used the historical images and data such as aerial photographs obtained from Department of Survey and recent data from Google Earth image. The 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. Georeferenced map was digitized in five major classes namely, Agriculture, Builtup, Forest, River and Road. The major problem was the exact location of the built up area in the aerial photograph. To minimize the error, local people who knew the exact location of the building in the recent past were consulted. The open area and agricultural land within the VDC boundariy were considered 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

Urbanization in Lubhu

The total population of Lubhu was 3741 in 1971 A.D. It increased to 7481 in 1991 and 10374 in 2011 with 2365 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 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.

Land pooling project was implemented in Lubhu from 1993 to 1996 which increased the selling away of the cultivable land resulting in increasing number of households reaching to 2365 households in 2011 from 1439 in 2001. The result from the future urbanization modeling showed if the current trend of urbanization in Lubhu continues, built-up area will grow by around 146 percent by 2030 as compared to that in 2010.

Figure 2. Increasing population trend in Lubhu
Figure 3. Urbanization trend in Lubhu VDC

Climatic variations in Kathmandu valley

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

number of hot days (> 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. Study by Baidya, Shrestha and Sheikh (2008) shows 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 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 states that no significant trend of rainfall was found. 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 period.

Figure 4: Temperature trend in Kathmandu

Besides scientific analysis of the hydro-meteorological data, the perception of the local people on climate change was also studied and showed that the daily temperature was in increasing trend while the precipiation in general was perceived to be in declining trend. 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 river to meet their domestic and irrigation water needs. These traditional water infrastructures were also closely linked to their culture and religious rituals. Many of these traditional water systems have however vanished over time due to urbanization and rampant construction of physical infrastructures. Prior to 1980s, nine traditional ponds existed in the VDC which were used for the purpose of irrigation, washing hands and legs and also for

groundwater recharge, but by 2000s, most of them had disappeared or reduced in size for the cost of constructing the public infrastructures. Similarly, traditional stonespouts are also deteriorated. At present, there are five stone spouts- Sankhadevi Dhara, Amrit Dhara, Bhagbati Lachi Dhara, Gaphal Dhara and Jharu Dhara. 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 started in 1981A.D. 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, few hours in the mornings and the evenings in the initial phase. Lubhu being located close to expanding sub-metropolitan city, 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 adversely affected and limited especially due to the combined effects of climatic variables and urbanization. Currently water is supplied only once a day. Moreover, it is irregular and only for few hours in the morning. This makes 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 are the major victims of disproportionate volume of water collected upon the investment of hours. Over the decade, five other community managed water supply have been in operation. However with massive increase in population, there has been no impressive improvement in the water availability for the inhabitants in Lubhu.

Similarly the negative impacts have been visible in irrigation systems as well. There are 7 community based irrigation canal in the VDC. Dovan River Rajkulo (state sponsored irrigation system) has been virtually degenerated after being damaged by the flood in 1996. Ultimately, this historical canal was covered for the expansion of road network passing through Lubhu. Furthermore local residents have been illegally draining the household sewerage in this underground canal. The irrigation systems in Lubhu lack maintenance and further destroyed due to land plotting for building construction and town planning in the area. While Dovan Rajkulo has defunct, the other smaller irrigation systems in Lubhu have increasingly been dependent on rainfall due to decreased water supply at the source itself. With reducing capacity of irrigation system, the agriculture in major parts of Lubhu is being rain-fed. The local communities have been visiting the concerned authorities for the maintenance of these canals however the outcomes have not been fruitful yet.

Godawari River flowing along the administrative border of Lubhu is also facing a problem of pollution. All the households' sewage has been discharged into this river making it as a major cause of river pollution. The effluents from the increasing number of textile factories further add to the river pollution. This has further been increased with the declining river flow due to upstream water extraction and irregularity in rainfall pattern.

Impacts on spring sources

In Nepal Chaur area of Lubhu, there were two natural spring sources prior to 2000s. Among two, Karange ko Padhero was tapped for Ban dhara water supply scheme. As a result of the changing rainfall patterns and cutting down of the trees for the construction of road and coming up of new houses around the spring sources, the yield in both the springs progressively declined. Finally the untapped spring vanished by 2000s while the yield of the tapped spring has declined significantly. As per the observation of the local people at Lubhu, there has been decline in the yield of spring sources in the neighbouring VDC and 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 the rainfall was in declining trend and was no more dependable. The combined effect of urbanization and climatic variables in Lubhu has increased crop damage due to increase pest attacks. As a result of increasing water scarcity the incidences of pest damages is increasing. The farmers also reported on the emergence of new pest in crops and felt this is impact of increasing temperature along with the disturbance in the natural pest predator system as a result of soil degradation resulted from unbalanced use of chemical fertilizers and pesticides. Consequently, the cost of production has been increasing however the crop production is declining. As per the recent estimation made by local government, only eight percent of the total households in the village have been able to sustain the family for whole year solely from agricultural productivity whereas fourty eight percent have agricultural production sufficient only for three months or even less. This has been a major cause of growing deviation from agriculture to non-agricultural occupation.

Adaptive strategies for water security

The adaptive practices varied with the nature of the stresses faced by the people at the local level, emerging from climate change and urbanization and were found encompassing spectrum of alternatives in the use and management of water at the domestic level and in the agricultural uses. Following are the summary of the adaptive practices of the people, noted at Lubhu.

Community initiatives in water management

There are six different community managed water supply schemes in Lubhu which have been supplying water to all the people throgh public stand posts. Chapakharka water supply scheme is the former most among all. Dovan Drinking Water Supply System was initiated in 1998 with water diverted from Dovan River with the aim of reducing the pressure on Chapakharka water supply system. This has been considered as the most reliable water source for Lubhu. However, the poor quality of water from this source is compelling Lubhu residents to still depend upon the earlier supply for drinking water. Local people spearheaded by Lubhu Water Resource Committee have defined two phases of achieving water security in Lubhu. One being improvement of the intake at Dovan River and construction of reservoir tanks (250,000 litres of total volume) and the other is installation of filtration system to treat the collected water. The committee has envisoned to shift from public stand posts to household based piped water supply as an ultimate water management plan for Lubhu. Similarly, the other water supply schemes have also been exploring the alternative water source and technical and financial support to improve their water service.

Household's water hoarding: Security for increased future demand

The women members, especially those who do not have private water taps or water source at the household level, spend a larger part of their time in the morning and evening in fetching and managing daily needs of water supply. The schedule of water fetching in the morning and evening often conflict with their other household responsibilities, such as, preparing children to go to the school. Given the unpredictability in water supply, on the days of good supply women collect as much water as they can so that additional water reserve could be maintained. This additional water reserved at the household helps meeting extra water needs during the festivals and also for the days of scarce supply. 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 events of extreme scarcity of water, fetching water from spring sources in the neighboring VDCs and depending upon tanker supply are the alternative left to the people. Ferrying water in the containers loaded on the bicycle is common sight at Lubhu. Often a number of households join and rent a vehicle to transport water in larger vessels. Since large quantity of water is transported in a single trip of the rented vehicle, this becomes an easy and cost effective alternative to them.

Depending on tanker water supply is another alternative for the households to deal with the scarcity in the dry season and in the events of disruption of water supply in Chapakhrka Water Supply Scheme, which gets destroyed frequently during monsoon due to frequently occurring landslides in the area. Those who cannot buy water in bulk may buy water in small quantity from the tanker operators- the usual rate charged by tanker operators for small quantity of water is Rs. 5 (US$0.05..) per g*agri* of approximately 15 liters.

Capturing roof top runoff: Innovation of low cost options

Some households at Lubhu have started innovative practice of capturing roof top rainwater and storing the harvested water for uses in cleaning, washing and other sanitary uses. 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 the needs in the 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. While one is shift from traditional cereal base farming to vegetable based farming in smaller area, which has been found economically more rewarding, and the other being people in farming shifting 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 high water requirement in growing the crop, lower economic return and higher input use and drudgery involve in crop cultivation. People in the area are shifting to

other occupations, such as, weaving traditional textiles, jobs in the government and private firms and industries and non-farm wage earning. A very important reason for shift in occupation has been increasing scarcity of water for irrigation and drudgery involved in farming. The usual practice at present is keeping small piece of land for cultivation of economically more rewarding cash crop, such as vegetables, and selling the additional land and shifting to non-farm occupations for additional earning.

Changes in the practice of water use

On account of the hardship of water fetching, female members go to the river for washing clothes despite the poor river quality and male members take bath 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 unavailability of dependable spring and groundwater source and also topographic limitations in 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 where people have shifted the location of their house form upland to low land areas.

Conclusions

The increasing water demand with increasing urbanization and declining water sources due to compounded effect of urbanization and changing climatic pattern have resulted into 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.

Figures and Tables

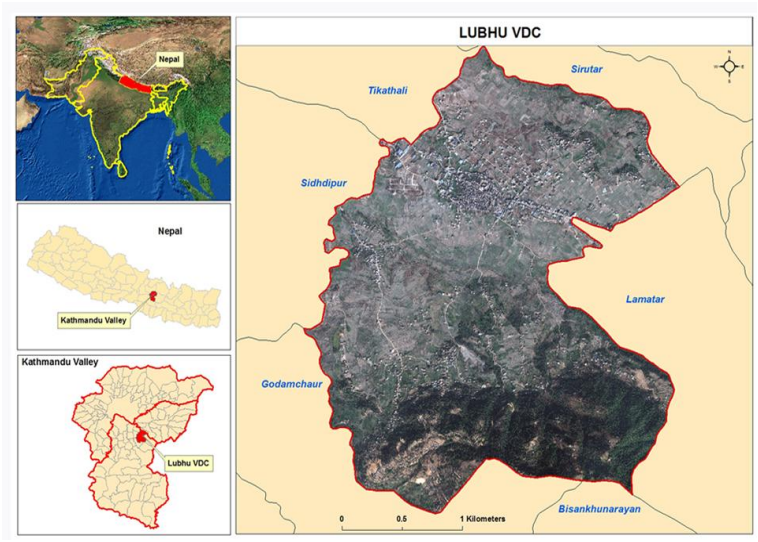

Figure 1: Map of study area: Lubhu VDC

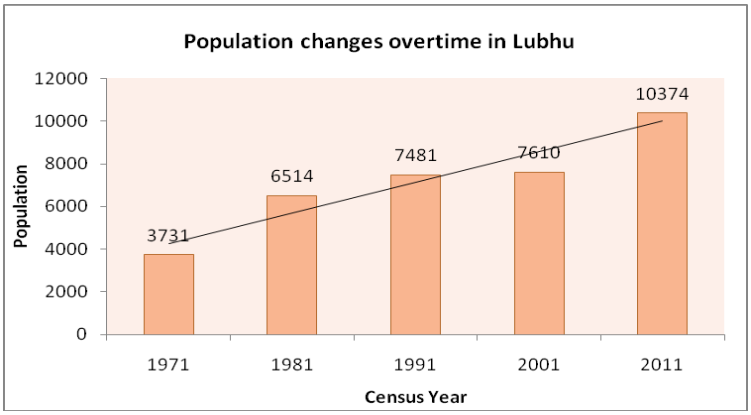

Figure 2: Increasing population trend in Lubhu

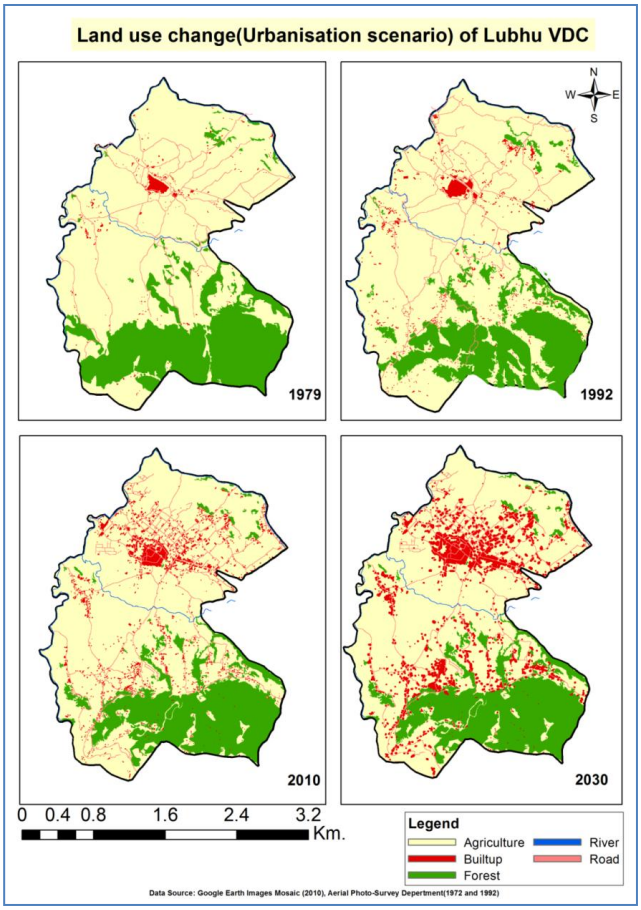

Figure 3. Urbanization trend in Lubhu VDC

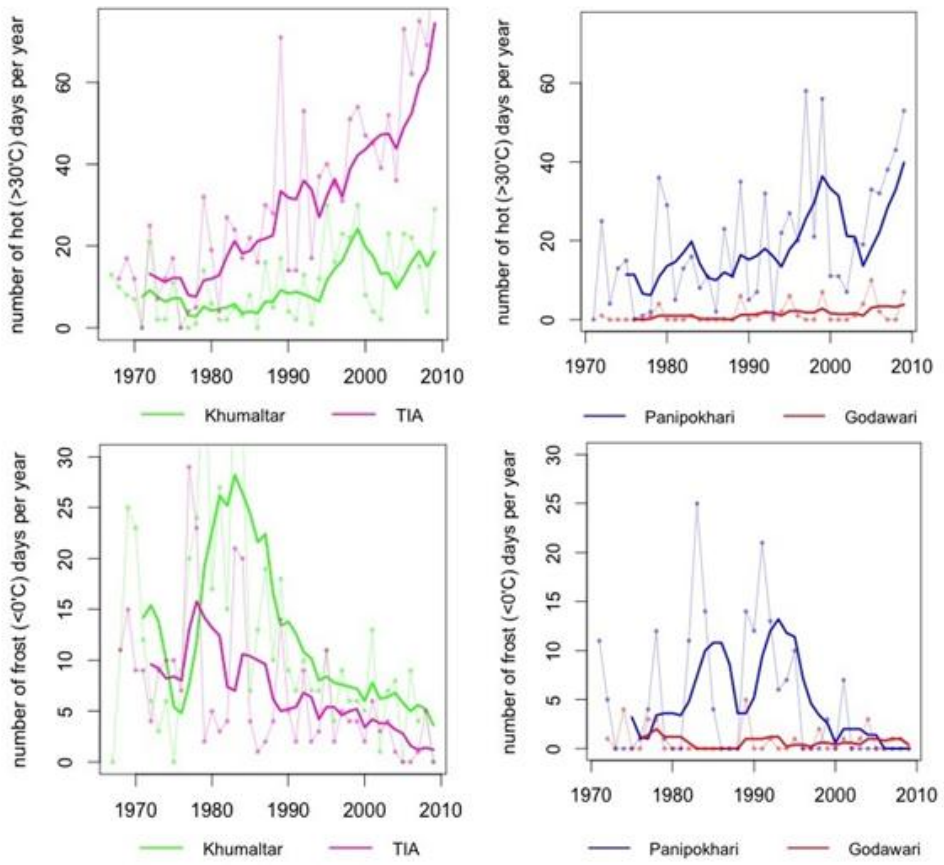

Figure 4: Temperature trend in Kathmandu valley

Table 1. Available climate variables and covered period per station

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	

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