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Discussion Paper Series

Water Security in Peri-Urban South Asia
Adapting to Climate Change & Urbanization

People's Experience and Facts of Changing Climate: Impacts and Responses

Rajesh Sada, Anushiya Shrestha, Melson Lieke and Ashutosh Shukla

Apart from modeling and quantitative analysis of climate change, it is also important to understand what local communities feel about climate change and how they are affected by it and are responding to those impacts in order to bring new policies and programmes in the particular area. This paper tries to analyze the connection between perceived changes in different attributes of climate change by the local people residing in peri-urban areas of Kathmandu Valley and the results obtained from analysis of recorded temperature and rainfall data of seven different hydro-meteorological stations located in different parts of Kathmandu Valley. Besides, the study also explores the impact of climate change on the local people and their responses in order to enhance their resilience. The study is based on focus group discussions with communities and household survey whereas the analysis of hydro-meteorological data is done in R software. The perception of most of the local people on changes in temperature is almost in line with the recorded long term climatic trend whereas the perception of decreasing monsoon and non-monsoon rainfall is not matched with the recorded data as it did not find any long term clear visible pattern of rainfall. However, out of seven stations, four illustrated decreasing trend in number of rainy days in non-monsoon and three stations demonstrated decreasing trend of rainy days in the monsoon period. People have been facing several impacts from these changes such as decrease in water sources, decrease in agricultural crop production, increase in insect-pest attack and increase in weeds in agricultural crops. Local people are responding to these impacts basedon their own skills and traditional knowledge. Household level water management, adoption of innovative technologies in agricultural practice, construction of wells, changing cropping pattern and systems and occupational diversification are some important responses they are adopting to adapt to the impacts of changes in climate.

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This is one of a series of Discussion Papers from the Peri Urban Project of SaciWATERs.

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People's Experience and Facts of Changing Climate: Impacts and Responses

Sada, Rajesh; Shrestha, Anushiya, Lieke, Melson and Ashutosh Shukla4

1. INTRODUCTION

Climate change has been a hot global issue and has gained momentum in Nepal as well. Several studies have been done and many are going on around the climate change issue. Most of these studies are about identifying the trend of change in temperature and rainfall; and forecasting the climate change based on the available hydro-meteorological data and regional and global circulation model. There is no doubt that these studies have high contribution in understanding the bio-physical processes and impacts of climate change globally and regionally whereas it has also been well realized that these climate change projections are unable to capture the micro-level impacts of climate change (IPCC 2007a). Besides, the scientific research and its results are not necessarily understood by all the people. Rebetez (1996) pointed out the difficulties in receiving and making use of scientific information in decision making process by policy makers, politicians, media personnel and even scientists from other disciplines; making use of their own experiences and perceptions in understanding issues. It is true that the change in climate is global but it is also equally true that the impacts of these changes are entirely local and so are the responses to the change by the local people. Smit and Wandel (2006) argued that the adaptation to the impact of climate change is local and contextual, specifically depending upon the availability of technology, institutions, social network, kinship and political situation. Hence there is a need for climate change studies at the local level through bottom-up approach in order to address the impacts of climate change (Kates and Torrie, 1998; Adelekan and Gbadegesin, 2005 and Piya et al., 2012). In Nepal, there are some studies undertaken at the local level based on perception of the local people. But, these studies have been done either in a rural setting and outside Kathmandu valley (Chapagain et al., 2009; Practical Action, 2010; Chaudhari and Bawa, 2011 and Tiwari et al., 2010) or focused only on a particular community (NCDC, 2010; Maharjan et al., 2011 and Piya et al., 2012) in the rural areas. Piya et al., (2012) stated that the perception of local people about the climate change can be entirely different from what science says about climate change. It is in these realities, that the aforementioned restricted research outputs, more so in the context of a peri-urban terrainare not enough to bring forward the ground realities of climate change, its impacts and the responses of the local people. Hence, this paper tries to explore the local knowledge on climate change, its impacts and the responses they are making to the changes on the basis of their perception.

1.MATERIALS AND METHODS

2.1 Study Area

Lubhu Village Development Committee (VDC) - a peri-urban area with mix of rural and urban livelihood is situated at the periphery of Lalitpur sub-metropolitan city. It is 700 years old traditional Newar settlement located at south-eastern part of Kathmandu Valley and lies at 85° 24″ East and 27" 39″ North. It has 2,326 households with 10,374 populations (male- 5,126 and female- 5,248) in an area of 4.76 km2 . This village is dominated by Newar caste households with around 62 per cent followed by around 27 per cent of Cheetris, 5 per cent Bhramins, 4 per cent Dalits (disadvantaged group) and 2 per cent Magars. Few households belonging to Tamangs and Gurungs are also present in this village. According to the VDC profile (2008), around 59 per cent households are involved in agriculture followed by 17 per cent in business, 7 per cent in service and around 17 per cent involved in other kind of jobs. Though most of the households are involved in agriculture, around 83 per cent of the income source is from off-farm activities and only 13 per cent of income source is from agriculture and floriculture and 4 per cent from livestock rearing.

2.2 Methods

This study used participatory tools in order to collect qualitative and quantitative information about climate change, its impacts and adaptation strategies to enhance their resilience capacity to climate change. The study started with a series of informal discussions with the local people on the local level climate change. This preliminary survey captured the general perception of the local people on climate change which helped in preparing a detailed check list of the perceived changes in different attributes of climatic parameters, the

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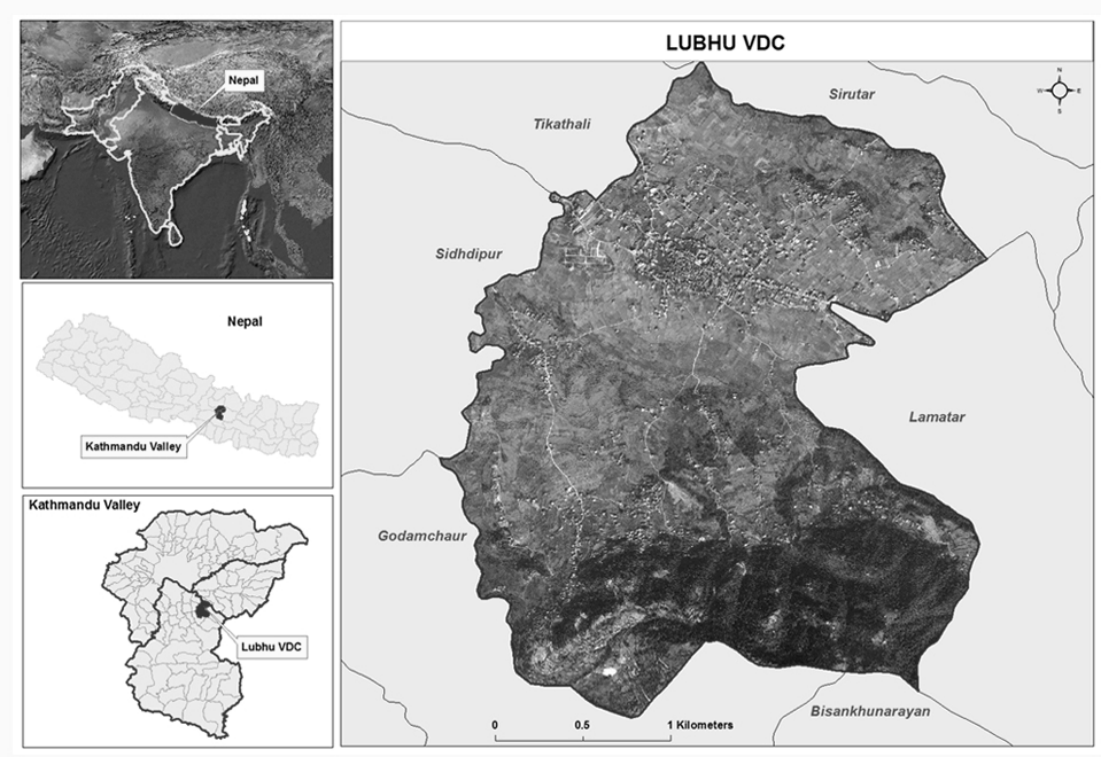
Figure 1: Location Map of the Study Area



perceived consequences on agricultural systems, natural resources, disasters and livelihoods.

A series of focus group discussions were organized with local people belonging to different age groups and occupational categories to capture the perception on climate change and its implications. A time frame was developed based on the major events that the local people could easily recall. This supplemented local people to recall the retrospective experiences on climate. The prepared check list was used to facilitate the participants of focus group discussion to recollect their memory on decadal change in the climate through a time frame of 40 years (defined as prior to 1980s, 1980s, 1990s and 2000s). Since the changes were primarily perceived in terms of the changes in rainfall and temperature, the discussions focused on capturing the perceived changes in various attributes of rainfall and temperature and the impacts of the changes as perceived by the local people including coping and adaptive strategies practiced by them. Besides, household survey was also conducted in 202 households to understand the individual perception on the changes in different attributes of climate and its impact on their livelihood.

Rainfall and temperature data were collected from the Department of Hydrology and Meteorology (DHM) for seven stations and for four different stations respectively within the Kathmandu valley and the climatic trend was analyzed. However, the climatic trend of Kathmandu valley has been used to interpret the long term climatic trend in Lubhu as it is a part of the Kathmandu valley, as the area was uncovered by hydro-meteorological station.

3. RESULTS AND DISCUSSION

3.1 Changes in Temperature: Perception and Actual Trend

During household survey, the respondents were asked about their perception of changes in various attributes of the climate. Among 404 respondents who were involved in the household survey, 76 per cent perceived the rising summer temperature while very negligible percentage felt the decrease in summer temperature. Nearly 44 per cent felt that the winters were getting warmer and around 27 per cent observed colder winters.. The analysis of the recorded data also showed the similar pattern. The deviation plots of 5 year moving average for temperature for all the stations showed that the minimum as well as the maximum temperature in monsoon and non-monsoon season seem to have increased in the recent years. The deviation plot of Khumaltar station is shown in figure 2 as an example.

More than fifty per cent of the respondents noticed increase in the number of extremely hot days, hot days and less cold winter whereas majority of respondents perceived decreasing cooler days and extreme cold winter days. Most of them also noticed decrease in cloudy and foggy days in winter. These are also

supported by the secondary hydro-meteorological data. Analysis of temperature data showed that there was a decrease in the number of days with temperature < 0°C and an increase in the number of hot days (> 30°C) (figure 3). Both the maximum and minimum temperatures of the hottest day of the year had increased and same was the case of the coldest day, which implies that the warmest day of the year had become warmer, and the coldest day of the year too. Based on Sen's Slope estimation of the complete series of data, average increase of 0.04°C per year was found for minimum temperature, and an average increase of 0.05°C per year for maximum temperature which is higher than the South-Asia and global average.

On an average 24 per cent of the respondents did not perceive any change in temperature related attributes which is comparable to the study by Piya et al., (2012) where they found 38.5 per cent perceive the same. In their paper, they agreed to the Vedwan and Rhoades (2001) where the perception of no change in parameters of temperature is attributed to the invisible features of change in temperature. The detail changes in different attributes of temperature according to the household survey are given in figure 4.

Figure 2: Deviation from long term annual mean max. (a and c) and mean min. (b and d) temperature in non-monsoon (a and b) and monsoon (c and d) period in Khumaltar, expressed in percentage. The line gives the 5 year moving average.

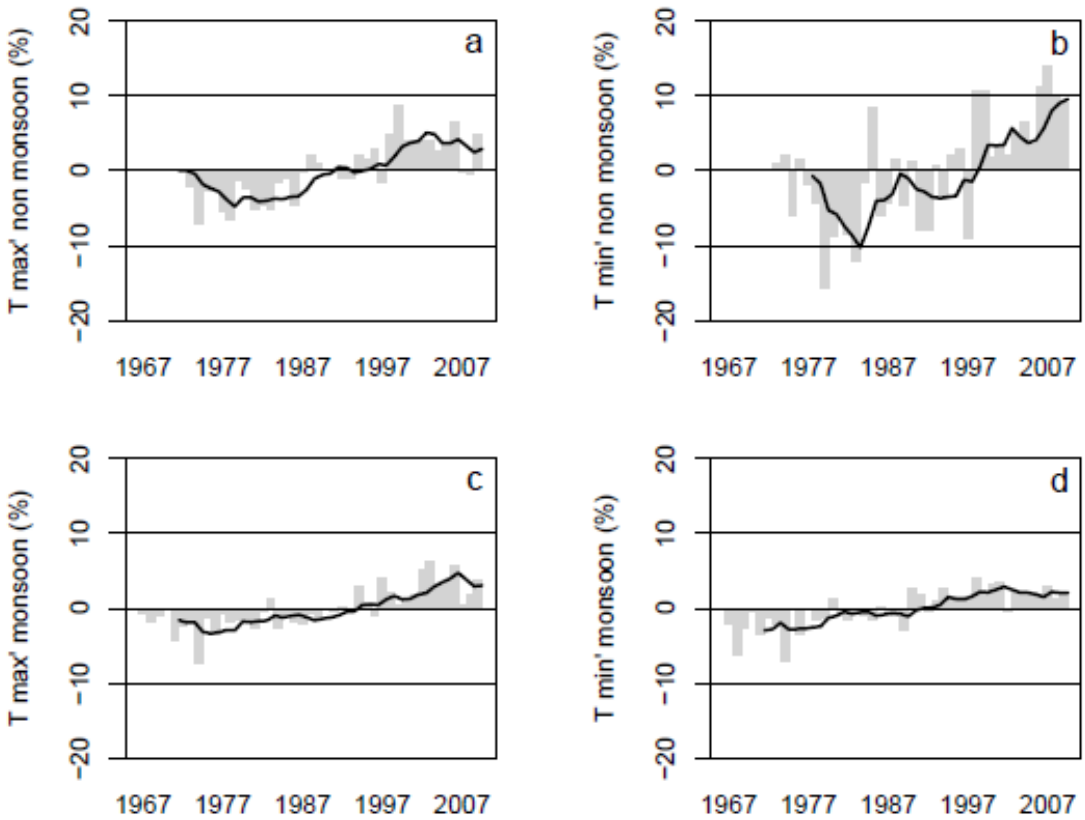


Figure 3: No. of days less than 00c and greater than 300 c per year

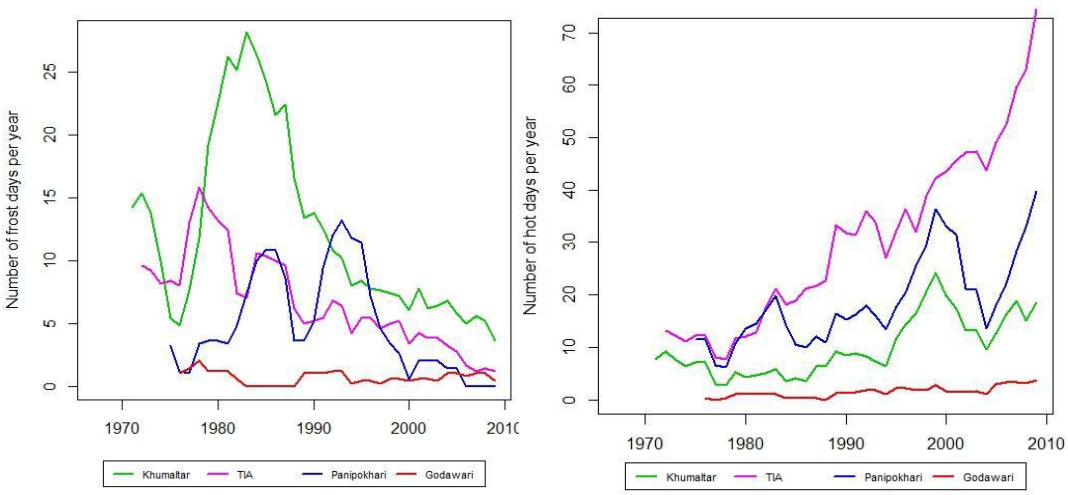
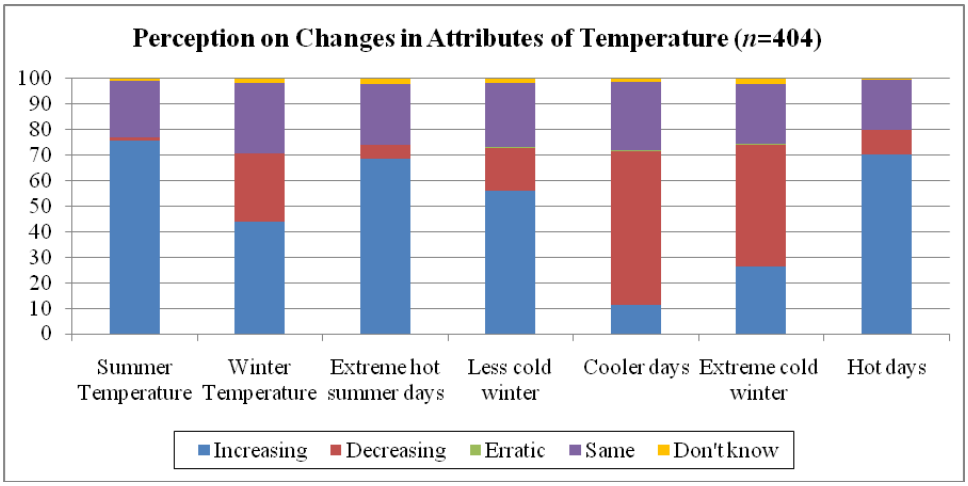


Figure 4: Perception of respondents on changes in different attributes of temperature



In the above figure, the x axis represents the proportion of responses, while Y axis represents specific weather parameters. These perceptions were substantiated through focused group discussions by exploring the changes in temperature during different time periods; relating to the religious and cultural activities. The respondents traditionally related the seasonal cycle of summer and winter to the rituals. Shree Panchami, a small Hindu festival celebrated during the month of February/March, was symbolized as the day for the onset of summer while winter was believed to start since Naag Panchami, a cultural day of worshipping a serpent celebrated in the month of July/August. There was an unequivocal opinion concerning the increasing duration of summer season and decreased duration of the winter season. Most of the respondents perceived a gradual increase in the summer period after 1980s and large increase in the post 2000. They perceived that if the duration of the summer season continued to expand at the perceived rate, winter season would vanish in the next few decades. Similarly, most of the respondents' experienced small decrease in the duration of the winter season in 1980s and 1990s while in 2000s, they perceived large decrease. They felt that the spring which was a distinct season starting around Falgu Poornima (full moon day and a festival of colors celebrated in the month of March) and autumn bringing in a festive weather during Dashain and Tihar (festivals celebrated during the month of October- November) were rather blurred. In spring, they felt the days were much hotter giving a feeling of summer. Similarly, they felt autumn had started very late and though the mornings were colder, the days were as hot as in summer. Prior to 1980s, people felt that winter season used to begin by Kartik (October/November) and the peak winter season months used to extend from November second week to mid February (Mangsir to Magh). In 2000s, they felt winter began much later and ended earlier. Even during the months considered as peak winter, they noticed that though the days were cold during the morning, temperature gained higher peak by the afternoon giving a very mild feeling of winter.

Elaborating the change in temperature pattern, the participants shared their experience of unexpectedly warmer winter afternoons with chilly mornings. Such incidences were recalled to have created discomfort due to the warm clothes worn based on the chills in the morning. Some of the participants explained the warmth of sun during winter which used to be appealing has no more remained so.

People also perceived that despite temporal increase in the trend of temperature within the village, the rise was not as extensive as they felt during their travels to the city cores. The expression indicated experiences of an urban heat island effect. Similarly, the respondents perceived a decline in the number of frost days. Most of the respondents felt that the decrease in frost days started in 1990s which became more intense in 2000s. They related this with a drastic decline in the practice of covering the potato plants with straws for protection against frost and decrease in the frost damage to winter crops as a result of decline in the frost days. People also shared their experience of tastier green leafy vegetables after the occurrence of frost during winters, which has not happened in the recent years.

People recalled the occurrence of icy film formed on the water surface (Thanto), prior to 1980s. This gradually declined during 1990s and stopped occurring in 2000s. They considered that the general trend of occurrence of frost was from the second week of November to second week of February after which invisible black frost (Kalo Tusaro) occurs by the third week of February. This was believed to be responsible for morning chills though the afternoon temperature was much higher by this time of the year. The black frost used to extend till first week of March but after mid 2000s, they have been experiencing decrease in usual frost while the period of black frost was extending up to the last week of March.

Similarly, people were clear about the occurrence of fog which according to them, started by the second week of September with the occurrence of light fog in the days prior to Dashain extending till February. They felt that at present, the occurrence of fog has started much later around second week of October in 2000s

and was much lighter by the mid of February. In addition, they also experienced a decline in the fog density and decline in foggy duration within a day. They believed that the days in the second week of December to second week of January used to be very foggy and the sun used to be visible only after 11 a.m. Owing to this weather pattern, a local statement "Poush Fas Fus" was generated indicating passing away of the days of Poush (December/January) by the time fog faded.

3.2 Changes in Precipitation: Perception and Actual Trend

The perception of respondents on different attributes of precipitation is given in figure 5. Most of the respondents had discernible views of decrease in both winter and spring rain whereas the deviation figures drawn showed that there is no clear visible pattern both in monsoon and non-monsoon period. A linear trend line for monthly precipitation sum also do not demonstrate clear visible pattern. Mann-Kendall test illustrated that there was no significant increase in or decrease in the total precipitation trends. An overview of the Seasonal Mann-Kendall test results are shown in table 1. These findings confirmed the conclusion of Shrestha et al., (2000) that there is no significant long term trend in precipitation. Although there is no clear pattern in changes in rainfall scientifically, the inter-annual variation and shifts in seasonality are likely factors to influence the perception of local people of decreasing rainfall. However, this perception in some way can be related to climatic data analysis while looking at the monthly sums, as it showed that the precipitation decreased mainly in the months October to March which is the period for winter rainfall implying decrease in winter rainfall. Increase in precipitation took place from April to September, except for June. June is the month for the onset of monsoon in Kathmandu. This average decrease in June can imply that the onset of monsoon had shifted to later in the season. This again in some way supports the perception of decrease in monsoon rainfall.

Figure 5: Perception of respondents on different attributes of precipitation

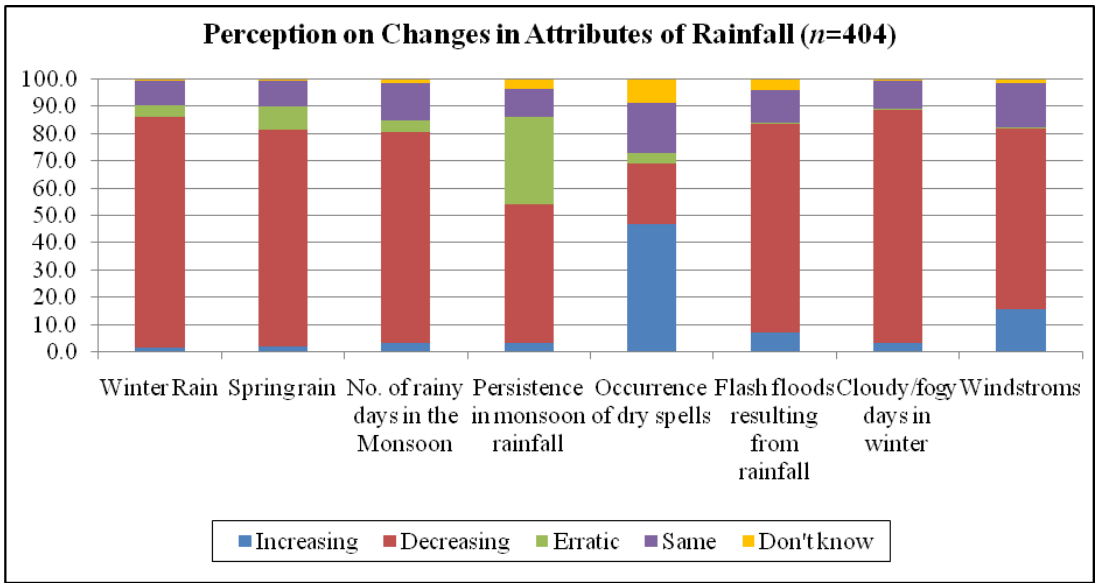


Table 1: Kendall Tau and significance of Seasonal Mann- Kendall

Station	Kendalls Tau	P-value (2 sided)
Khumaltar	0.00	0.996
TIA	0.01	0.703
Godawari	0.01	0.801
Panipokhari	0.02	0.514
Changunarayan	-0.02	0.633
Sankhu	-0.02	0.594
Naikap	-0.05	0.324

Similarly, the perception of respondents about decreasing number of rainy days in monsoon and persistency in monsoon rainfall is somehow supported by the analysis of recorded hydrological data. The number of days of rainfall every year for all the stations were counted for monsoon and non-monsoon period

separately, which verified that four out of seven stations show a decrease in the number of rainy days in non-monsoon period. Although this is not really convincing (also with very low R2 values as in table 2 the pattern can recognize that the negative direction (decrease in number of rainy days) seems to be a stronger signal than the positive directions. For monsoon period, only three out of seven stations show a decrease in the number of rainy days. Again, it is recognizable that the negative numbers are in general stronger than the positive numbers. Naikap station seems to give the strongest decrease in the number of rainy days, both within and outside the monsoon period but only 13 years of data is available from Naikap station, which is too short a period to be able to draw any conclusion concerning climate.

Table 2: Slope of trend line through number of rainy days per year

Station	Non-Monsoon	R^2	Monsoon	R^2
Khumaltar	0.22	0.09	0.19	0.10
TIA	0.35	0.17	0.16	0.13
Godawari	0.12	0.01	0.12	0.01
Panipokhari	-0.68	0.33	-0.11	0.04
Changunarayan	-0.46	0.16	-0.31	0.18
Sankhu	-0.35	0.09	0.06	0.01
Naikap	-1.03	0.25	-2.03	0.52

Around 47 per cent respondents perceived increase in the occurrence of dry spells whereas 22 per cent perceived decrease and around 18 per cent felt neither increase nor decrease in dry spells. Majority of respondents noticed decrease in windstorms and number of flash floods from rainfall. However, analysis of recorded data did not show identifiable patterns in the number and length of dry spells whereas an increase of events with > 50 mm of precipitation was found for most stations.

Similar to temperature, while breaking down the changes into different time periods and linking with different religious, cultural and agricultural activities in a year, during focused group discussion, most of the respondents perceived a continued decrease in the total amount of rainfall starting from 1990s which further declined in 2000s. However, 2010 onwards they perceived a situation which has been better and some even considered that the climate was taking its original trend. The change in the rainfall pattern was perceived to be more stressful than the changes in the total annual rainfall. Very recently starting from mid 2000s, unusual changes in the pattern of rainfall were noticed making rainfall no longer predictable. The respondents were also surprised with the incidences of intense rainfall in one part while other areas remained completely dry.

The practice of relating the rainfall events to traditional rituals celebrated annually was a common practice and those events commonly linked with rainfall were Krishna janmaastami celebrated during August/ September (Bhadra), Shiva Ratri that falls in the month February/ March (Falgun). Similarly Nag Panchami Jhari, Shaune Jahri, Shora Shraddha Jhari, Naurat Jhari, Maghe Jhari were associated with persistent rainfall. The term Jhari indicated persistent rainfall lasting for days.

The traditionally established belief was that prior to 1980s, the date on which winter rain starts during December/ January (Poush) and January/ February (Magh), it used to be the same date to start rain on June/July (Ashad) and July/August (Shrawan) respectively. Winter rain recalled as Maghe jhari, rainfall occurring during the month of January/ February; used to be very common till 1980s. Most of the respondents agreed that this trend got gradually disturbed from 1990s, though there was variation in the perceived magnitude of decline in the number of rainy days. The situation got further disturbed in 2000s since a further decline in the number of rainy days making the rainfall erratic and unpredictable

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Monsoon normally starts in the second week of June and reaches full development in July. Monsoon is the main source of precipitation, which enters the country from the eastern part of Nepal (Rai et al. 2011). Changes in monsoon rainfall was related with the timely completion of paddy transplanting in the area, availability of water in irrigation canals and standing water in the paddy fields at the time of weeding and soil moisture retention at the time of harvesting of the crop. Similarly, onset of the monsoon was related to the sufficiency of water retained in the farms for starting rice transplantation whereas the cessation of monsoon was characterized with the occurrence of short intensive rainfall and usually monsoon rain used to stop prior to Dashain, a hindu festival celebrated in the month of September- October.

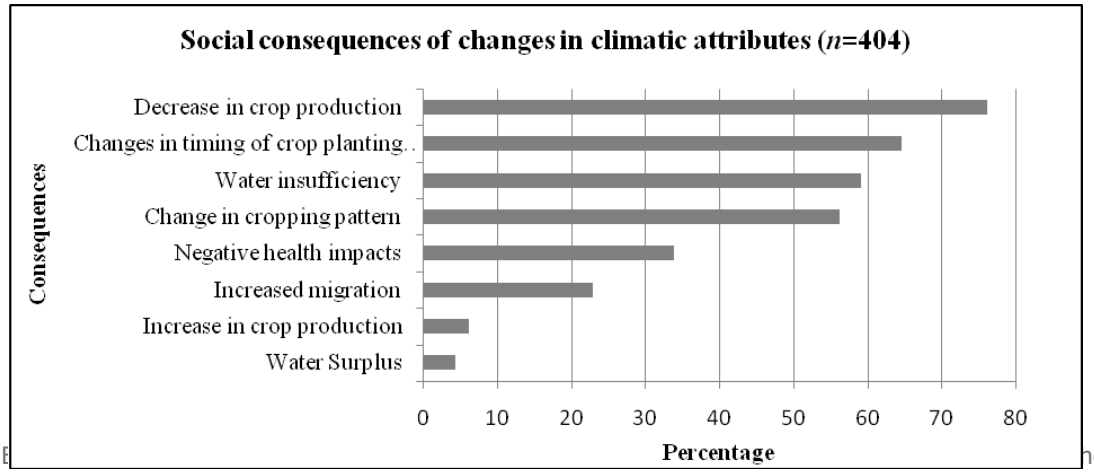
Farmers recalled the occurrences of persistent rainfall lasting over days and nights prior to 1980s in such a way that they could not leave "Ghum" (folded mat made from bamboo strips and leaves and used by

farmers as an umbrella) for a long time and remembered the incidences of occurrence of Lice in Ghum which they locally called "Ghum ma Likha Parthyo". This was a regular event during monsoon and termed as "sat din sat rat jhari" (rainfall lasting for days and nights for seven days) which as per the respondents has remained only in their memory. Shaune jahri (rainfall during July/August), Shora Shraddha Jhari (rainfall during September), Naurat Jhari (rainfall during September/October), Maghe jhari (rainfall during January/February) were recalled as common incidences prior to 1980s. Most of the respondents noticed slight decline in the rains during monsoon started in 1990s and started declining more profusely after mid 2000s. People elaborated this through a local statement saying "Shrawan ma aakash ma euta tara dekhiyo vane, ek lakh muri anna ghattcha" meaning there will be huge reduction in agricultural production if we could see a single star in the sky during July/ August.

3.3 Implications of Climate Change

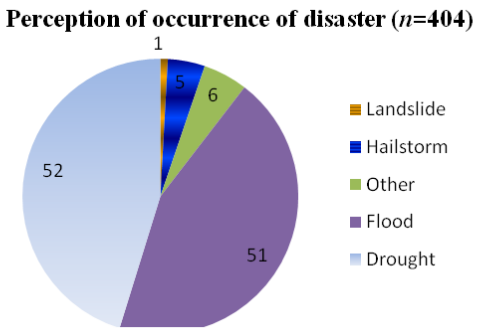
The respondents were asked about the social consequences of climate change. Seventy six per cent of the respondents perceived a decrease in crop production due to climatic variability whereas 65 per cent observed changes in timing of crop planting and harvesting. The other major impacts were water insufficiency, change in cropping pattern, negative health impacts and increased migration. However, very few respondents also perceived increase in crop production and water surplus. The perceived consequences attributed to changes in different above mentioned attributes of climate change are shown in figure 6.

Figure 6: Perceived consequences of changes in climatic attributes



E he climatic variability. The most commonly observed and remembered water induced disasters that they reported are drought and flood. Around 50 respondents perceived the occurrence of droughts and floods. There were few respondents who experienced hailstorm, landslide and other types of disasters as well.

Figure 7: Perception of occurrence of water induced disaster due to climatic variability



The impacts of climate change were again substantiated through focus group discussion. According to the participants, natural spring sources have been adversely affected by rainfall variability. Either the yield of spring sources have been declining or the whole system had vanished. However, they observed that these changes in spring sources were not solely due to climatic variability but these were the compounded impact of climate change and urbanization which as rightly pointed by Manandhar (2011:336) stating that "climate change is not always the main reason behind these changes but may have acted in many cases as a catalyst".

Similarly, the local people perceived that crop damage due to increased pest attacks had increased. The farmers also reported on the emergence of new pests in crops and felt, it was an impact of increasing temperature along with the disturbance in the natural pest predator system as a consequence of soil degradation due to unbalanced use of chemical fertilizers and pesticides. Consequently, the cost of production has been increasing while crop production is declining. Literature also showed that an increase in maximum temperature can enhance invasive weeds to enter the area (Dukes and Mooney, 1999) and also it increases the risk of vector borne and rodent borne diseases (Patz et al., 2006). A decrease in the number of days with < 0°C also can cause an increase in insects and pests because of less winter kill (Ziska et al., 2011). People perceived that the occurrence of weeds increased in 2000s which has increased the need of weeding practice more. While Sama (Echinochloa colona), Ketu, Kasauti, Phuke, Dubo (Cynodon dactylon) were indigenous weeds, new weeds like Maobadi Jhar, Navo, Madila, Tantane, Pire (Polygonum barbatum), Mothe (Cyperus difformis), Baspate, Pani ghans appeared in rice field and progressively increased in 2000s. Similarly, the diseases called Sete (the tip of the leaves turning white as a result of inundation for longer period) and Rate were increasing in rice plants. The farmers recall the regular occurrence of green aphids which started appearing from the1990s while black aphids appeared only in 2000s with the latter being considered to be more destructive. Though the occurrences of pests were lower during winter season as compared to the summer season, it was observed that the pest population was gradually increasing with the winters slowly being milder.

People remembered that the rice transplantation used to begin in the second week of June till 1980s and continued for a month across fields in different terrace. They also recalled occurrence of floods in 1981 and 1993 which deteriorated the condition of the state sponsored irrigation canal called Singha Rishi Dovan Rajkulo and reduced its command area. After 1990s, the period of rice transplantation was delayed to later in July though in some years they could still begin within June. During 2000s, the farmers felt that the rainfall was erratic and no distinct trend in starting the rice transplantation activity could be identified. The farmers also perceived an increase in the yield of all the agricultural crops from period prior to 1970s to 1990s but a declining trend in production from the year 2000 onwards. They perceived this decline as a compounded effect of poor rainfall during pre-monsoon, delayed onset of monsoon and shift in the peak monsoon rainfall during August/September affecting the harvestable maize and increasing pest incidences along with degrading soil quality due to extensive use of chemical fertilizers. WECS (2011) also showed a similar trend. Accordingly, Nepal was self sufficient in food grain production until 1990. Due to incidence of drought conditions in 2005-2006, production fell short by 21,553 metric tonnes and by 1,79,910 metric tonnes respectively in 2006 and 2007 due to drought and other natural calamities. The rising maximum temperature and increase in minimum temperature had a negative impact on the rice yield, through a decline in the yield due to early maturity of the crop (Rai et al., 2011. If increase in the minimum temperature is less stronger than the increase in maximum temperature, the daily variability of temperature increases which can decline crop yields (Wheeler et al., 2000).

3.4 Responses to the change

3.4.1 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 only alternatives available to the people. Ferrying water in containers loaded on the bicycle and push carts is a common sight at Lubhu, which is not only time consuming but also involves lot of physical drudgery. Often several households join and rent a vehicle to transport water in larger vessels. Since large quantities of water are being transported in a single trip through a rented vehicle, it becomes an easy and cost effective alternative.

Tanker water supply is another alternative for the households to deal with scarcity during the dry season and in the event of disruption of the water supply through Drinking Water Supply Scheme, which is interrrupted frequently by the landslides during the monsoon. The usual rate charged by a tanker operator for small quantities of water- approximately 15 liters (one gagri) is 5 NPR.

3.4.2 Capturing Roof Top Runoff

Some households at Lubhu have started capturing roof top rainwater and storing the harvested water for uses in cleaning, washing and other sanitary uses. A pit dug in the homestead for storing water for uses apart from drinking and livestock watering is becoming a common option. Some households have also developed roof top and underground water storage tanks to store enough water to meet the needs during periods of extreme scarcity.

3.4.3 Increasing number of dug wells at households

People earlier depended on river water, community dug wells, and kuwas. With the increasing water demand, changing life style and degrading water quality of these traditional sources, the preference towards the use of traditional sources has decreased. The rivers and traditional community dug wells have

been facing the problem of "Tragedy of Commons" whereas, at the household level, private dug wells have been increasing rapidly. Nowadays, almost all the households have dug a well in their homestead. People have even started digging two or even more dug wells at the individual household level. These households use the extracted ground water for domestic purposes other than drinking and also for irrigating agricultural crops.

3.4.4 Shifting cropping practices

Farmers have stopped cultivating wheat due to high water requirement in growing the crop, lower economic returns and higher input use and the drudgery involve in the cultivation process. The other winter crop commonly grown is broad windsor fava bean (bakulla) which is now also declining due to increasing pest attack. Varieties of Pea and red lentil (pulse) are new preferences due to their less demand for water and good market value. However, as red lentil requires irrigation during its flowering period, its cultivation has also been reduced but pea is continuing considering its less demand for labour and good market value. Farmers are also found increasingly shifting towards soybean and barley cultivation. Barley, being a drought resistant crop, has suited water scarce areas of Lubhu and has been preferred due to its good market demand for religious activity and is cultivated instead of wheat after paddy harvest. Similarly soybean is cultivated from January end to April and marketed in the form of green pods and dried bean.

Some of the farmers have also started leaving the land fallow during winters. The winter crops that have replaced wheat are also not getting a favourable environment to grow well as the soil moisture is very poor in the rice fields due to delayed harvesting of rice and erratic rainfall and unfavourable temperature at the time of winter cropping. Therefore the farmers are left with no other option but to leave the land fallow.

The farmers earlier would spread rice straw over the land surface for drying it and after few days of drying, they would collect and stack them, and plant winter crops thereafter. Over the last few years, farmers have started planting winter crops immediately after paddy harvest before the residual moisture in the soil reduce further because of the lack of water for irrigation. Common crops planted with this changed cropping calendar included wheat, mustard, red lentil (musur), broad windsor fava bean. In addition, the farmers have started to sow pea prior to paddy harvest so that the pea germinates using the soil moisture of rice field and grows to young plant prior to the harvest of paddy. The farmers believed that this had provided them dual benefits of optimum use of soil moisture and they also observed that the chopping of the growing tips of pea plants during paddy harvest helped better growth of pea plants and hence improved the pea yield.

Similarly, farmers also started using wet rice straw for mulching. With the decreasing residual soil moisture during the time of paddy harvest and decline in winter rainfall, farmers have modified the practice of drying rice straw and use it as a mulching agent for winter crops. The farmers have been managing the fields immediately after the paddy harvest and the seeds of the crops selected for the winter season are sown. The straw is then spread over the surface for drying. With the straw spread for drying, loss of soil moisture is also reduced and hence water retained helps germination of the winter crops.

The traditional varieties of rice Taichin-242 and Tainan- 176 required more water and fertilizer. Khumal-4 was started in Lubhu around a decade earlier. Its resistivity to drought and less water and fertilizer requirement as compared to Tainchin has made farmers prefer this variety. With declining irrigation and changing rainfall pattern, preference over this less water demanding variety has been increasing in Lubhu.

3.4.5 Migrating from the Upland to Low Land

The availability of water is always a constraint in the upland areas due to unavailability of dependable spring sources and groundwater sources and also limitations due to the terrain, in developing piped water supply system. In order to avoid this difficulty, there is an 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 No. 8 of Lubhu where people in large numbers have shifted the location of their house from the upland to the low land areas and access to dependable water source was noted to be important consideration for taking this decision.

3.4.6 Increasing use of pesticide

The increasing temperature, declining occurrence of frost and variation in the pattern and amount of rainfall are the climatic variations that are perceived as the major causes of increasing occurrence of pest and diseases in crops in Lubhu. The most commonly used pesticide is metacede. With increasing occurrence of pests, farmers complained about the increased need in the frequency of use and amount of pesticide. Farmers noted that one bottle of pesticide costing NRs. 80 would be sufficient earlier for a ropani of land during winter cropping but with increasing pests and diseases; the requirement of pesticide has increased three times over a period for the same piece of land.

3.4.7 Occupational Diversification

People are shifting to off-farm 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 pieces 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.

3.4.8 Technological Innovations

Farmers have initiated using water pumps for lifting water from river to agricultural land. They initiated it in 2008 with the financial support of Micro Irrigation Support Program under the Multiple Use Water System (MUS) implemented through International Development Enterprise's (IDE) Small Irrigation Market Initiative (SIMI) Project Nepal. The committees have been collecting area based irrigation service fee of NRs 300 to 350 per ropani of land from the farmers based on the location of field to be irrigated and they have been using this fund in operating and maintaining the pump sets.

Beside this, they have also started drip irrigation from the same period. Currently, 57 drip irrigation services are in operation, out of which 42 are operated through Mahila Bishankhu Samuha, the farmers committee from the minority groups whereas 15 are operated by Tri-ek farmers committee.

3.4.9 Initiation of charging irrigation service fee

Following the renovation of irrigation system, farmers in Lubhu have improved their mechanism of irrigation system management. In the traditional practice of irrigation, water in the irrigation canal was diverted to the lowlands only after the accomplishment of irrigation in the upland areas and was provided free of cost. After the renovation of Majha kulo in 2012 AD, the farmers in ward number 8 of Lubhu have initiated collection of irrigation service fee/tariff. The irrigation water users are charged on the basis of area to be irrigated ranging from NRs.100 to 150 per ropani of land irrigated depending upon the location of the field. The collected service fee has been used for paying remuneration to the two canal operators selected by the farmers committee. This new system has helped farmers to manage water in the canal, based on the demand and hence free access of the limited water resource, has been reduced considerably.

4.Conclusion and Recommendation

This study has analyzed the perception on climate change, by local people residing in the peri-urban area of Kathmandu valley, its impacts and responses thereto. The analysis of secondary data showed an increasing trend in temperatures in both monsoon and non-monsoon period and for both maximum and minimum temperature which is comparable with the perception of the local people on changes in different attributes of temperature. Similarly, the perception of decreasing rainfall is in some way matched with analysis of rainfall data, however, the analysis did not show clear visible patterns of increase and decrease. The difficulties in matching perception and analysis of the actual recorded data for rainfall is because monthly averages can give the picture of total amount of rainfall but do not give a picture of timing of rainfall. The unavailability of a meteorological station and the micro-climate effect at Lubhu can be another reason for the perceptions not fitting exactly in line with the analysis of data.

The people have been experiencing several impacts of changes in temperature and rainfall. The major impacts were decrease in crop production, changing cropping patterns and agricultural practices, declining yield of natural springs, frequent destruction of water infrastructure from flood and landslide and increase in insect-pest attack and weeds in agricultural crops. People have been responding to the water scarcity through household level water management, purchasing water from private water entrepreneurs and digging wells whereas leaving land fallow, shifting agricultural crops, changing cropping pattern, increasing use of pesticide and different technological innovations are the major adaptation strategies followed by the farmers to enhance their resilience capacities against the adverse impacts of changes in climatic attributes.

The government has to develop a mechanism in transferring knowledge of climate change to the local level and should implement the Local Adaptation Plan of Action (LAPA) through local level organization including local people. Similarly, Village Development Committee should incorporate the issues of climate change and adaptation strategies in their annual work plan. Since the climatic variability has been an uncertain phenomenon, local people should be prepared and their soft and hard resilience capacities should be enhanced in order to adapt better to the changing climate. Training of the local school teachers and students from high school, on climate change it's possible impacts including different adaptation strategies to tackle the adverse impacts of climate change would help in multiplying and expanding knowledge at the grass root level.

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Water Security in Peri-Urban South Asia

Adapting to Climate Change & Urbanization

Water Security in Peri Urban South Asia: Adapting to Climate Change and Urbanization

Working primarily on water security issues in Peri-Urban South Asia, across India, Bangladesh and Nepal, the project's main concerns are the rapidly changing peri-urban landscapes due to urbanisation and implications for water security in specific locations in the larger context of climate change. As an action research project, working across four locations in South Asia, it will serve as a basis for capacity-building at the grass roots level to address concerns of the poor, marginalised and other vulnerable communities to water security and seek to understand the dynamics of adaptation in the specific locations, for action and policy agenda at the regional level. It will build their capacities to cope with climate change induced water in-security.

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Bangladesh University of Engineering and Technology (BUET) is the oldest and leading university in Bangladesh in the area of technology. IWFM is a premier institute for the advancement of knowledge and development of human resources in water and flood management.

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