People's experience and facts of changing climate: impacts and responses

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Abstract

Purpose – This paper aims to explore the local knowledge on climate change, its impacts and the responses they are making at the household or community level to deal with the changes on the basis of their experiences and perceptions.

Design/methodology/approach – The study was based on household survey conducted with one male and one female respondent in 202 households. Alongside, series of focused group discussions were conducted with local people to capture the perception on about climate change, its impacts and adaptation strategies applied to enhance their resilience capacity to changing climate. Rainfall and temperature data were collected from Department of Hydrology and Meteorology (DHM) for seven and four different stations, respectively, within Kathmandu Valley and analyzed to understand the climatic trend.

Findings – The perception of most of the local people on changes in temperature was almost in line with the recorded long-term climatic trend both showing an increasing trend, whereas the perception of decreasing both monsoon and non-monsoon rainfall did not match with the recorded data as the rainfall data analysis did not reflect any clear long-term pattern. People have been facing several impacts such as decrease in water sources, decrease in agricultural crop production, increase in new crop pest and weeds in agricultural crops. Local people are responding to these impacts as per their own skills and traditional knowledge.

Originality/value – This is totally original research article and the impacts and adaptations measures documented in this article may represent the case of peri-urban areas of least developed countries like Nepal.

Keywords Climate change, Responses, Perception, Impacts

Paper type Research paper

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1. Introduction

Climate change has been hot global issue and has gained momentum in Nepal as well. GoN (2010) has reported that the Nepal is highly vulnerable to climate change. It also stated that more than 1.9 million people are highly vulnerable and 10 million are increasingly at risk with climate change likely to increase this number in future. Several studies have been done and many are going on in climate change issue. Most of these studies are on 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 modeling. 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, 2007). Nepal Climate Vulnerability Study Team (NVCST) in 2009 stated that the global circulation models (GCMs) have not properly represented the topographic features of Nepal which is very important for determining the climate of Nepal and hence can best produce projections at large-scale only but not at local scale. Besides, all the scientific researches and their 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 interpretations in understanding the 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 changes made by the local people. Smit and Wandel (2006) argued that the adaptation to the impacts of climate change is local and contextual, specifically depending upon the availability of technology, institutions, social network, kinship and political situation. NCVST (2009) argued that the local observations and perceptions shape livelihood systems, infrastructures and economic activities and therefore are important for enhancing the resilient capacity of local people against the impacts of climate change. Hence, there is a need of climate change studies at 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 on local level climate change based on the perception of the local people. However, these studies are done either in a rural area or outside Kathmandu Valley (Chapagain *et al.*, 2009; Chaudhary and Bawa, 2011; Tiwari *et al.*, 2010, 2012) or focused only on a particular community (NCDC, 2010; Maharjan *et al.*, 2011; Piya *et al.*, 2012) of 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, the aforementioned few literatures are not enough to bring forward the ground realities of climate change, its impacts and the responses of the local people. Moreover, there is a dearth of literature on these types of studies in peri-urban area, a transition zone of urban and rural areas of Kathmandu Valley, where there is a mix of both urban and rural characteristics. Hence, this paper tries to explore the local knowledge on climate change, its impacts and the responses they are making at the household or community level to deal with the changes on the basis of their experiences and perceptions.

2. 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 (Figure 1). It has 2,326 households with 10,374 populations (male – 5,126 and female – 5,248) in an area of 4.76 square kilometers. This village is dominated by Newar caste households with around 62 percent followed by around 27 percent of Cheetris, 5 percent Bhramins, 4 percent Dalits (disadvantaged group) and 2 percent Magars. Few households of Tamang and Gurung also reside in this VDC. According to VDC (2008) profile, around 59 percent households are involved in agriculture followed by 17 percent in business, 7 percent in service and around 17 percent involved in other kinds of income generating activities. Though most of the households are involved in agriculture, around 83 percent of the income source is from off-farm activities and only 13 percent of income source is from agriculture and floriculture and 4 percent from livestock rearing.

2.2 Methods

Household questionnaire survey was conducted to understand the individual perception on the changes in different attributes of climate and impacts experienced on their livelihood. The multi-stage stratified random sampling technique with proportional allocation was adopted to ensure geographical representation from each of wards. The administrative hierarchy in Nepal has divided VDC into nine different wards. Considering these wards as first unit of classification, social stratification was done

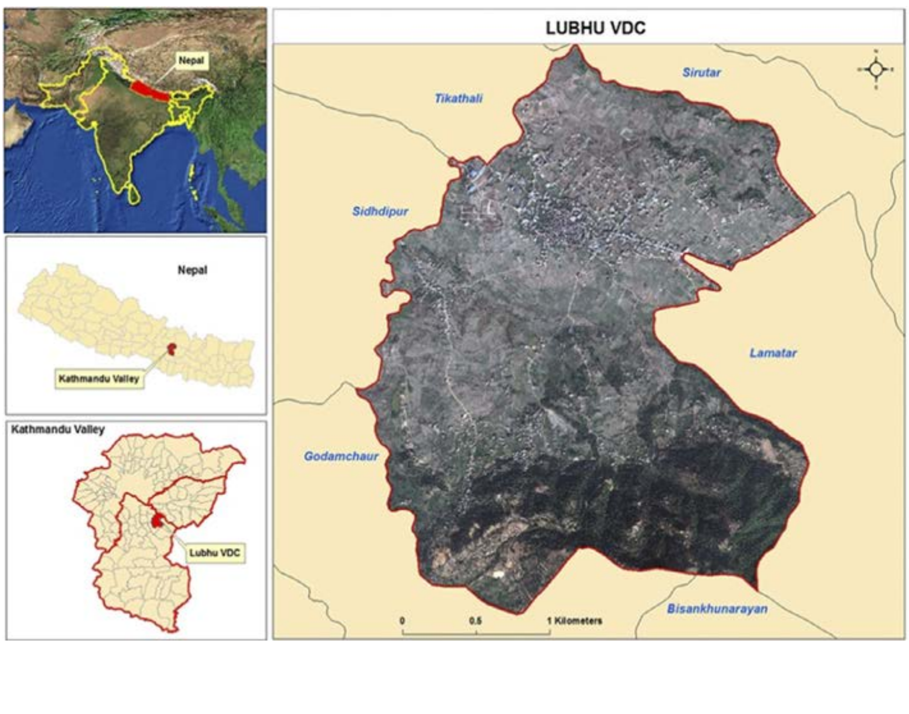


Figure 1.
Location map of the study area

within each of the wards based on caste group. A total of 404 respondents from 202 households (one male and one female from a household) including all the caste groups of the VDC were selected for interview. The major reason behind selecting one male and one female respondent is to understand how male and female perceived changes in different climatic parameters and how they are responding to the impacts. However, there are not much of differences in the perception between male and female and hence the analysis and interpretation were made in aggregate.

Alongside, the perceptions on changes in climatic parameters were also captured through series of focused group discussions with local people. The check list prepared based on the findings from preliminary survey conducted to understand general climatic perception was used during these discussions to recollect retrospective perceptions on decadal trend of change in the climate through a time frame of over past 40 years (defined as prior to 1980s, 1990s and 2010s). Since it was not possible to map the perceptions in absolute values, the perceptions were documented in terms of relative impressions over time focusing on perceived changes of various attributes of rainfall and temperature including the impacts of the changes as perceived by the local people and the coping and adaptive strategies practiced by them.

Rainfall and temperature data were collected from Department of Hydrology and Meteorology (DHM) for seven and four different stations, respectively, within Kathmandu Valley and analyzed to understand the climatic trend. The overview of the hydro-meteorological stations used for analysis is given in Table I. In absence of hydro-meteorological station within the study area, the climatic trend of Kathmandu Valley has been used to interpret the long-term climatic trend in Lubhu as it is a part of Kathmandu Valley.

3. Results and discussion

3.1 Changes in temperature: perception and actual trend

Among 404 respondents of surveyed households, 76 percent perceived the rising summer temperature while very negligible percentage felt the decrease in summer temperature which is comparable to the study made by Mertz *et al.* (2009) in rural Sahel. Nearly 44 percent felt that the winter is getting warmer and around 27 percent noticed that the winter is becoming colder. GoN (2010) also stated that people from mid-hills of central region perceived increase in temperature. The analysis of the recorded data also showed the similar pattern. More than 50 percent of the respondents noticed increase in

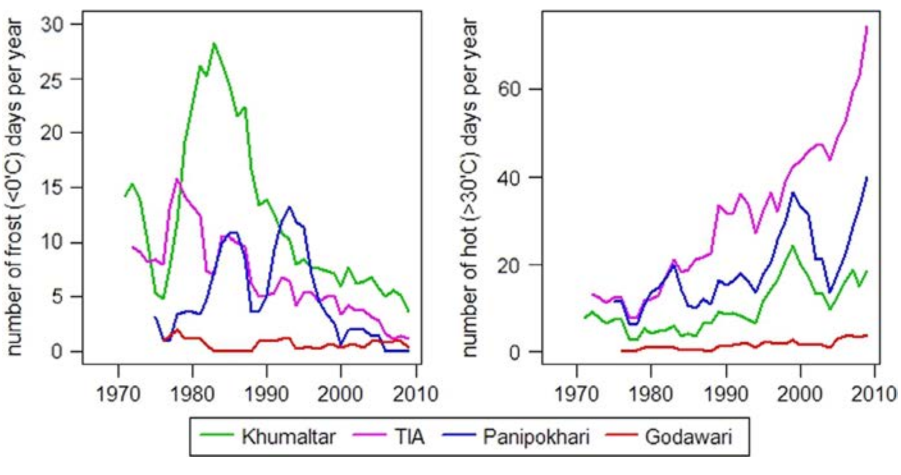
		Location (deg. min.)			Time periods for which records are available	
Index no.	Station	Latitude	Longitude	Altitude (m) above msl	Rainfall	Temp.
1029	Khumaltar	27°40′	85°20′	1350	1967-2009	1967-2009
1030	TIA	27°42′	85°22′	1337	1968-2009	1968-2009
1022	Godawari	27°35′	85°24′	1400	1953-2009	1972-2009
1039	Panipokhari	27°44′	85°20′	1335	1971-2009	1971-2009
1059	Changunarayan	27°42′	85°25′	1543	1971-2009	
1035	Sankhu	27°45′	85°29′	1449	1971-2009	
1076	Naikap	27°41′	85°15′	1520	1997-2009	

Table I.
Summary of hydro-meteorological records used for analysis

extreme hot days and less cold winter and 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 analysis of temperature data which showed that there was a decrease in number of days with temperature $< 0°C$ and an increase in the number of hot days ($> 30°C$) (Figure 2). Both the maximum and minimum of the maximum temperature of the year and the maximum and minimum of the minimum temperature of the year had increased, which imply that the warmest day of the year and the coldest day of the year had become warmer. This signal was more prominent for the maximum temperature. 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.

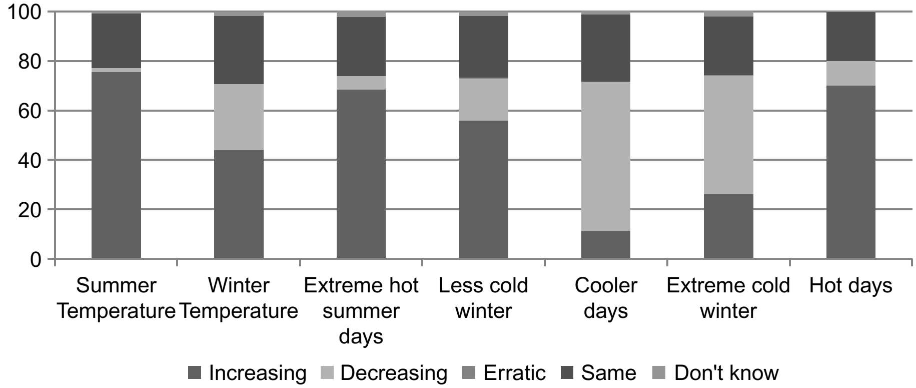
In an average 24 percent of the respondents do not perceive any change in temperature related attributes which is comparable to the study by Piya *et al.* (2012) where they found 38.5 percent perceive same. In their paper, they agreed to the Vedwan and Rhoades (2001) where the perception of no change 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 shown in Figure 3.

During the focus group discussions, the respondents related the seasonal cycle of summer and winter to the traditional 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 celebrated in the month of July/August for worshipping serpent. Most of the respondents perceived a gradual increase in summer period after 1980s and large increase in the 2000s. They perceived that if the summer duration continued to expand in the perceived rate, winter season would be vanished in next few decades. Similarly, most of the respondents' experienced small decrease in duration of winter season in 1980s and 1990s while in 2000s they perceived large decrease. They felt the spring that used to be distinct starting around *Fagu Poornima* (full moon day and a festival of



Source: Raw data from DHM

Figure 2.
No. of days less than 0°C and greater than 30°C per year



Source: Field survey (2011-2012)

Figure 3.
Perception of respondents on changes in different attributes of temperature

colors celebrated in the month of March) and autumn seasons bringing festive weather during *Dashain* and *Tihar* (festivals celebrated during the month of October-November) were no more distinct. In spring, they felt that the days were much hotter giving feeling of summer. Similarly, they felt autumn started very late and though the morning were colder the days were as hot as in summer. Prior to 1980s, people felt that winter 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 no more feeling of winter and creating discomfort due to the warm clothes worn based on the chills in the morning. People also expressed that despite the temporal increasing trend of temperature within the village, the rise was not as extensive as they felt during their travels to city cores which indicated experiences of the urban heat island.

People recalled the occurrence of icy film formed on the water surface (*Thanto*) during peak winter prior to 1980s. As distinctly indicated by the temperature data analysis most of the respondents felt decrease decline in frost days starting since 1990s which became more intense in 2000s. This gradually declined during 1990s and stopped occurring in 2000s. They considered that the general trend of occurrence of frost was from the November second week to February second week and then invisible black frost (*Kalo Tusaro*) used to occur by 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 experienced decrease in usual frost while the period of black frost was extending up to March last week. Additionally the local people felt the delay in the occurrence of fog in 2000s starting around second week of October which earlier used to have started by second week of September. In addition, they also experienced the decline in the fog density, foggy duration within a day and overall foggy period in every passing year. 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.

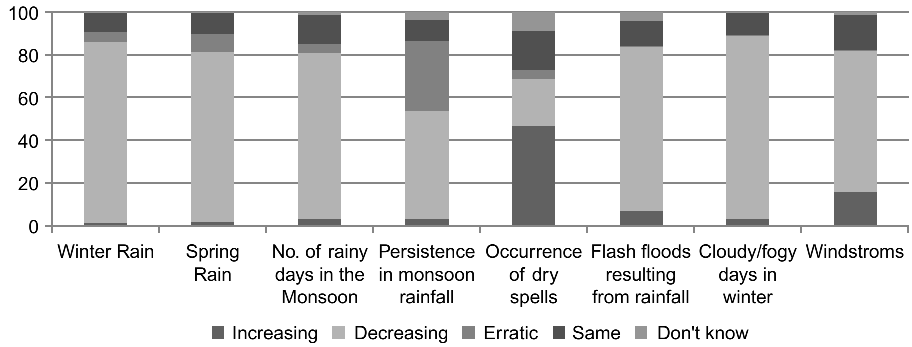
Owing to this weather pattern, a local statement "*Poush Fas Fus*" was generated indicating passing away of the days of *Poush* (December/January) by the time fog got faded.

These changes noticed by local people support the general warming trend of the warmest and the coldest day of the year as showed by the temperature records.

3.2 Changes in precipitation: perception and actual trend

The perception of respondents on different attributes of precipitation is shown in Figure 4. Most of the respondents perceived decrease in both winter and spring rain and this response is comparable to what Tiwari *et al.* (2012) found in mid-hills of Nepal and Mertz *et al.* (2009) in Eastern Saloum, Senegal. However, the deviation figures drawn for the precipitation record showed that there is no clear visible pattern both in monsoon and non-monsoon period. A linear trend line for monthly precipitation sum also did not demonstrate clear visible pattern. Mann-Kendall test illustrated that there was no significant increasing or decreasing trends in total precipitation. An overview of the seasonal Mann-Kendall test results are shown in Table II. These findings confirmed the conclusion of Shrestha *et al.* (2000) and Practical Action (2009) that there is no significant long-term trend in precipitation. Though the people's perception on changes in rainfall do not coincide with the analysis of recorded data, the actions they take based on these perceptions and resulting consequences are real (Glantz and Degefu, 1991).

Relating the rainfall events to traditional rituals such as *Krishna janmaastami* celebrated during August/September (Bhadra), *Shiva Ratri* that falls in the month



Source: Field survey (2011-2012)

Figure 4. Perception of respondents on different attributes of precipitation

Station	Kendalls τ	p-value (Two 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

Table II. Kendall τ and significance of seasonal Mann-Kendall

February/March (Falgun) to the annual rainfall trend the participants during focus group discussions elaborated on the perceived decline in the total rainfall, monsoon as well as winter rainfall amounts and therefore no more dependable for their traditional practices of livelihood activities mainly agriculture. They perceived a continued decrease in the total amount of rainfall starting since 1990s further declined in 2000s which, 2010 onwards was better and some even considered that the climate was taking its original trend.

The annual rituals such as *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). Respondents 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 the small decline in 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.

The traditionally established belief was that prior to 1980s, the date on which winter rain started 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 further disturbed in 2000s since when there have been a further decline in the number of rainy days making the rainfall erratic and unpredictable.

Although rainfall data analysis did not show any distinct trend in the total annual rainfall amount unlike decline perceived, it showed decline in the monthly total rainfall in the months October to March which is the period for winter rainfall implying decrease in winter similar to the perception. Monsoon is the main source of precipitation, which enters the country from Eastern part of Nepal (Rai *et al.*, 2011). It normally starts in the second week of June and reaches full development in July. The monthly rainfall data analysis for Kathmandu Valley showed an increase in precipitation from April to September, except for June which is the month for the onset of monsoon in Kathmandu. This decrease in June can imply that the onset of monsoon had shifted to later in the season.

In the study area, the 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. Considering the significance of monsoon rain in water arrangement for paddy transplantation, the major monsoon crop in the study area, the unavailability of the rainwater for paddy transplantation at the regular time as expected based on their traditional agricultural practice could have resulted into the overall perception of decline in rainfall amount. However, 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 more predictable. The respondents also surprised with the incidences of intense rainfall in one part of area and remaining completely dry in other part which is also mentioned by Meze-Hausken (2004) in North Afar, Ethiopia by saying "while it rains on one horn of ox, it can be dry on the other".

Similarly, the perception of respondent on decreasing number of rainy days and persistency is in line with findings from the analysis of hydrological data. The number of days with rainfall counted separately for monsoon and non-monsoon period for every year for all seven stations showed a decrease in number of rainy days in non-monsoon period at four stations while only three out of seven stations have a decrease in number of rainy days for monsoon period. Although not very prominent (with very low R^2 values shown in Table III) the pattern in the negative direction (decrease in number of rainy days) showed relatively stronger signal than the positive directions. Naikap station gives the strongest decrease in number of rainy days, both in and outside monsoon period, but has only 13 years of data available which is too short to draw any conclusion concerning climate.

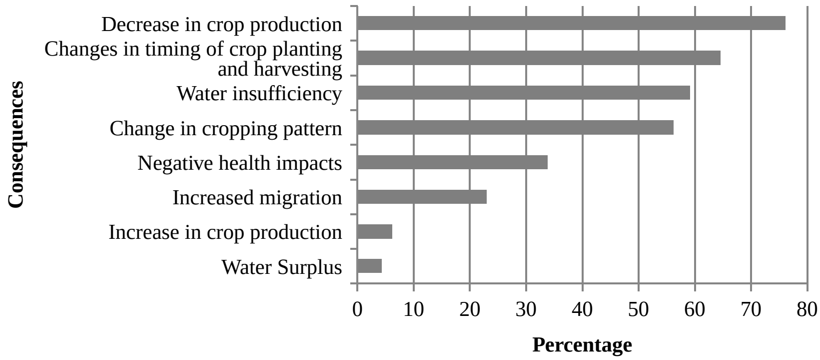
Household survey showed that 47 percent respondents perceived increase in occurrence of dry spells whereas 22 percent perceived decrease and around 18 percent felt neither increase nor decrease in dry spells. Analysis of recorded data did not show identifiable pattern in the number and length of dry spells whereas an increase of events with >50 mm of precipitation was found for most stations however there is large variation in the yearly number of days with >50 mm precipitation events (shown by low R^2 values).

3.3 Implications of climate change

During household survey 76 percent of the respondents perceived decrease in crop production due to climatic variability whereas 65 percent observed changes in timing of crop planting and harvesting. The other major impacts are 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 5.

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

Table III. Slope of trend line through number of rainy days per year



Source: Field survey (2011-2012)

Figure 5.
Perceived consequences of changes in climatic attributes

Besides these impacts, respondents also perceived the occurrence of water induced disaster due to the climatic variability. The most commonly observed and remembered water induced disasters are drought and flood. Around 50 respondents perceived the occurrence of drought and flood. There were few respondents who experienced hailstorm, landslide and other types of disasters as well. One of the major impacts of the water induced disaster in Lubhu has been the destruction of their canal irrigation system and the piped water supply system supplying water from spring source from neighboring VDC, where the latter has almost been a regular annual phenomenon.

The impacts of climate change were again substantiated by focus group discussion. According to the participants, natural spring sources have been adversely affected by rainfall variability resulting decline in the yield of spring sources as found by SAGUN (2009) and stone spouts, and even complete vanishing of such sources. The VDC lacks perennial springs within its administrative boundary, however, the respondents stressed on the drastic decline in the number of seasonal springs that used to emerge following the monsoon season. Similarly, the respondents also explained about the decline in the yield of the neighboring VDC which have major implication on their water security. However, they observed that these changes in water sources were not merely the impacts of climatic variability rather were the compounded implications of climate change and urbanization which is rightly pointed by Manandhar *et al.* (2010) and Tiwari *et al.* (2012) stating that climate change is not always the main reason behind these changes but may have acted in many cases as a catalyst. Meze-Hausken (2004) also argued that peoples' perceptions about climate are a combination of various environmental aspects.

The farmers participating in the FGD explained about a drastic decline in the practice of covering the potato plants by straw as a protection against frost due to the decline in occurrence of frost during winter which however resulted into increased crop damage due to increasing pest attacks. The farmers also reported on the emergence of new pest in crops, similar response as in GoN (2010) and felt this as impact of increasing temperature along with the disturbance in the natural pest predator system as consequences 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. 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). Literature also showed that an increase in maximum temperature can enhance invasive weeds to enter the area (Dukes and Mooney, 2000) and also it increases the risk of vector borne and rodent borne diseases (Patz *et al.*, 2000).

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 recalled the occurrence of green aphids started in 1990s while black aphids appeared only in 2000s and considered the latter to be more destructive. Though the occurrences of the insect pests were lower during winter season as compared to the summer season, it was observed that the pest population was gradually increasing with winter being milder.

People remembered that the rice transplantation used to begin in June second week till 1980s and used to continue for a period of month across fields in different terraces. They had fresh memory on the flooding events that occurred in 1981 and 1993 as it deteriorated the state sponsored irrigation canal called *Singha Rishi Dovan Rajkulo* and reduced its command area. After 1990s, the period of rice transplantation delayed to July though in some years they could start it within June. In 2000s, the farmers felt the rainfall was being erratic and there was no distinct trend in beginning of rice transplantation. The farmers also perceived an increase in the yield of all the agricultural crops from period prior to 1970-1990s but a declining trend in production 1990s onwards which continued in 2000s. They perceived the earlier increase was primarily due to the beginning of use of chemical fertilizers and high yielding seed plant varieties. The decline after was perceived as 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. According to it, Nepal was self sufficient in food grain production until 1990. Due to drought condition in 2005/2006, production fell short by 21,553 metric tonnes and by 179,910 metric tonnes in 2006/2007 due to drought and natural calamities. The rising maximum temperature had a negative impact on the rice yield and increase in minimum temperature can also lead to yield decline due to early maturity of the crop (Rai *et al.*, 2011; Lal, 2011). If the increase in minimum temperature is less strong 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 and during the disturbance in the community based piped system due to water induced disaster, 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 and push carts is common sight at Lubhu, which is not only time consuming but also involves lot of physical drudgery. Often a number of households jointly rent a vehicle as an easier and cost effective alternative option to fetch large quantity of water in a single trip of the rented vehicle.

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 Drinking Water Supply Scheme, which gets destroyed frequently during monsoon due to frequently occurring landslides in the area. The usual rate charged by tanker operators for small quantity of water is Rs 5 per *gagri* of approximately 15 liters.

3.4.2 Increasing number of dug wells at households and capturing roof top runoff. People used to depend upon river water, community dug wells, stone spouts and spring sources, long years back. With the increasing water demand, changing life style and degrading water quality of these traditional sources, the preference towards use of these traditional sources decreased and these public water sources have been facing the problem of "Tragedy of Commons" (Hardin, 1968). On the other hand, the household level or private dug wells have been increasing rapidly such that almost all the households have dug a well in their homestead. People have even started digging two or even more dug wells at an individual household level. These households use the extracted ground water for domestic purposes other than drinking and also for irrigating agricultural crops.

Similarly, 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 non-drinking uses 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 in the periods of water scarcity.

3.4.3 Migrating from the upland to low land and occupational diversification. There has been an increasing preference and trend among the people in ward no. 8 of Lubhu to shift the location of their houses from the upland to lowland areas in order to avoid the hardship of daily water management. This is due to drying of the limited dependable spring sources and no access to groundwater extraction at up hills along with the topographic constraints limiting the piped water supply system.

Similarly, 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. After the deterioration of the irrigation canal mentioned earlier, farmers in Lubhu have been increasingly dependent on rainfall for irrigation and a very important reason for shift in occupation has been increasing scarcity of water for irrigation adding drudgery for farmers. 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.

3.4.4 Shifting cropping practices. The traditional paddy plantation and harvest cycle has undergone delay by around a month due to delay in the onset of monsoon. 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 Taichin has made farmers preferred to this variety. With declining irrigation service and changing rainfall pattern, preference over this less water demanding variety has been increasing in Lubhu.

Wheat cultivation has drastically declined due to high water requirement in growing the crop in addition to its lower economic return and higher input use and drudgery involved its cultivation. The other winter crop commonly grown was broad bean (*bakulla*), the cultivation of which is also declining due to increasing pest attacks which as per farmers earlier was naturally managed by winter chills. Varieties of Pea and red lentil (pulse) are new preferences due to their less water demand and good market value. However, as red lentil required irrigation during its flowering period, preference towards it reduced but pea has been continued considering its less labor demand and good market value. Farmers are also found increasingly shifting towards soybean and barley cultivation mainly due to their less water demands and better market availability. In the areas where the residual soil moisture is extremely low to support germination of winter crop cultivars, the farmers are left with no option besides leaving the land fallow. The delayed rice harvest as a result of delayed transplantation due to erratic rainfall further adds temperature as a limiting factor for the timely winter cropping compelling the farmers to leave land fallow during winter.

The farmers used to spread rice straw over the land surface for drying it and after few days of drying, they collect and stack them for storage, and they plant winter crops thereafter. Over the last few years, farmers have started to plant winter crops immediately after paddy harvest or prior to the harvest of paddy. By this practice, winter crop germinates using the residual soil moisture 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.

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 started to use it as a mulching for winter crops. The farmers have been managing the fields immediately after the paddy harvest and the seeds of crops selected for the winter season are sown over the field. The straw is then spread over the surface for drying them. As the straw remains spread for drying, the loss of soil moisture is also reduced and hence water remain available for germination of the winter crops.

3.4.5 Increasing use of pesticide. The increasing temperature, declining occurrence of frost and variation in the pattern and amount of rainfall are the climatic variation 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 and amount of pesticide use. Farmers noted that one bottle of pesticide costing NRs 80 used to be sufficient for a *ropani* (0.05 hectare) of land during winter cropping but with increasing pests and diseases, the requirement of pesticide has increased three times over a period of decade for same period and same piece of land.

3.4.6 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 300-350 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.

3.4.7 Initiation of charging irrigation service fee. The increasing undependability in rainfall has a major role in motivating the farmers to reunite for revival of the degraded canal irrigation system in Lubhu. 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 low lands 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 collecting irrigation service fee. 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 the water in canal based on the demand and hence free riding of the limited water resource has been reduced.

4. Conclusion and recommendation

This study has analyzed the perception of local people residing at the peri-urban area of Kathmandu Valley on climate change, its impacts and responses thereto alongside correlated the locally perceived climatic changes with the findings from scientific climatic data analysis. There was an unequivocal opinion concerning the increasing duration of summer season and decrease duration of winter season. The analysis of recorded data also showed the increasing trend of temperature in both monsoon and non-monsoon period. However, the analysis did not show clear visible pattern of increasing and decreasing while the local people perceived a declining rainfall. This variation in the perception and rainfall data analysis could be because of the declining water availability for the local people due to the compounded effect of increase in population and rainfall variability resulting into the impression of declining rainfall. The unavailability of meteorological station to interpret the micro-climatic information of Lubhu can be a reason for not being the perceptions exactly in line with analysis of recorded data. Also there could be some more aspects of climatic data, more detailed analysis of which could show changing trend if any more present, more distinctly.

The people have been associating several impacts as results of changes in temperature and rainfall. The major impacts were decline in crop production, changing cropping pattern and practice, declining yield of natural springs, frequent destruction of water infrastructures from flood and landslide and increase in insect-pest attack and weeds in 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 capacity against the adverse impacts of changes in climatic attributes.

The study found the growing climatic impression among the local people on the changing climate and therefore stresses on the need of developing a mechanism in transferring knowledge of climate change to the local level and simultaneously exploring the local adaptation practices to identify the strengths and weaknesses and thus ultimately creating climate resilient community. Similarly, the study found that the direct and indirect impacts of climate change are coming forward and thus should emphasize on the need of exploring the possible support to strengthen the adaptation capacities of local people. Local level institutions and local community should communicate the knowledge on the climatic uncertainty and adaptive practices for replicating the successful measures to enhance and expand the climatic resilience of wider community.

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