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PERCEPTION, TRENDS AND IMPACTS OF CLIMATE CHANGE IN KAILALI DISTRICT, FAR WEST NEPAL

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Abstract

Perception and place-based studies give useful information on climate change in context of Nepal due to having its wide geographical, climatic, biological and cultural diversity. A household survey and focus group discussions were carried out in this study to document local people's perceptions on climate change in Kailali district of Nepal. Most of respondents in the study area have perceived that temperature and fog are increased; and rainfall and hail are decreased with severe fluctuation. Trend of temperature supports local people's perception. People have noticed impacts of these changes in vegetation, plant phenology and agriculture. Fundamentally, they have observed that certain plant species are decreasing, increasing and showing changes in flowering and fruiting time. This information could have significance for future research to identify climate change sensitive or indicator plants.

Keywords: climate change, peoples' perception, temperature, rainfall, vegetation

Introduction

Climate change has become a global challenging issue since few decades. There are several consequences of climate change such as floods, droughts, storms, spreading of infectious diseases and extinction of species (Parry et al., 2005). Global trend of surface temperature is consistently increasing since about 1950 (Solomon et al., 2007) and in the high mountain areas the changes are likely to increase more (Shrestha et al., 1999). Along with temperature, precipitation is another climatic factor showing changes in amount and pattern. Global land precipitation has increased by about 9 mm over the twentieth century (New et al., 2001).

The trend of temperature in Nepal are similar to the global trend but concerning precipitation, a significant variability have been observed in the country (Shrestha et al., 1999, 2000; Tiwari et al., 2010). Most of perception based studies show that local peoples' perception matches with these trends of temperature and precipitation (eg. Timilsina-Parajuli et al., 2013; Devkota, 2014). However; change in climatic factors, its impacts and perception at different regions are still remained to be documented (Shrestha et al., 2012) which are fundamental to identify local and global contexts, and for constructing generalized theory around how people response towards changing environment and associated risks (Crona et al., 2013).

Inhabitants of rural areas are still not known about climate change and its impacts on various aspects but they perceive unexpected events to their surroundings (Chaudhary and Bawa, 2011). People are good observers of their local environment who can identify and interpret changes occurring in their surroundings, which can play a key role in shaping collective response to climate change (Byg and Salick, 2009). As there is much to learn from community-based approaches in different geographical locations about climate change, we have carried out this study to document local people's perception, trend of temperature and rainfall and changing events in vegetation, phenology and agriculture in Kailali district of Far West Nepal.

Methods

Study Area

The study was carried in Kailali district of Far Western Development Region, Nepal. It is part of tropical Tarai and Churiya region having warm climate throughout the year except short winter. The district lies between 28°34'N and 80°34'E and covers an area of 2742 square kilometers with population 142480 (*CBS Nepal, 2012)*. The landscape altitude ranges from 179 m to 1957 m above sea level. This study was concentrated in two VDCs (Shahajpur and Pandoun) located at subtropical Churiya range and two municipalities (Dhangadhi and Tikapur) located at tropical Tarai region (Fig. 1).

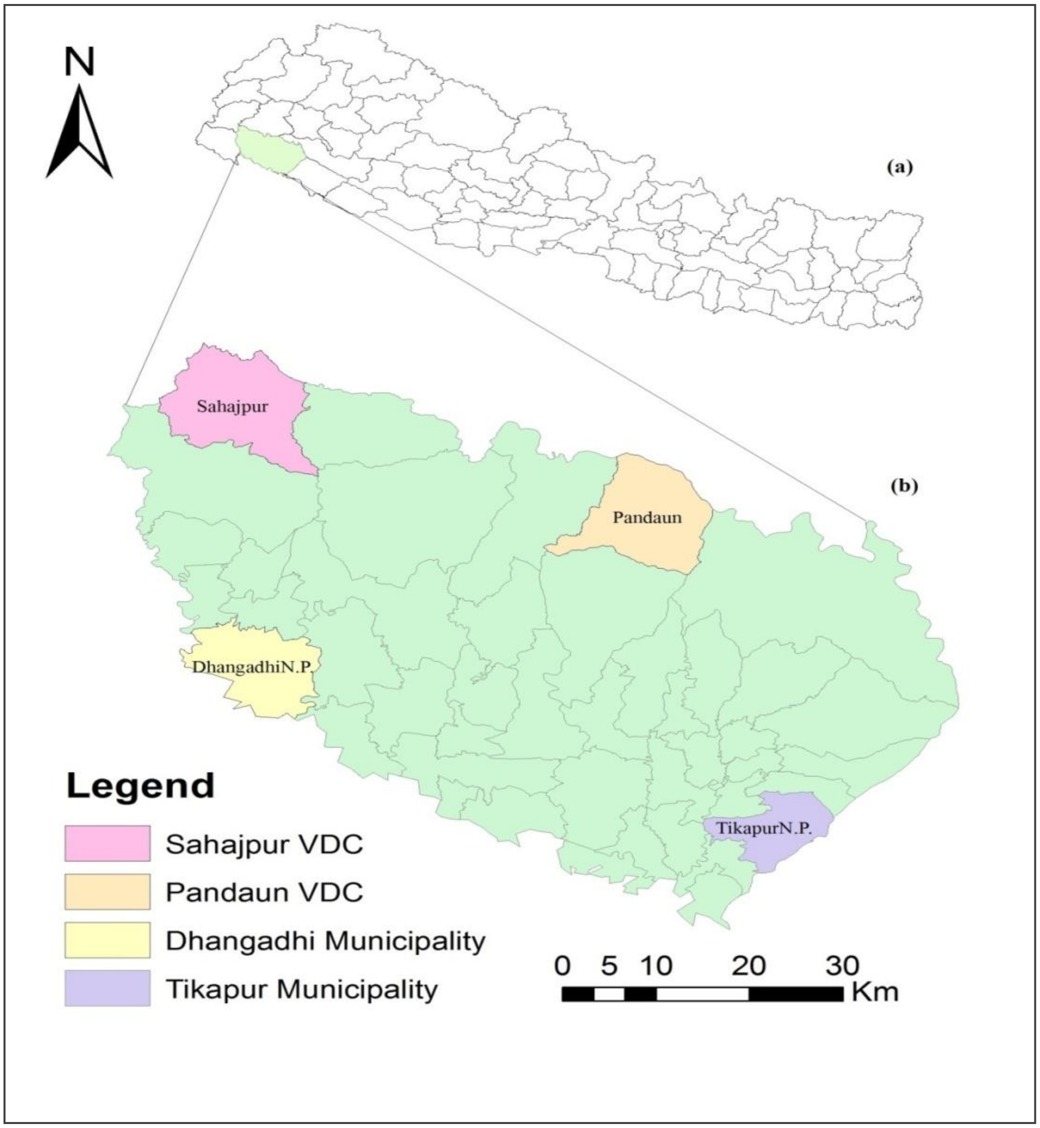

Fig. 1 Study sites; (a) Nepal, (b) Kailali district and VDCs

Household survey and interview

A purposive sampling method was used to capture experienced local people's knowledge and their views on climate change. Respondents were selected from a total of 120 households (30 from each study VDC and municipality). The survey focused Koltadi, Khimadi and Kunthapaani villages in Paundaun VDC; Bayala, Belghari and Lakhi villages in Sahajpur VDC; Badhara and Chatakpur villages in Dhangadhi municipality and Bangaun and Kerabari villages in Tikapur municipality. Among the total respondents majority of them were farmers (59.16%) and others were businesspersons (22.50%) and jobholders (18.33%). The people of age forty years and above were included in interview. A questionnaire for interview was prepared prior to the fieldwork. In each study site focus group (5-10 people) discussions were conducted. The participants were asked to enumerate all the information, which they have perceived mainly to identify changes in climate and impacts of such changes particularly on vegetation, agriculture and livelihood. Direct observation and transect walk survey was also done to observe and identify vegetation types, individual plants and agricultural fields. The plant species (recently appearing/increasing or decreasing) as noticed by local people were collected and identified in the field. The survey was carried out during October 2012 to February 2013. Temperature data recorded by Tikapur and Godawari stations and rainfall data recorded by Tikapur, Sadepani and Godawari stations of Kailali district were obtained from Department of Hydrology and Meteorology (DHM), Government of Nepal, Ministry of Science, Technology & Environment, Kathmandu, Nepal.

Results

People's perception on climatic factors

Four options viz. *increasing, decreasing, same* and *don't know* were given to the respondents to express their perception on climatic factors (temperature, rainfall, fog, storm and hail). Opinion of 83% respondents was on '*increasing*' for temperature while 9% said that there is no change in temperature (Fig 2A). Concerning rainfall, 77.50% had opinion towards decreasing rainfall and 11% noticed that there is no decrease in rainfall (Fig 2B).

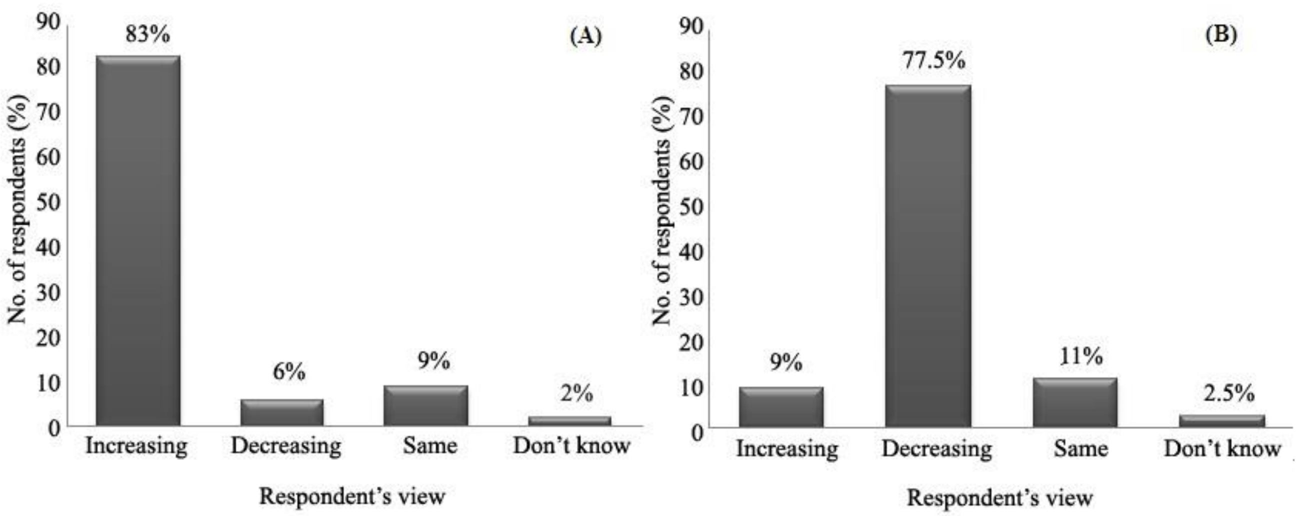

Fig. 2 Respondent's perception on temperature (A) and rainfall (B)

Local people have experienced irregular pattern of rainfall different from previous rainfalls in the area. Seventy six percent respondents said that the rainfall occurs lately in present days (Fig 3A). Similarly, majority of the respondents (58%) gave opinion that fog is increasing and opinion of 24% respondents was it is decreasing (Fig 3B). Based on people's experience, the fog moves from low land (Tarai) to uplands (Subtropical range) in winter. The people of uplands had no experience of such event about 15-20 years ago. Variation in percentage of respondents about perception on hail was low i.e. 49% gave opinion of decreasing hail and 32% had agreement with there is no change in hail. (Fig 3C). In case of storm, majority of respondents (48%) perceived that storm is increasing whereas 28% respondents had experience of decreasing storm. Nearly to the second opinion, 21% respondents said that pattern of storm is same (Fig 3D).

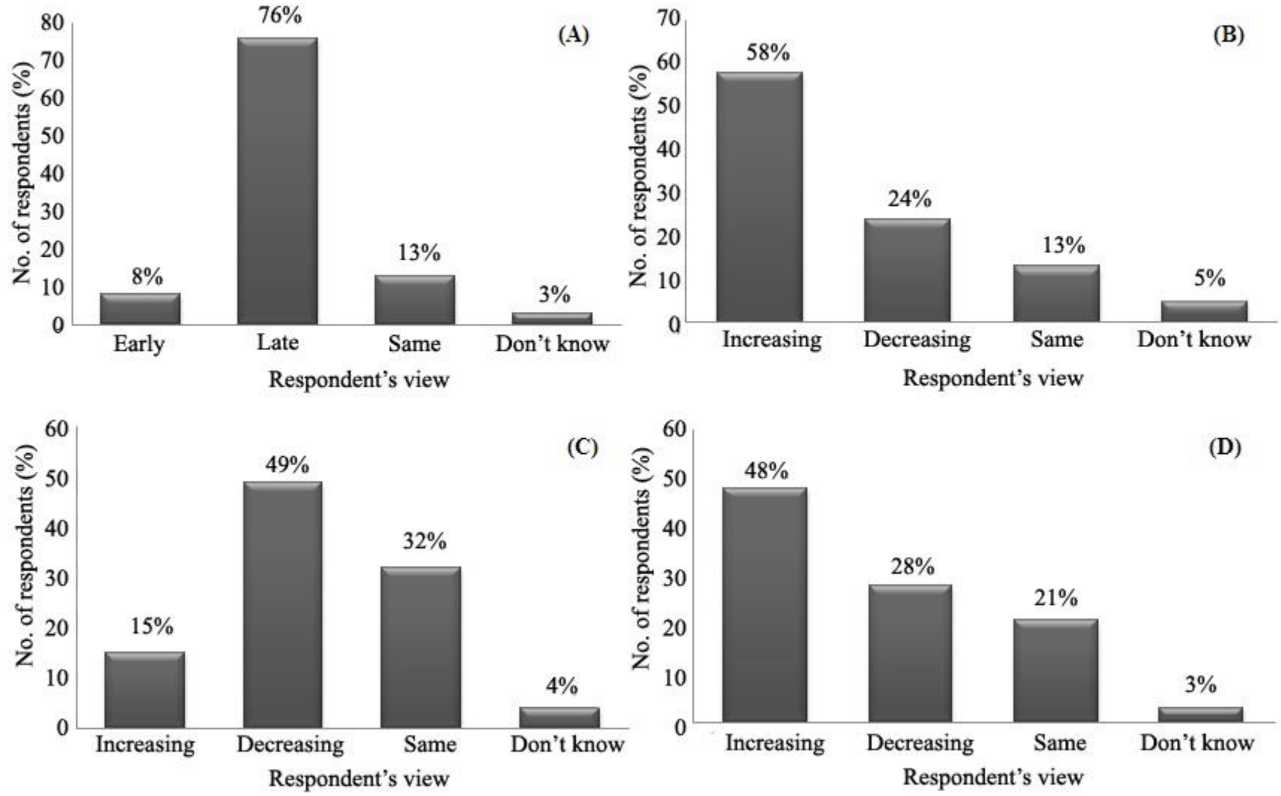

Fig. 3 Respondent's perception on pattern of rainfall (A), fog (B), hail (C) and storm (D)

Climate change impact on vegetation and phenology

Most of the respondents (85%) had opinion towards changing vegetation (Fig. 4A). The people's argument was that there is important role of community people to destroy natural vegetation due to population pressure and lack of awareness, but the people have noticed changes in composition of vegetation by appearance and increasing of certain new species or decreasing of certain native species population in the nature. The respondents enumerated a total of 13 plant species decreased in surrounding and 9 plant species increased surprisingly around natural habitats since 2-3 decades (Table 1 and Table 2). The decreasing species are classified according to respondents' opinion into rare (R) and extremely rare (ER) (Table 1).

Local people's important notice was on plant phenology i.e. flowering and fruiting time has been changed according to 56% respondents. The plants showing phonological changes enumerated by them were *Myrica esculenta* Buch.-Ham ex D.Don (**Kafal,** Myricaceae), *Rhododendron* **(Gurans,** Ericaceae**),** *Ficus hispida L.f.* **(Tote,** Moraceae**),** *Psidium guajava* L. **(Amba,** Myrtaceae**),** *Mangifera indica* Wall **(Anp,** Anacardiaceae**),** *Punica granatum* L. **(Darim,** Punicaceae**),** *Ficus auriculata* Lour. **(Timila,** Moraceae**),** *Berberis* **(Chutro,** Berberidaceae**)** and *Prunus persica* (L.) Batsch **(Aru,** Rosaceae**).** They have noticed that the flowering time of *Rhododendron*, *P. guajava*, and *M. indica* has been shifted 15 days to 1 month before than 20-30 years ago. Similarly, fruit-ripening time of *P. persica, M. esculenta*, *F. hispida, P. guajava, M. indica* and *Berberis* also has been shifted by same pattern. They also have shown that the flowers of *P. granatum* and fruits of *F. auriculata* in off seasons and sometimes throughout year since recent 5-7 years. Other respondents (36%) said that they have not noticed phenological changes in these plants (Fig 4B).

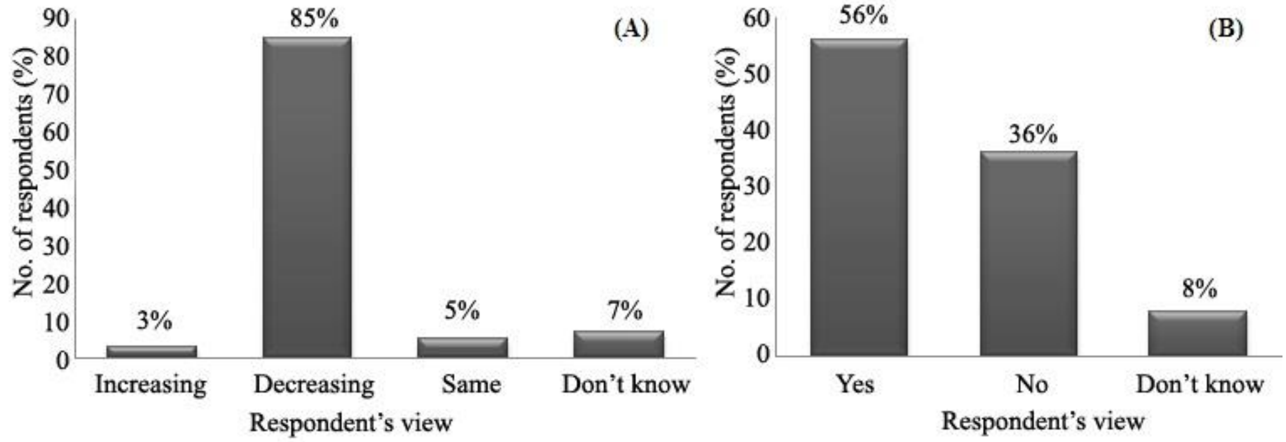

Fig. 4 Respondent's perception on vegetation (A) and phonological changes in plants listed by respondents (B)

Table 1: List of plants decreased in natural habitat

SN	Name of Plants	Local Name	Family	Remarks
1	*Calotropis gigantea* (L.) Dryand.	Ank	Asclepiadaceae	ER
2	*Artemisia indica* Willd.	Titepati	Asteraceae	R
3	*Anaphalis busua* (Buch.-Ham. ex D. Don) DC	Buki	Asteraceae	ER
4	*Cannabis sativa* L.	Bhang	Cannabaceae	ER
5	*Cuscuta reflexa* Roxb.	Akas Beli	Convolvulaceae	ER
6	*Asparagus racemosus* Willd.	Kurilo	Asparagaceae	R
7	*Smilax* sp.	Kukurdaino	Smilacaceae	ER
8	*Viscum album* L.	Hadchur	Loranthaceae	ER
9	*Thysanolaena maxima* (Roxb.) O. Kuntze	Amriso	Poaceae	R
10	*Cynodon dactylon* (L.) Pers	Dubo	Poaceae	R
11	*Imperata cylindrica* (L.) P. Beauv	Siru	Poaceae	R
12	*Urtica dioica* L.	Sisnoo	Urticaceae	R
13	*Tinospora cordifolia* (Willd.) Miers.	Gurgo	Menispermaceae	R

Note: R; rare, ER; extremely rare

Table 2: List of plants increased in natural habitat

SN	Name of Plants	Local Name	Family	Problematic
1	*Ageratum conyzoides* L.	Gandhe	Asteraceae	OA, F, CL
2	*Ageratina adenophora* (Sprengel) King and Rob.	Banmara	Asteraceae	OA, F
3	*Spilanthes calva* DC.	Marathi	Asteraceae	OA, CL
4	*Parthenium hysterophorus* L.	Badmas jhar	Asteraceae	OA, F
5	*Cyperus rotundus* L.	Mothe	Cyperaceae	OA, F, CL
6	*Cyperus iria* L.	Chhatare	Cyperaceae	OA, F, CL
7	*Cassia tora* L	Chhinchhine	Fabaceae	OA, F
8	*Argemone mexicana* L.	Thakalikada	Papaveraceae	OA, CL
9	*Lantana camara* L	Kuri	Verbenaceae	OA, F

Note: OA; open area, F; forest, CL; crop land

Climate change impacts on agriculture

According to 72% respondents the agricultural practices are different from earlier practices as they know (Fig. 5A). Fluctuation of planting time, unexpected drought and rainfall since last 15 to 20 years is becoming major problem in agriculture. This has been affecting sometimes positive and frequently negative in crop production. All the respondents of both municipalities said that they have been using chemical fertilizers and pesticides since many years. The respondents of both VDCs also said that they have started using chemical fertilizers due to less production of compost fertilizer with decreasing number of cattle and also pesticides has become common since last 10 to 15 years.

Respondents (63%) have perceived that pests and pathogens are increased and the people have no option of using pesticides to control crop diseases. Some respondents (22%) said that there is no increase of crop diseases because they have started using modern pesticides (Fig. 5B). Common crops of study areas are cereals (maize, wheat and rice), pulses (gram and lentil) and oil crop (mustard). Regarding productivity of these crops, the perception difference did not vary greatly, only 42% respondents agreed in 'decreasing' for all crops and 37% said 'increasing' while no change was perceived in productivity by 17% respondents (Fig. 6). Nowdays productivity depends on fertilizers and pesticides used and irrigation from local *Kulo* or *tube well water*. Respondents said that they also have started changing crop varieties due to frequent impacts of changing environment on agriculture. Local cereal crops (maize, wheat, rice) and vegetables (potato, brinjal, tomato, chilly, gourds) are replaced by hybrid ones in both VDCs and Municipalities. In addition, the local people have abandoned traditional seed storage practice because hybrid varieties are available in local market from where they can buy when needed but the local people of Pandaun VDC still have not changed traditional practices.

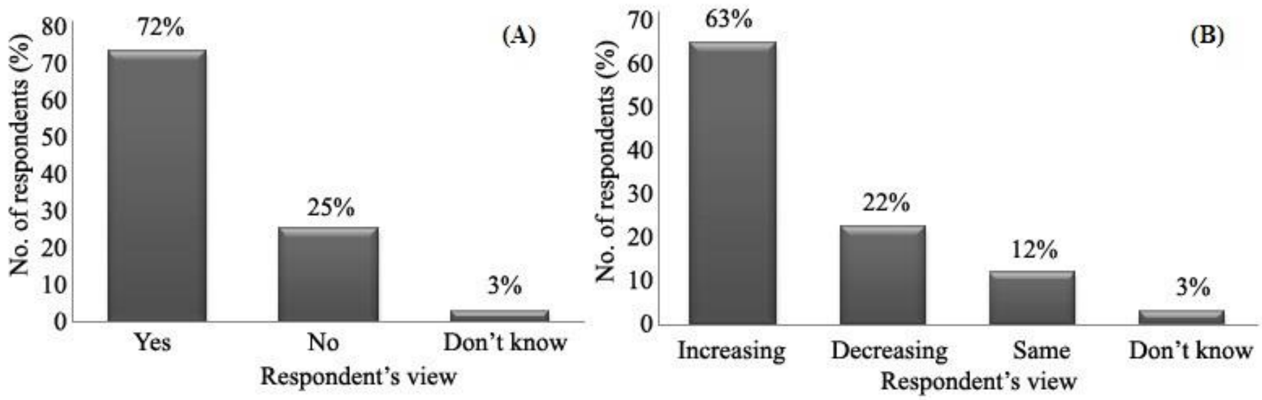

Fig. 5 Respondents' perception on changing agriculture practice (A) and crop diseases (B)

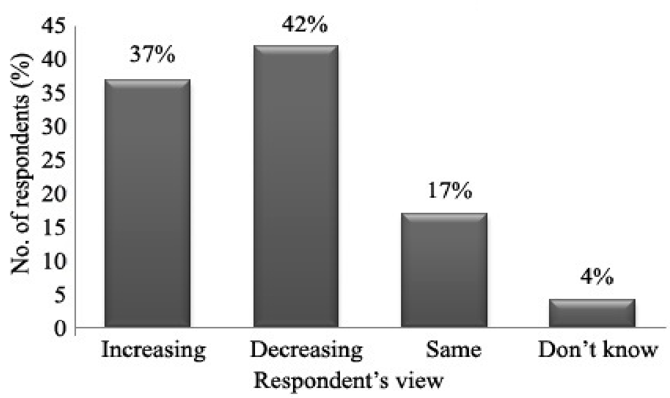

Fig. 6 People's perception on productivity (cereal crops, pulses and mustard)

Trend of changing rainfall and temperature

Observed trend of yearly rainfall in different parts of Kailali district of last 30 years was fluctuating between 967.1 mm to 2313 mm (total rainfall per year). The trend was decreasing from 1982 to 1997 in all three parts (Tikapur, Sadepani and Godawari) and after that each five years mean of total annual rainfall/year shows either increasing or decreasing trends (Table 3). Fig. 7 shows the trend of rainfall of all three stations (Tikapur, Sadepani and Godawari) of Kailali district.

Table 3. **Difference in rainfall amount (5 years mean of total rainfall/year from 1982 to 2011)**

Year	Total rainfall/year (mm)					
	Tikapur station	Difference	Sadepani station	Difference	Godawari station	Difference
1982-1986	1896.16	…	2099.2	…	2405.46	…
1987-1991	1706.52	-189.64	1974.1	-125.1	2306.36	-99.1
1992-1997	1377.7	-328.82	1663.38	-310.72	2229.06	-77.3
1997-2001	1863.1	485.4	2117.28	453.9	2537.4	308.34
2002-2006	1481.56	-381.54	1669.38	-447.9	1910.46	-626.94
2007-2011	1776.18	294.62	2244.66	575.28	2550.74	640.28

Note: Raw data obtained from Tikapur, Sadepani and Godawari stations (Source: DHM)

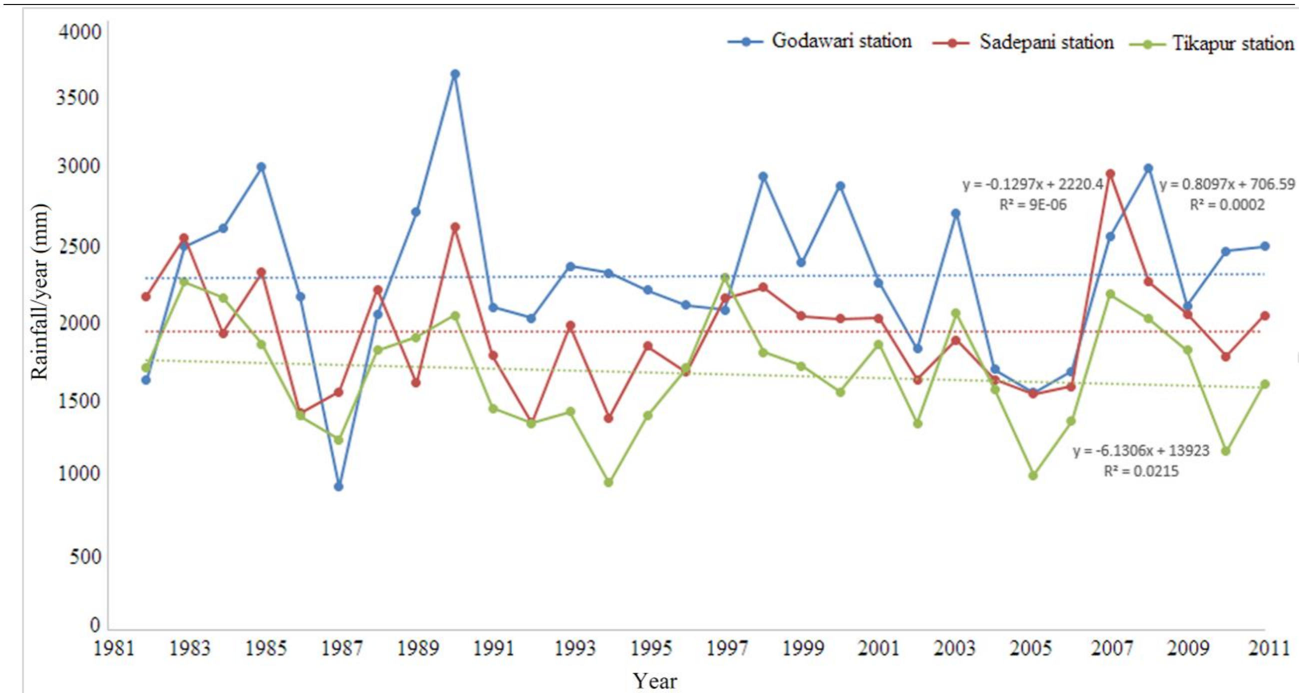

Fig. 7. Trend of rainfall in Kailali district (total rainfall/year, Source: DHM)

Regarding temperature, Tikapur had experienced annual maximum temperature fluctuating between 28.75°C to 31.69 °C and minimum temperature between 12.17°C to 18.88°C during the period of last 30 years (1982 – 2011). Whereas the record of Godawari station near to Dhangadhi and Sahajpur shows that, the average annual maximum temperature was fluctuated between 27.8°C to 32.4 °C and minimum temperature between 16.5°C to 20.7°C. Trend of average annual temperature of both stations showed increasing pattern from 1982 to 2001 while it was opposite since 2002 to 2011. Five years mean temperature of 1987-1991 was greatly differed from the mean of 1982-1986 (1.11^{0}C) in Tikapur while decreasing differences are lesser than the increased difference (Table 4). Similarly, record of Godawari station shows greater differences in five years mean between 1997-2001 and 1992-1996

(0.34^{0}C) while decreasing difference was higher than the increased difference in 2002-2006 (Table 4, Fig. 8). Comparison between the mean of 1982-1986 and 2007-2011 confirms that the temperature had been increased by 1.5^{0}C in Tikapur and 0.21^{0}C in Godawari. Fig. 8 shows the trend of both maximum and minimum temperature in two stations (Godawari and Tikapur) of Kailali district.

Table 4. Difference in temperature (5 years mean of average temperature/year from 1982 to 2011)

Year	**Tikapur station** *(temperature ℃)*				**Godawari station** *(temperature ℃)*			
	Max	Min	Mean	Difference	Max	Min	Mean	Difference
1982-1986	29.80	15.46	22.63	…	29.59	19.80	24.70	…
1987-1991	30.24	17.25	23.74	1.11	30.01	19.59	24.80	0.11
1992-1996	30.52	17.46	23.99	0.25	30.48	19.72	25.10	0.29
1997-2001	30.28	18.02	24.15	0.16	30.89	19.98	25.44	0.34
2002-2006	30.54	17.77	24.15	0.00	30.20	19.67	24.94	-0.50
2007-2011	31.12	17.14	24.13	-0.02	30.87	18.95	24.91	-0.03

Note: temperature (⁰C); raw data obtained from Tikapur and Godawari stations (Source: DHM)

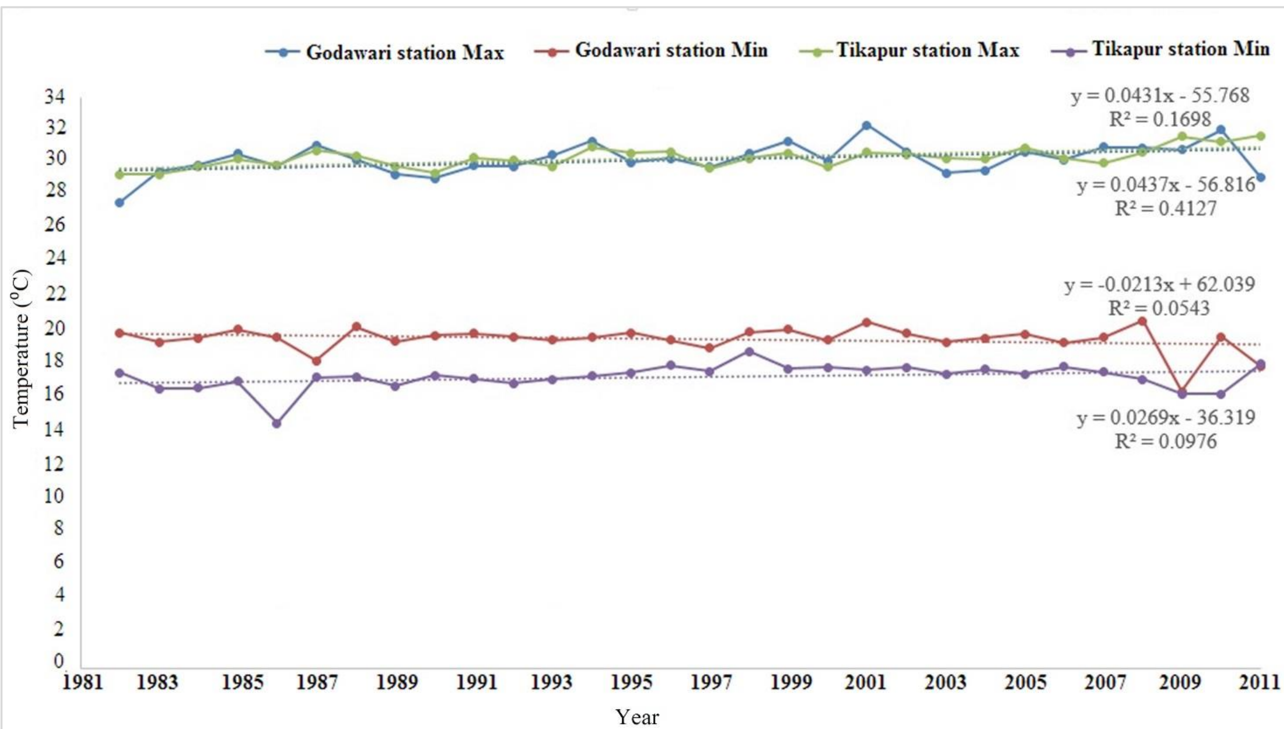

Fig. 7. Trend of temperature in Kailali district (average temperature/year, *Max = maximum; Min = minimum;* Source: DHM)

Discussion

According to the results, most of respondents in the study area have noticed changes in climatic factors in comparison to past 2-3 decades. Meteorological data of temperature before 2001 supports opinion of local people. Still people perceived increasing trend of temperature might be due to access of modern facilities with extension of electricity in the villages. The data shows that rainfall was decreased since 1982 to 1997, which can coincide with respondents' perception, but the fluctuating trend is shown from 1998-2011 which differ from peoples' perception. Similar trends of temperature and rainfall, and perceptions of local people were observed in various districts of Nepal eg. in Chitawan, Rampur (Paudel et al. 2014), Banke and Dang (Devkota, 2014), Kaski (Timilsina-Parajuli et al., 2014), Doti and Surkhet (Bhandari, 2013), Rupandehi (Dahal et al., 2015); Shankarpur VDC of Kanchanpur and Gadariya VDC of Kailali (Maharjan et al., 2011). The trend of temperature in whole country was increasing from 1975 to 2006 by 1.8^{0}C and rainfall pattern was more erratic in the Nepal (Malla, 2008). In addition, peoples' perception on other factors such as fog, hail and storm was not much conflicting. Peoples' perception and the trend of both temperature and rainfall in Kailali district indicate that the district is also one of the vulnerable districts of Nepal to climate change and climate change impacts on various sectors.

Peoples are wondering on decreasing natural vegetation, change in vegetation composition with decreasing or increasing certain plant species in their surrounding and natural habitats (Table 1 and 2). The people accept that anthropogenic disturbances could be one important causes of decreasing vegetation but the disturbances have been controlled since 10-15 years before and they have conserved forests as community forest with strict rules and regulations, however, they have not noticed reformation of vegetation with composition as it was in the past. It confirms that the changing climatic factors have influenced and altered vegetation composition. Invasive alien species can be introduced intentionally or unintentionally and they have wide range of capabilities to spread and colonize novel habitats, which includes fast growth, self-compatibility, many seeds, and general habitat requirements etc (Baker and Stebbins, 1965; Bates et al., 2013). The relationship of alien invasion and climate change is complex; even though, increased CO_2, temperature, and precipitation pattern help alien species to introduce to exotic range (Dukes and Mooney, 1999; Bradley et al., 2010). Invasive alien species, then affect native biota, genetic diversity, ecosystem process, crops and human health (Didham et al., 2005; Charles and Dukes, 2007). The report of certain alien species such as *A. adenophora*, *P. hysterophorus*, *L. camara*, *A. mexicana* in the study area may create various problems in local environment and ecosystems. Further studies are necessary to confirm the relationship of increasing alien species (Table 2) or decreasing native species (Table 1) with climate change.

People's perception on plant phenology could have great significance for future research and provide basis to find out climate change sensitive plant species through scientific investigations. Local people observe closely the local environment, they can identify and interpret changes occurring in their surroundings as well as this knowledge can play a key role in shaping collective response to climate change (Byg and Salick, 2009). Use of wild fruits by local people is common practices in the villages (Cunningham, 2001; Shrestha and Dhillion, 2006; Thapa et al. 2014) and therefore the people every year get chance to observe flowering and fruiting events. It cannot be neglected that the introduced hybrid fruits might have changed peoples' perception on phenology in comparison to local varieties but respondents claim that the local varieties have been showing changed phenological behavior since few decades. They suspect that the unexpected trend of climatic factors might have brought these changes in vegetation pattern and composition including plant phenology, and usually they discuss together in community level and conclude that these are common events of '**Kaliyug** (Age of Demon)'. Some previous studies also have reported similar shifting phenology in plants due to climate change around the world (Hughes, 2000; Hulme, 2005; Parmesan, 2006; Cleland et al., 2007; Walther, 2010).

The yield of cereal crops is correlated with the seasonal rainfall (Bhandari, 2014). The people's agreement on changing agricultural practice in the study area such as fluctuation of planting time of crops due to unexpected drought and rainfall indicates that the farmers have achieved frequently negative and rarely positive benefits on crop production. Similar to our study Dahal et al. (2015) also reported that climate change decreases agricultural production in Rupandehi district of Nepal. In spite of peoples' awareness on effect of chemical fertilizers and pesticides, they have no alternate of using chemical fertilizers and pesticides in agricultural lands as they have felt that the soil quality is reduced and, pests and diseases are increased. Local people, especially indigenous communities have adopted indigenous knowledge and traditional means to cope with climate change impacts but this study shows people's dependency on modern practices in the study sites. Use of chemical fertilizers and pesticides without proper knowledge and awareness would increase risk of changing soil quality and health hazards. The governmental bodies should implement programs such as training, awareness and education as well as monitoring and control pesticide trade, use and practice (Tilahun and Hussen, 2014).

In conclusion, most of respondents in the study area have perceived increasing temperature, fog and storm as well as reduced and fluctuating rainfall and hail. The temperature has been increased by 0.21 to 1.5^{0}C in comparison to past 25 year's data which supports local people's perception. Changes in climatic factors have impacts on local vegetation, agriculture and people's livelihood. Increasing or decreasing certain plant species has increased risk of alien species invasion and endangerment or extinction of native species. Peoples' opinion indicates that there is relationship of increasing alien species and decreasing native species with climate change. In addition, change in phenology of some fruit plants is important sign of climate change. These findings have significance for future research and provide basis to find out climate change sensitive plant species through scientific investigations.

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