Research Article

FARMER'S PERCEPTION ON VULNERABILITY OF CROPPING PATTERN AND ADAPTIVE MECHANISM IN PANCHTHAR AND CHITWAN, NEPAL

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ABSTRACT

A study was done in Chitwan and Panchthar districts of Nepal during 2017 and 2018 with the objective to learn vulnerability of major cropping pattern, mainly with weather variability and farmers' current practices to adapt them so that information would be useful in formulating appropriate strategies. A total of 240 respondents were identified, and face to face structured questionnaire was used to collect the primary information. Focus Group Discussion (FGD) and Key Informants' Interview (KII) were also done in order to triangulate the major findings obtained from survey. Majority of the respondents in both the districts had a strong perception that precipitation related unpredictable consequences to the cropping pattern was more visible in the recent past years along with the fluctuation of temperature that impacted on overall low production. Respondents from both the districts also reported drastic rise in summer temperature for the last few years with the declining rainfall pattern, resulting lower ground water table. The FGD and KII findings are consistent with the trend of rise in summer temperature as revealed from the Hydro-meteorology data. In the monsoon, the pattern of rainfall has changed over time. In general, weather variability related vulnerability and its impact to the cropping system has been seriously felt by the respondents, but they are cautious about possible adaptive measures, and are adjusting in the agronomical practices such as, sowing dates, and to some extent introduction of new crop species and varieties. However, there was a significant difference on majority of perception related parameters as opined by the respondents in Chitwan and Panchthar ($p<0.001$), suggesting need to consider these variations in responses while formulating site specific strategies instead of generalizing them. In-depth and comprehensive study covering larger niches would provide concrete information to develop appropriate strategies and policies to the weather variability in order to safeguard cropping pattern, and to increase productivity under the possible vulnerable context.

Key words: Adaptation, temperature, precipitation, perception, climatic variability

INTRODUCTION

Climate refers to weather patterns experienced over a long period of time. Climate change is the long-term change in climate and is usually used in the context of manmade climate change (Callo-Concha, 2018). Climatic variability has become a global concern since it can adversely affect elements of various systems and sectors that threated human wellbeing (Somboonsuke et al., 2018). Fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2013) provided clear evidence of changes in climate due to human activities. In the recent decades, increased climatic variability caused by the impact of changing climate has made food security threats more pronounced in the developing countries (Misselhorn et al., 2012). Climate change is considered to be one of the most serious threats to sustainable development.

Agricultural activities have been shown to contribute immensely to climate change as it ranks third after energy consumption and chlorofluorocarbon production in enhancing greenhouse emission. Land use changes, often made for agricultural purposes, contribute another 8%, or so to the total (Ozor & Nnaji, 2011). Climate change, especially weather variability with long-term changes in rainfall pattern and shifting temperature are expected to have significant negative effects on agriculture. Impacts of temperature variations also associated to the soil organic matter decomposition (Davidson & Janssens, 2oo6). These decomposed soil organic matters are important for agricultural productivity (Lehmann & Kleber, 2015). Variability of temperature and precipitation may also affect seed dormancy and germination (Walck et al., 2011) leading to decrease in crop production (Shimola & Krishnaveni, 2017) as a result of climate change, affects food insecurity in the least developed country like Nepal.

The Intergovernmental Panel on Climate Change (IPCC, 2007) defines adaptation as "adjustments in natural or human systems in response to actual or expected climatic effects, which moderates harm or exploits beneficial opportunities. Adaptation has three possible objectives: (a) to reduce exposure to the risk of damage; (b) to develop the capacity to cope with unavoidable damages; and (c) to take advantage of new opportunities" (IPCC, 2007). Climate change adaptation involves manipulation in agricultural management practices in response to changes in climatic conditions (Bastakoti Bhatrai & Doneys, 2019). It often involves a combination of various individual responses at the farm-level and assumes that farmers have access to alternative practices and technologies available in hand.

Agricultural production remains the main source of livelihood for most rural communities of developing

countries like Nepal (Bastakoti Bhatrai & Doneys, 2019) where agriculture provides a source of employment for more than 60 per cent of the population, and contributes about 30 per cent of Gross Domestic Product (GDP). Climate change will have greater impacts, especially to the smallholder farmers as they have the lowest capacity to adapt changes in climatic conditions (Shimola & Krishnaveni, 2017). Adaptation measures are therefore important to help these vulnerable communities to better face extreme weather conditions and associated climatic variations (Ozor & Nnaji, 2011). Site specific information is crucial to develop strategies to suit with local adaptive measures. This study aimed in identifying the most appropriate adaptation strategies such as use of traditional knowledge, indigenous seeds and the local institutional approaches for combating climate change impacts and vulnerability at the local level, particularly in line with changing in cropping pattern. Findings of this study are important to help develop appropriate strategies and policies about readjusting the cropping pattern in relation to climate change and adaptation practices. The following were major research questions to be answered by this study research.

Research Questions

1. What are trends of climatic variability and farmer's perception of the likelihood changes in cropping pattern in Chitwan and Panchthar? And whether there are similarities or differences in farmer's perception on these issues across the locations?
2. What is the impact of climatic variability in adjusting agricultural system in general and cropping pattern in particular in Chitwan and Panchthar?
3. What factors are responsible to influence in crop production in Chitwan and Panchthar?
4. What are the adaptation strategies used in crop production practices with the possible climatic variability in Chitwan and Panchthar?

This study was conducted with the objective to compare farmers' perceptions on climatic variability and vulnerability of cropping pattern, and identify impacts of changing climate on farm activities in the contrast context of hills and Terai so that responsible factors affecting crop production could be examined to analyze similarities, or differences applying as adaptation measures.

RESEARCH METHODOLOGY

Study area and population

The study was done in two locations, and in two different years. Accordingly, Kalyanpur of Madi Municipality and Madhavpur-Tandi of Ratnanagar Municipality were purposively selected from Chitwan district to carry out the study during 2017. Similar study was done in Ekteen and Sidin of Faalelung Rural Municipality, Panchthat district during 2018. In the case of Chitwan, a total of 120 respondents were randomly selected whereas similar number of respondents was randomly chosen from Panchthar district as well. Thus a total of 240 respondents' responses were considered for this study in terms of analysis and interpretation. These responses were subjected to explore and compare the perception on vulnerability of cropping pattern in relation to possible weather variability and its ways to adapt. Panchthar is located in the eastern hills, and the Chitwan lies in the central Terai region of Nepal. Agriculture is the main economic activity and source of livelihood in both the study area. Nepalese farmers have limited land, and farming system is generally characterized by an integration of crops and livestock on a subsistence level (Devkota et al., 2000-20001). The cropping pattern of Chitwan and Panchthar was different. Accordingly, rice-wheat/legumes-maize, or rice-legumes/pulses-maize was common cropping pattern in the Chitwan. In the case of Panchthar, sloppy land was mostly covered by cultivation of large cardamom, broom grass, ginger as a source of cash income whereas the plain area was cultivated by rice-barley/legumes/pulses-maize, or rice-vegetables/legumes-maize.

Data collection methods

The study mainly examined current changes of weather variability, impacts and adaptation strategies of cropping pattern at the household, and community level by employing case study as methodological triangulation approaches (Bryman, 2008). Methodological triangulation was employed to obtain data from different sources such as Observations, Interviews, and Focus Group Discussion (FGD) helped to harness diverse ideas about the same issue and assisted in triangulation of the results, and consequently to increase the validity and reliability of the findings (Bryman 2008; Rialp & Rialp, 2006). The primary data were collected from field observation, key informant interview; household survey, and FGD whereas published documents and meteorological data obtained from the respective departments were also used as a secondary source of information. Respondents were interviewed to know about household attributes, food security and livelihood status, awareness about climate change, perception on weather variability, its impact on agriculture, and adaptation strategies. Pre-testing of the questionnaire was also done prior to the data collection to avoid ambiguity and irrelevant question. Besides household survey, a total of six key informants in Chitwan (3 from Madi and 3 from Tandi) and three from Panchthar were interviewed to get the

in-depth knowledge about prevailing farming practices and the alteration in cropping pattern (if any) as a coping mechanism during the last 30 years. Likewise, two focus group discussions in Chitwan (one from each site) and one in Panchthar were conducted that comprised of mixed group of male and female farmers to validate the information obtained from household survey.

Climate change trend analysis

The temperature and rainfall scenarios of the study sites of Chitwan and Panchthar districts were assessed by analyzing the available weather data from the nearest weather station of Chitwan and Illam district (which is closer to Panchthar). Climate change trend graph was constructed using the last 30 years rainfall and temperature data obtained from Department of Hydrology and Meteorology station of Chitwan and 8 years data in the case of Panchthar obtained from Hydrology and Meteorology station of Dharan.

Statistical analysis

The collected data was analyzed using descriptive statistics. Data was tabulated and statistically analyzed using Microsoft Office Excel 2010 and SPSS 21. The descriptive statistics were used to describe respondents' household attributes such as age, sex, ethnicity, family size, education, occupation, food security and livelihood status, perception towards vulnerability impacts and adaptation strategies as adopted in agricultural practices across the districts. Qualitative information obtained from key informant interviews and focus group discussions were first translated and interpreted to complement and supplement the quantitative information collected from household interviews.

RESULTS AND DISCUSSION

Demographic characteristics

The mean age of the respondents in the Chitwan was 45 years, and almost similar mean age (44 years) was found in the Panchthar with the average household size of five members in both the districts. About four-fifth of the respondents (84%, 101/120) in the Chitwan and less than half of the respondents (45.8%, 55/120) in Panchthar were Brahmin/Chhetris. Nearly one-tenth of the *Janajati* and very few of *dalits* were also included in the Chitwan whereas more than half of the respondents (52.5% 63/120) were *Janajati* with a very few (2.7%) of them comprised of *dalits* in the Panchthar. There were 59 male and 61 female farmers interviewed in the Chitwan while 89 male and 31 females participated for the same in the Panchthar. The majority farmers of Chitwan (77%; 92/120) were educated compared to only about one-fifths in the Panchthar district. Majority of the respondents' occupation was farming in both Chitwan (76%; 91/120) and Panchthar (67.5%; 81/120) districts. Fewer respondents in both districts were also engaged in government job, business and some were fully depended on remittance income. It was also learnt that few of the respondents worked as a wage laborer for their livelihood support.

Food security and livelihood

More than half of the respondents of Chitwan relied on crops and vegetables production (56%; 66/120) to support livelihood followed by crops, vegetables and livestock integration (42.5%; 51/120). It was learnt that fewer respondents are still continuing only livestock as a source of life sustaining option (2.5%; 3/120) in the Chitwan. Almost the entire respondents in the Panchthar relied on crops along with vegetables production and livestock integration (99.2%; 119/120) whereas very few of them produced only crop and vegetables to support their livelihood. Majority of the respondents in Chitwan reported self-sufficiency (76.7; 92/120) in food availability throughout the year, but few of the sampled households did not have enough food for the whole year and often relied on either remittances or income from wage laborer as a livelihood support. This information was part of the basis to analyze about food security situation in the study districts, but specific relation of these information to the crop production and weather variability related issues were beyond the scope of this study to consider.

Awareness about climate change

Respondents were asked about their level of knowledge and perception on recent changes of climatic parameters across the globe such as rainfall/precipitation, temperature, cold stress and so on. Study findings revealed that level of awareness in both the study districts was significantly varied (Table 1). Accordingly, significant numbers of respondents in Panchthar district were known about the recent changes in climatic parameters compared to those in the Chitwan ($p<0.001$). For example, respondents' response in Panchthar was close to 100% which was about twenty percent less in the Chitwan (Table 1).

Table 1. Respondents' level of awareness about changes in climatic parameters in the Chitwan and Panchthar districts

Awareness on change in climatic parameters	Chitwan (n=120)	Panchthar (n=120)	Pearson Chi-Square (*p*-value)
Know about changes in climatic parameters	92 (76.7)	119 (99.2)	138.017 (0.000)***
Climatic parameters			
Inadequate or no rainfall	54 (59.3)	94 (78.3)	459.029 (0.000)***
Fluctuation in temperature	15 (16.5)	25 (20.8)	
Hotter days causing outbreak of unknown diseases	5 (5.5)	-	
Short monsoon and early rainfall	13 (14.3)	-	
Cold stress	2 (2.2)	-	
Untimely rain	2 (2.2)	1 (0.8)	

Source: Field Survey, 2017/18

Note: Figure in parentheses indicates Percent respondent's response. Significant at 0.001 (***)

There was significant difference in responses ($p<0.001$) on changing scenarios of climatic parameters in the two districts (Table 1). Nearly three-fifth of the respondents in the Chitwan felt about inadequate, or often no rainfall in the recent years which was supported by more than three-fourth of the respondents in the Panchthar. Response about fluctuation in temperature was about similar in both the districts (Table 1).

Perception on climatic variability

Survey results confirmed significant differences on farmers' perceptions towards characterizing weather pattern across the districts ($p<0.001$). Findings revealed that less than half of the respondents in the Chitwan and about three-fifth of the Panchthar had experienced similar trend of winter light rain and summer monsoon with short rain. About more than one-fourth of the respondents in the Chitwan also felt that there have been shift in rainfall pattern thus the amount and duration of precipitation is pretty unpredictable that was agreed by more than one-third of the respondent of Panchthar (Table 2).

Table 2. Respondents' criteria on characterizing weather pattern in the Chitwan and Panchthar

Criteria on characterizing weather	Chitwan (n=120)	Panchthar (n=120)	Pearson Chi-Square (*p*-value)
Following similar trend of winter light rain and summer monsoon rain	55 (45.8)	72 (60.0)	61.725 (0.000)***
Pretty unpredictable like there is a shift in rainfall pattern	37 (30.8)	48 (40.0)	
Winter rain is low in volume and summer starts late	28 (23.4)	-	

Source: Field Survey, 2017/18

Note: Figure in parentheses indicates Percent respondent's response. Significant at 0.001 (***)

The experience of respondents in terms of changes in weather related variables were inconsistent across the districts (Table 3). For example, about less than two-fifth of the respondents of Chitwan felt variation in start of monsoon possibly the indication of global warming whereas only one-tenth of the respondents' of Panchthar shared similar experiences of rise in temperature in the recent years. Nearly two-fifth of the respondents of Panchthar reported about rise of temperature and felt hotter days in the recent years (Table 3). On the other hand, about one-third of the respondents experienced the changes in rainfall and temperature pattern compared to the past years. It was also revealed that in the recent year's volume of rain is becoming lower with rises in temperature and perceived unpleasant hotter days (Table 3). Fewer respondents' of Panchthar had responded about the start of erratic and unpredictable rainfall while this was not a strong response in the Chitwan (Table 3).

Table 3. Respondents' experiences about changes in climatic parameters in the Chitwan and Panchthar districts

Experiences on changes in climatic parameters	Chitwan	Panchthar
Volume of rain is low and temperature rises compared to the past	25 (28.4)	19 (16.0)
Temperature increases every year as they feel hotter days	17 (19.3)	44 (37.0)
Increased deforestation impacts to climatic parameter	11 (12.5)	4 (3.4)
Use of more chemical pesticides impacts climate	3 (3.4)	14 (11.8)
Variation in start of monsoon/ global warming	32 (36.4)	12 (10.1)
Erratic and unpredictable rainfall	-	26 (21.7)
Total	88	119

Source: Field Survey, 2017/18

Note: Figure in parentheses indicates Percent respondent's response.

FGD findings revealed about the experiences of respondents on climatic shock, as majority have realized high temperature and short winter followed by hailstones and wind storms along with unpredictable rainfall. Early ripening and maturity of agricultural crops such as yellow berries (*Ainselu*); immature ripening of tomatoes; early ripening of maize, early maturity and ripening of rice were also noticed by the respondents of Panchthar. Majority of the respondents responded that there have been noticeable changes on temperature as it has been increasing every year with hotter days. On the other hand, heavy use of chemical pesticides, deforestation, and variation in the start of monsoon are perhaps related to the global warming, as they perceived (FGD, 2018). Likewise, respondents in the Chitwan had complained about no grain setting in the maize cobs, possibly due to hot summer (FGD, 2017).

Farmers' perception on weather pattern and climate trend

The findings revealed that there was a distinct variation in the response on weather variability ($p<0.001$). All of the respondents in the Panchthar agreed that summer temperature has increased and start early which was not agreed by nearly one-tenth of the respondents in the Chitwan (Table 4). Majority of the Panchthar respondents had experience of decrease in winter temperature that was also supported by the Chitwan respondents (Table 4). There was a variation on respondents' response on amount of monsoon rainfall. Nearly eighty percent of the Panchthar respondents felt that there has been increased in the amount of monsoon rainfall, in contrast, about less than half of the Chitwan respondents reported decreased amount of monsoon rainfall (Table 4).

Table 4. Respondents' perception on climate trend and weather pattern for the past 10 years, since 2008 in the Chitwan and Panchthar districts

Weather pattern	Chitwan (n=120)	Panchthar (n=120)
Summer temperature: Pearson Chi-Square (*p*-value) 612.433 (0.000)***		
Increased/ early	106 (88.3)	120 (100)
Decreased/late	5 (4.2)	-
Erratic/ unpredictable	3 (2.5)	-
No change	6 (5.0)	-
Winter temperature: Pearson Chi-Square (*p*-value) 331.167 (0.000)***		
Increased/ early	21 (17.5)	25 (20.8)
Decreased/late	84 (70.0)	95 (79.2)
Erratic/ unpredictable	8 (6.7)	-
No change	7 (5.8)	-
Amount of monsoon rainfall: Pearson Chi-Square (*p*-value) 80.233 (0.000)***		
Increased/ early	10 (8.3)	95 (79.2)
Decreased/late	58 (48.3)	-
Erratic/ unpredictable	44 (36.7)	25 (20.8)
No change	8 (6.7)	-
Monsoon rainfall (time): Pearson Chi-Square (*p*-value) 179.800 (0.000)***		
Increased/ early	15 (12.5)	-
Decreased/late	36 (30.0)	29 (24.2)
Erratic/ unpredictable	52 (43.3)	91 (75.8)
No change	17 (14.2)	-
Duration of monsoon rainfall: Pearson Chi-Square (*p*-value) 224.167 (0.000)***		
Increased/ early	13 (10.8)	-
Decreased/late	43 (35.8)	111 (92.5)
Erratic/ unpredictable	53 (44.2)	9 (7.5)
No change	11 (9.2)	-
Amount of winter rainfall: Pearson Chi-Square (*p*-value) 227.633 (0.000)***		
Increased/ early	33 (27.5)	-
Decreased/late	61 (50.8)	99 (82.5)
Erratic/ unpredictable	14 (11.7)	21 (17.5)
No change	12 (10.0)	-
Start of summer: Pearson Chi-Square (*p*-value) 74.817 (0.000)***		
Increased/ early	67 (55.8)	120 (100
Decreased/late	53 (44.2)	-

Source: Field Survey, 2017/18

Note: Figure in parentheses indicates Percent respondent's response. Significant at 0.001 (***)

Finding revealed that time of monsoon rainfall is becoming erratic and unpredictable as perceived by about three-fourth of the respondents in the Panchthar. The rest of the respondents of Panchthar felt that there is no specific prediction of time for monsoon rainfall (Table 4). Duration of monsoon rainfall was thought decreasing compared to the past years as responded by more than ninety percent respondents in Panchthar whereas about two-fifth of the Chitwan respondents felt erratic with the decreased volume (Table 4). More than half of the respondents in the Chitwan responded that summer starts quite early whereas the rest of the respondents' perceived reverse; but all of the respondents of Panchthar felt that summer starts early and thus hotter days has increased (Table 4). These all scenarios clearly supported the fact that there are variations in people's perception on characterizing weather pattern.

Climate trend and weather pattern analysis was mainly considered for temperature and rainfall. Data obtained from Department of Hydrology and Meteorology revealed that there has been unpredictable trend of precipitation in the Chitwan district for the last 30 years. Accordingly, the amount and the pattern of precipitation both were found to be different compared to the past years (Figure 1).

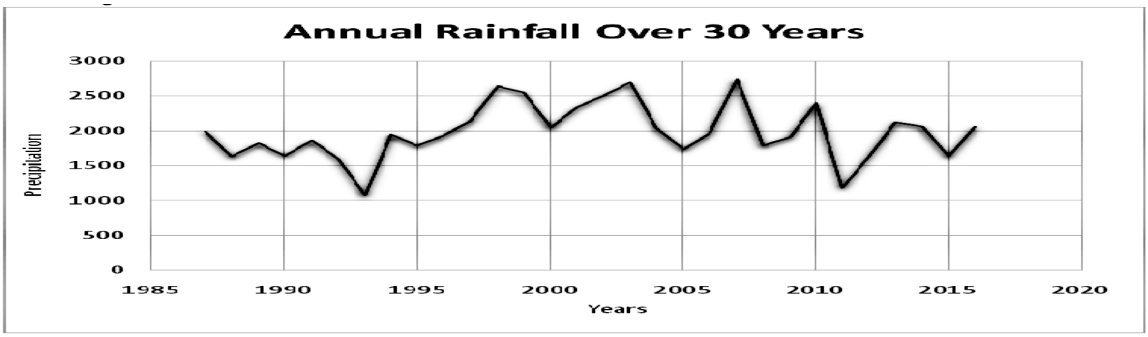

Figure 1. Mean annual precipitation (mm) in Chitwan for last 30 years (1985-2018)
Source: Department of Hydrology and Meteorology, Nepal

There was a variation in maximum and minimum temperature in the past 30 years (Figure 2). Accordingly, spells of high and very low temperatures have been observed in the recent years as compared to past thus increasing the vulnerability of the agriculture system.

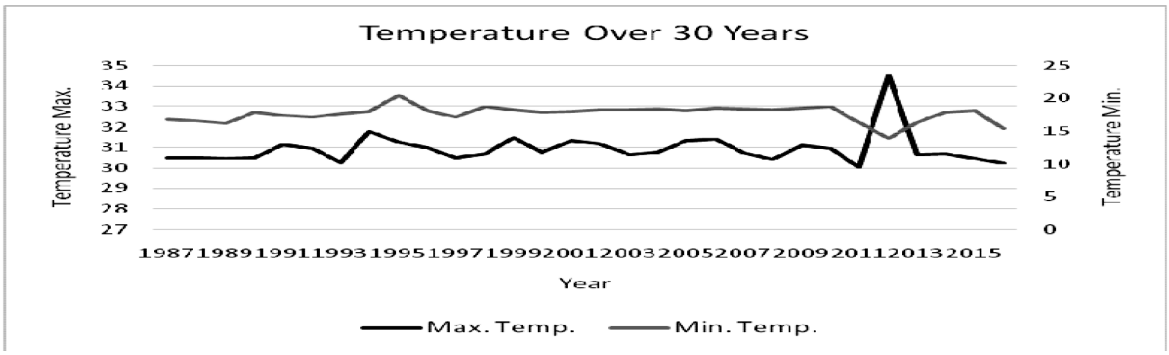

Figure 2. Annual temperatures (minimum and maximum, ^{0}c) in Chitwan for last 30 years
Source: Department of Hydrology and Meteorology, Nepal

Data obtained from Department of Hydrology and Meteorology revealed that there has been unpredictable trend of rainfall and precipitation in the Illam district during 2010 to 2018. Illam is closer to the Panchthar district thus rainfall data has been collected from the nearest Hydrology and Meteorology Station of Dharan (Figure 3). These sources of information clearly revealed the changes in the pattern of precipitation and rainfall across the years.

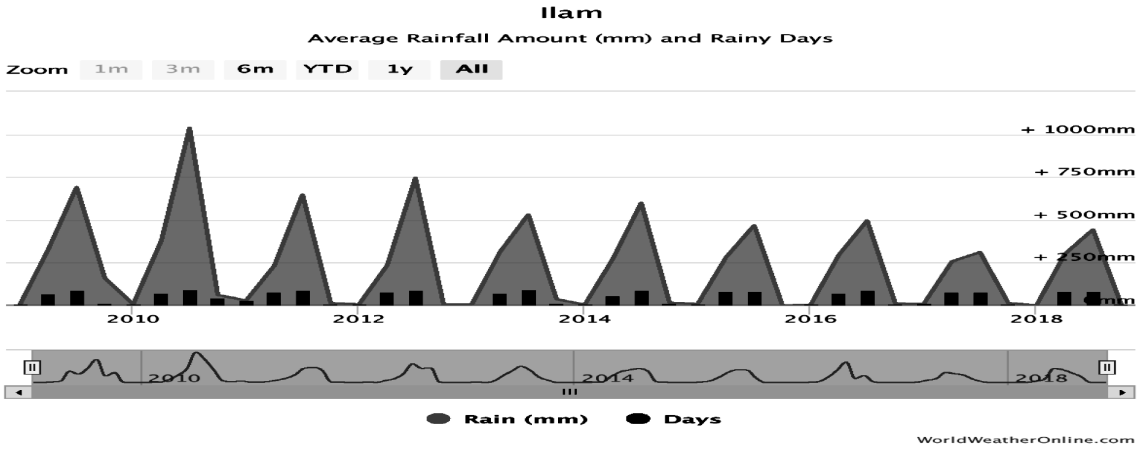

Figure 3. Average rainfall (mm) and rainy days in Illam (2010 to 2018)
Source: Department of Hydrology and Meteorology, Nepal

Figure (4) shows the variation in maximum and minimum temperature of Illam for the last eight years (2010 to 2018). Illam is closer to the Panchthar district. The date shows spells of high and very low temperatures as recorded in recent years, resulting the vulnerability situation in the agriculture, particularly to the given cropping system.

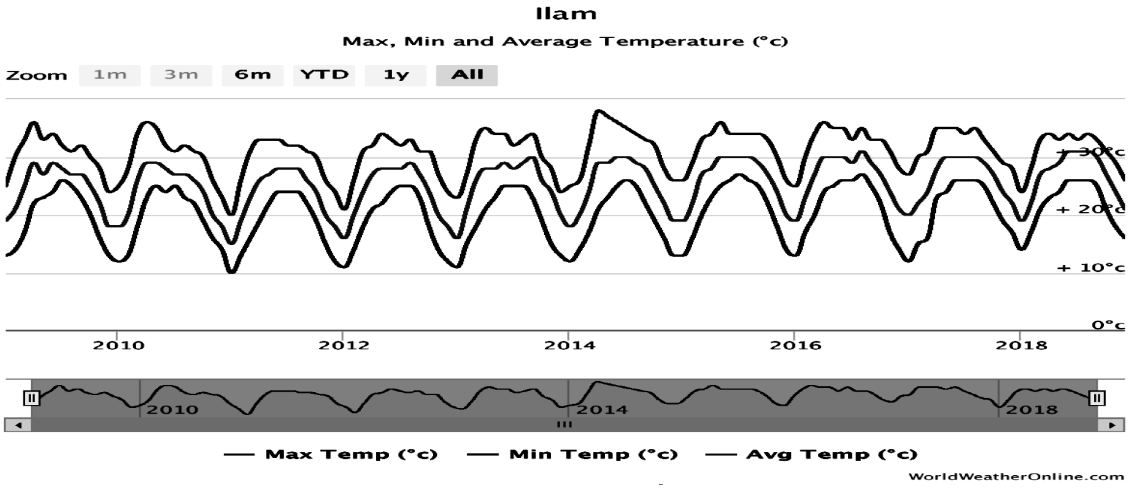

Figure 4. Annual temperature (minimum and maximum, ^{0}c) in Illam (2010 to 2018)
Source: Department of Hydrology and Meteorology, Nepal

Vulnerability of cropping pattern

It was learnt that there is a significant difference between the perception of Chitwan and Panchthar respondents about the vulnerability of cropping pattern ($p<0.001$). More than four-fifths of the respondents of Panchthar felt that cropping pattern is changing to cope with the change in rainfall pattern thus cropping pattern is highly vulnerable. This statement was, however, not supported by three-fifths of the respondents in the Chitwan (Table 5).

Table 5. Respondents' perception on vulnerability of cropping pattern in the Chitwan and Panchthar districts

Vulnerability of cropping pattern	Chitwan (n=120)	Panchthar (n=120)	Pearson Chi-Square (*p*-value)
Cropping pattern is changing to cope with change in rainfall pattern thus it is highly vulnerable	48 (40.0)	104 (86.7)	97.300 (0.000)***
There has been slowly changing in weather pattern thus moderate level of vulnerability exists	33 (27.5)	9 (7.5)	
Same crops and cropping pattern have been followed thus there exists less vulnerability	39 (32.5)	7 (5.8)	

Source: Field Survey, 2017/18
Note: Figure in parentheses indicates Percent respondent's response. Significant at 0.001 (***)

Factors influencing crop production

Several multiple choices of possible influential factors for crop production were asked to the respondents during the survey (Table 6).

Table 6. Respondents' response on factors influencing crop production in the Chitwan and Panchthar districts

Factors	Chitwan (n=120)	Panchthar (n=120)	Pearson Chi-Square (*p*-value)
Unpredictable rainfall, low soil fertility, increased insect, pest and diseases	58 (48.3)	14 (12.7)	12.225 (0.002)***
Unpredictable rainfall, increased insect, pest, diseases, high price of farm equipment, shortage of farm labor	17 (14.2)	46 (38.3)	
Unpredictable rainfall, increased insect, pest, diseases and low access to farm inputs	45 (37.5)	60 (50.0)	

Source: Field Survey, 2017/18

Note: Figure in parentheses indicates Percent respondent's response. Significant at 0.001 (***)

Respondents' perceived choices of possible influential factors for crop production were significantly differed ($p<0.001$) across the districts (Table 6). Accordingly, almost half of the respondents of Chitwan reported multiple responses, such as unpredictable rainfall, low soil fertility, increase insect, pest and diseases along with poor agricultural practices as influencing factors to the crop production. Along with these factors as perceived by the Chitwan farmers, low access to farm inputs with high price and shortage of farm labor were a major problem in the case of the Panchthar (Table 6). Low soil fertility and low access to farm inputs including unpredictable rainfall and insect, pest and disease outbreak were the major problems for crop production as responded by the majority of respondents in the Chitwan district. This information clearly showed the fact that perception of people differs as per the individual differences and the place of settlement, or location (Table 6). Thus, there is a need of niche specific strategy development to deal with the vulnerability issue in agriculture that is related with weather variability.

Climate change impact

Respondents' perception and experiences as revealed on climate change related impacts has been reported in multiple areas. Accordingly, draught, flood, wind storm, heavy rainfall, low yield, untimely or immature ripening of fruit, crops and vegetables were the noticeable impacts of climate change as perceived by the respondents of Panchthar district. Attack of insect and pest has been extensively observed. Increasing temperature, winter draught, and short monsoon along with the unpredictable weather pattern such as hailstones, extreme rainfall causing wilting and fruit damage was also common in Panchthar. Very few of the respondents in Panchthar have not yet realized the impact of climate change on agriculture. Majority of the respondents of Chitwan had also experienced the draught and hotter days, low crop yield, untimely ripening of fruit, crops and vegetables, along with insect and pest attack to the crops. Likewise, as they perceived, summer monsoon starts late with increased temperature that has direct impact on agricultural farm as well as the human being. The fluctuating weather pattern and hailstones are some of the other factors that have impacted rural farming systems. Extreme rainfall during the cropping season might causes wilting and fruit damage.

Local adaptation strategies against climate change

Findings of this study clearly envisaged that there are distinct variations across the district in terms of use of local adaptation strategies followed by the respondents ($p<0.001$) (Table 7).

Table 7. Respondents' response about local adaptation strategies adopted to reduce the impacts of climate change in agriculture in the Chitwan and Panchthar districts

Adaptation strategies to minimize the effects of climate change	Chitwan (n=120)	Panchthar (n=120)	Pearson Chi-Square (*p*-value)
Manipulation of crop selection and cropping calendar/ change planting dates/ use of draught resistance varieties (ginger in Panchthar)	39 (32.5)	95(79.2)	179.186 (0.000)***
Better management of production factors such as inputs and improved water management	21 (17.5)	15 (12.5)	
Manipulation of crop selection and cropping calendar, better management of factors such as inputs; use of organic manure to improve soil quality, and improve water management technology such as drip irrigation	60 (50.0)	10 (8.3)	

Source: Field Survey, 2017/18

Note: Figure in parentheses indicates Percent respondent's response. Significant at 0.001 (***)

Accordingly, majority of the respondents in the Panchthar have been following the practices of manipulation in crop/varieties selection and changing in the cropping calendar by altering planting/sowing dates of crops and vegetables. Such manipulations are not widely practiced by the respondents of Chitwan (Table 7). Apart from the information presented in the table (7) respondents also reported several unique examples of adaptation in both the districts with respect to their perception to weather change and adaptation practices. For example, respondents of Chitwan felt that often tomatoes are affected and ripened at immature stage due to effect of fluctuating temperature. The information obtained from FGD also well supported to the fact that effects of temperature and draught might be the causes of immature ripening of tomatoes (FGD, 2017). On the other hand, majority of the respondents in the Chitwan have been using multiple adaptation strategies, such as manipulation in crop selection and maintaining cropping calendar; use of organic manures to maintain the soil fertility, and use of improve water management technology, such as drip irrigation (Table 7).

FGD findings from Chitwan revealed that typical changes in crops and species grown were reported in Madi of Chitwan to adjust with the change in precipitation pattern. For example, respondents used to cultivate upland rice in several areas of Madi, but maize was not common until 1980. Slowly the cultivation of upland rice is decreasing in area, and the traditional cropping system has replaced by rapeseed, lentil, *khesari*, potato, and wheat to increase the diversity (FGD, 2017). Until 1980/82 maize crop was not common in these areas, however, it is now common in all areas including swampy lands (in case of less rainfall). Other adjustments are such that the fish farming was introduced in 2006 and it gained popularity among the farmers having swampy land where the production of rice was only practiced previously. Majority of the non-Tharus cultivate subsistence level of vegetable farming whereas some Tharus of Madi had introduced commercial vegetable farming. These are the changes in agricultural practices mainly related to adjust with the precipitation and its variability to cope with possible vulnerability in the agricultural systems (FGD, 2017).

We also found some of the common mitigating measures adopted by the respondent of the Chitwan through-adjusting seed sowing and plating time as per the onset of rainfall. In Upland area of Tandi, maize is grown as a spring and winter season crop; and wheat as late winter crop. Apart from these crops, pea, lentil, barley, oat, potato is also commonly grown to increase the degree of crop diversification. There are some changes in the cultivation practice, for example-wheat sowing has been practiced till mid of December whereas rapeseed cultivation has been significantly reduced compared to other crops due to alarming aphid infestation in rapeseed in the recent years. The common varieties of rice cultivated in the past were- *Masuli, Basmati, Aanpjhutte, Joginimasino* and *Achhamimasino* whereas at present- *Sabitri* in swamps, and *Taraknath, Loknath, Gorakhnath* in the other areas are commonly introduced. Trend in rice cultivation is such that there has been increased use of hybrids and modern cultivars in the Tandi of Chitwan. This information is the reflection of the fact that climate change impact has been slowly visible in agriculture with the local level of adaptation to cope with the climatic variability.

Rice, maize, millet, cardamom, broom grass (*Amriso*), ginger, seasonal vegetables, Kiwi fruit, oranges, and lemons are the common crops and vegetables of Panchthar district. The findings of the Focus Group Discuss clearly revealed that fallow land has increased due to dryness in the study areas of Panchthar (FGD, 2018). Production of maize has decreased due to unpredictable and erratic rainfall pattern as expressed by the respondents. Earlier, two cob bearing was common in all maize plant which has changed to only one cob. Again, there is a problem of maize grain setting. There is no uniformly ripening of maize cobs even when sowing dates are similar (FGD, 2018). Farmers' are trying to cope with this climatic variability and thus have altered the cultivation time for maize. Millet is also commonly grown in Panchthar district. Now-a-day, quality of millet grain has been deteriorating, perhaps due to effect of climate change, as expressed by the Key Informant (KII, 2018). Untimely ripening of tomatoes is a common phenomenon in the recent years. The color and quality of tomatoes has also changed thus farmers are in great loss due to poor market price. Earlier farmers had happily planted lemon and oranges in their farm land at the 900-1000 masl, but they have shifted to the hill side to grow lemon and oranges as these crops needed favorable weather and climate. Cardamom cultivation has been affected largely by insect borer and blight. Tomatoes are badly affected by Tuta, Nematodes, blight and white fly. Potatoes are affected by blight which was not common in the past. Dryness has increased. Rice varieties: *Champasali, Rambhog, Bhangeri, Atte, Belkuti* (taste preference). *Radha-9, Tarahara-1, Sukhha*-3 are also commonly grown, but in a subsistence level. Local varieties are disease resistance thus farmers prefer to cultivate more of local varieties. In deed farmers are trying to adjust the cropping pattern with the climatic variability by altering the time of cultivation, variety change, and by following appropriate technology with the hope to get the good harvest.

DISCUSSION

Climate change has been a topic of discussion in Nepal due to its increasing stress on water resources and other climate-sensitive resources thereby affecting agricultural production, food security and livelihood (Devkota & Dhakal, 2017). Increase in temperature has impacted on the changes in timing, intensity and volume of rainfall

and rising carbon dioxide levels. Floods have increased phenomenon every year and have taken lives, destroyed physical assets, displaced people and deposited sediments on agricultural land. Terai region is the most prone to flooding. The drought has been another phenomenon of climate change and has affected both winter and summer crops. Climate change is becoming a major issue in Nepalese agriculture sector and has already lost valuable arable land due to flood and erosion. It has seen changes in the monsoon affecting agricultural production and has experienced water shortages and drought. Hence, climate change has become serious threat to Nepalese agriculture. Nepalese agriculture is predominantly small-scale farming, around half of which are dependent on natural rainfall. Rainfall and other climatic factors are critical to crop yields because only 46.5% of overall cultivated area is irrigable of which 69.5% is actually irrigated (MoAC, 2012). Agriculture sector has also been seriously affected by droughts (FGD, 2018). Climate change is expected to lead to increasing dryness in drought-prone areas and to wetter conditions in wet areas and there have already been alarming signs of sharp and sustained decline in food security in Nepal (Regmi & Paudyal, 2009). For example, winter food crop harvests for 2009 in all regions of Nepal have declined perhaps due to climate change. In the recent decades, small holder farmers are experiencing lots of changes primarily due to the effect of climate change (Shimola & Krishnaveni, 2017). Climate change has mainly impacted on phenological stage of crops where irregular rainfall, increasing temperature and decreasing moisture content leads to adverse effect on crops such as changes in the new leaf formation, flowering stage, fruit bearing time and decrease overall production (Rawat, 2013).

Findings of this study revealed that there have been slowly building a kind of impact of change in climatic variability, mainly rainfall and temperature to the agricultural production. This could result several negative impacts in establishing appropriate cropping calendar (Shimola & Krishnaveni, 2017). Indeed, a number of negative effects of climate change, such as change in cropping calendar, vegetation shifts, change in routine activities like grazing, harvesting and storing have been observed in agriculture in Nepal. Over the past years, the delay in monsoon season, onset and ending of monsoon has been experienced in Nepal resulting to the adjustment in cropping pattern (Dahal et al., 2011). Findings of the research have shown that such shift and adjustment would mean delayed in the planting and harvesting season often that could be by a month, which has in turn would affect to the entire cropping pattern and cropping calendar (Shimola & Krishnaveni, 2017). On the other hand, the delay in monsoon season has resulted hundreds of hectares of farm land kept fallow due to unavailability of rain in planting time that would ultimately reduce agricultural production (Attavanich et al., 2014). Climate change, such as rising annual temperature, delayed monsoon season, increased annual rainfall resulting from increased glacial melting and increased occurrence of intense rainfall among others has affected many rain-fed farms communities in Nepal (Regmi & Paudyal, 2009). These scenarios are not very strongly reflected in Chitwan, except draught and increased temperature-led hotter days and its consequences to the agriculture that are getting vulnerable in terms of adapting new cropping calendar (Devkota & Dhakal, 2017). The present study findings revealed that there are variations on peoples' perception while experiencing the climatic variability and vulnerability of cropping pattern (Table 7). Vulnerability is an individual or groups reduced capacity to cope with, resist, and recover from the impacts of natural or human-made hazard (Birkmann, 2006).

Information obtained from Focus Group Discussion and Key Informants' Interview also supported these findings. The changes in climatic parameters such as temperature and rainfall lead to the unpredictable and erratic rainfall patterns, warmer temperature, increase evapotranspiration, increased deforestation and ecosystem fragmentation, frequency of drought, changes in livelihood patterns of communities, increased incidence of disease and epidemics, increased rural-urban migration from fragile environment. Major concern regarding the climate change was related to the rainfall and temperature. Available literatures suggest that local people adopt various adaptation practices to deal with climate change impacts (Bastakoti et al., 2017). Most of the farmers elsewhere follow various adaptations measures during drought periods, but by not following scientific adaptation strategies to climate change (Ndamani & Watanabe, 2015). Nevertheless, adaptation measures include- change in the sowing dates- depending on the onset of monsoons; increased use of organic fertilizers, changes in crop variety with high yielding and short duration crops; crop rotation and inter cropping, drip irrigation, and keeping land fallow for certain time of the year.

Knowledge gaps also influence on peoples' perceptions about climate change (Tegart et al., 2012). The perception of risks from the psychological studies descried that people intend to look upon recent risk levels as unacceptably high for most activities. People's perception of risk is subjected by a variety of psychological and social aspects, such as experience of the individual, length of touch and emotion, imagery, belief and traditional values (Slovic & Weber, 2013). Thus, it is considered that farmer's adaptation strategies to environmental and climate change is strongly influenced by perceptions and opinion as well as belief and social-cultural value system (Makate et al., 2017). Changes in phenology of crops as a result of climate change can reduce crop productivity because of earlier anthesis and grain maturity at warmer temperature thus shortening the duration of growth and reducing grain yield (Anwar et al., 2015). It is also well evident from the findings of our study that farmers have

been adjusting with changing temperature and rainfall pattern. A majority of farmers altered sowing and harvesting dates; changed the crop varieties, and cropping pattern, to adjust with the changing scenarios of weather pattern.

CONCLUSIONS

Unpredictable extreme rainfall and precipitation related consequences to the cropping pattern is more visible as experienced in the recent past years compared to the temperature related fluctuation and its impact to the cropping pattern in the study districts. Farmers are cautious about climatic variability related vulnerability and its impact to the cropping system so as to adapt possible measures, such as adjusting in the sowing dates, and changing the crop species/varieties, however, distinct scenario of such adaptation are not yet fully visualized.

The significant differences on majority of perception related parameters in Chitwan and Panchthar, clearly suggest the need to consider these variations in responses while developing appropriate strategies and formulating site-specific policies instead of generalizing them grossly. In-depth and comprehensive study covering larger niches would provide concrete information to develop appropriate strategies and policies related to the weather variability to safeguard cropping pattern and to increase productivity under the possible weather vulnerable context of climate change.

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