A
F
U

ISSN: 2594-3146

# Journal of Agriculture and Forestry University

Volume 2 2018

**Agriculture and Forestry University**
Rampur, Chitwan

ISSN: 2594-3146

# Journal of Agriculture and Forestry University



**Volume 2** **2018**

| | |
|---|---|
| Frequency of Publication | Annual |
| Editorial Policy | A medium of publishing original scientific papers |
| Official Language | English |
| ISSN | 2594-3146 |
| Subject of Interest | Plant Science, Animal Science, Veterinary Science, Forestry, and Social Science |

Subscription

| **Category** | **Rate** |
|---|---|
| SAARC countries | US$ 10.00 postage extra |
| Other countries | US$ 15.00 postage extra |
| AFU faculty | NRs. 200.00 |
| AFU students | NRs. 100.00 |
| Other Nepalese citizen | NRs. 300.00 |
| Other organization in Nepal | NRs. 500.00 |

| | |
|---|---|
| Mode of Payment | By Bank Draft or Cheque on Bank of Kathmandu, Narayangarh, Chitwan, Nepal. It should be addressed to AFU-Directorate of Research and Extension (Exp), Rampur, Chitwan, Nepal |
| Correspondence | JAFU Secretariat<br>Agriculture and Forestry University, Rampur, Chitwan, Nepal<br>E-mail: dor@afu.edu.np |



**Correct citation**: Authors detail with surname of first author, first name, followed by first name and surname of other authors in sequence (2018). Title of the article, Journal of AFU (Volume 2): pages, Agriculture and Forestry University, Chitwan, Nepal.

**Agriculture and Forestry University**
**Rampur, Chitwan, Nepal**

**Journal of Agriculture and Forestry University (JAFU)**

**Volume 2** **2018**

**Review Articles**

1. Association of nutritional status to reproductive performance in buffaloes 1-7
**B. Devkota**

2. Can organic materials supply enough nutrients to achieve food security? 9-21
**J.Timsina**

3. Current diagnostic techniques of *Mycobacterium avium* sub sp. *paratuberculosis* in domestic ruminants 23-34
**S. Singh, I. P. Dhakal, U. M. Singh, and B. Devkota**

**Research Articles**

1. Effects of climate change on mountainous agricultural system in Makwanpur, Nepal 35-44
**A. P. Subedi**

2. Assessment of gender involvement and decisions in agriculture activities of rural Nepal 45-52
**D. Devkota, I. P. Kadariya, A. Khatri-Chhetri, and N. R. Devkota**

3. Gender roles in decision-making across the generation and ethnicity 53-62
**D. Devkota and K. N. Pyakuryal**

4. Out-migration and remittances in Nepal: Is this boon or bane? 63-72
**R. R. Kattel and N. Upadhyay**

5. Economic valuation of pollination service in Chitwan, Nepal 73-77
**S. C. Dhakal**

6. Behavioral practices of supply chain actors on quality maintenance of raw milk in Nepal 79-89
**U. Tiwari and K. P. Paudel**

7. Livelihood improvement through women empowerment for a broader transformation in the way of living: A case of Churia area 91-99
**Y. Humagain and D. Devkota**

8. Effect of organic and conventional nutrient management on leaf nutrient status of broad leaf mustard *(Brassica juncea* var. *rugosa)* 101-105
**B. P. Bhattarai, K. P. Shing, S.M. Shakya, G. B. K.C., and Y. G. Khadka**

9. Effect of planting dates of maize on the incidence of borer complex in Chitwan, Nepal 107-118
**G. Bhandari, R. B. Thapa, Y. P. Giri, and H. K. Manandhar**

10. Growth, yield and post-harvest quality of late season cauliflower grown at two ecological zones of Nepal 119-126
**H. N. Giri, M. D. Sharma, R. B. Thapa, K. R. Pande, and B. B. Khatri**

11. Efficacy of commercial insecticide for the management of tomato fruit borer, *Helicoverpa armigera* hubner, on tomato in Chitwan, Nepal 127-131
**R. Regmi, S. Poudel, R. C. Regmi, and S. Poudel**

12. Efficacy of novel insecticides against South American tomato leaf miner (*Tuta absoluta* Meyrick*)* under plastic house condition in Kathmandu, Nepal 133-140
**R. Simkhada, R. B. Thapa, A. S. R. Bajracharya, and R. Regmi**

13. Simulation of growth and yield of rice and wheat varieties under varied agronomic management and changing climatic scenario under subtropical condition of Nepal 141-156
**S. Marahatta, R. Acharya, and P. P. Joshi**

14. Wet season hybrid rice seed production in Nepal 157-163
**S. N. Sah and Z. Xingian**

15. Nutritional parameters in relation to reproductive performance in anestrus chauri (Yak hybrid) cattle around Jiri, Dolakha 165-169
**B. P. Gautam, B. Devkota, R. C. Sapkota, G. Gautam, and S. K. Sah**

16. Changes in physiological and metabolic parameters of sheep (*Ovis aries*) during trans-humance at western himlayan pastures 171-175
**K. Bhatt, N. R. Devkota, I. C. P. Tiwari, and S. R. Barsila**

17. Reproductive status and infertility in Chauries around Jiri, Dolakha 177-182
**R. C. Sapkota, B. Devkota, B. P. Gautam, T. B. Rijal, G. R. Aryal, and S. K. Sah**

18. Determining chemical constituents of the selected rangeland to help improve feed quality under the context of climate change in the districts of Gandaki river basin 183-189
**S. Chaudhari and N. R. Devkota**

19. Productivity and chemical composition of oat-legumes mixtures and legume monoculture in southern subtropical plains, Nepal 191-198
**S. Dangi, N. R. Devkota, and S. R. Barsila**

20. Effect of forced molting on post molt production performance of locally available commercial laying chicken 199-204
**S. Sapkota, R. Shah, D. K. Chetri, and S. R. Barsila**

21. Supply chain analysis of carp in Makwanpur, Chitwan and Nawalparasi districts of Nepal 205-210
**K. Adhikari, S. Rai, D. K. Jha, and R. B. Mandal**

22. Efficacy of tamoxifen on sex reversal of nile tilapia (O*reochromis niloticus*) 211-216
**N. P. Pandit, R. Ranjan, R. Wagle, A. K. Yadav, N. R. Jaishi, and I. Singh Mahato**

23. Performance of pangas (*Pangasianodon hypophthalmus*) under different densities in cages suspended in earthen pond 217-224
**S. N. Mehta, S. K. Wagle, M. K. Shrestha, and N. P. Pandit**

24. An assessment on abundance of aquatic invasive plants and their management in Beeshazar lake, Chitwan 225-230
**A. Sharma, S. Bhattarai, and B. Bhatta**

25. In the search of end products of commercially important medicinal plants: A case study of yarsagumba *(Ophiocordyceps sinensis)* and bish *(Aconitum spicatum)* 231-239
**G. Kafle, I. Bhattarai (Sharma), M. Siwakoti, and A. K. Shrestha**

26. Carbon stocks in *Shorea robusta* and *Pinus roxburghii* forests in Makawanpur district of Nepal 241-248
**P. Ghimire, G. Kafle, and B. Bhatta**

**Research Article**

# EFFECT OF CLIMATE CHANGE ON MOUNTAINOUS AGRICULTURAL SYSTEM IN MAKAWANPUR, NEPAL

**A. P. Subedi***
Agriculture and Forestry University, Rampur, Chitwan, Nepal

## ABSTRACT

Climate change is one of the burning issues of this era for sustainable development which has great impact on ecosystem and agriculture. Changes in climatic factors such as temperature, solar radiation and precipitation has great potentials to influence on cropping system, landscape and biodiversity of hilly areas. In this context, this study was done covering randomly selected 60 farming households in Makawanpur district of Nepal with the objectives to assess trend of change in climatic variables, adaptation strategies at farmers' level, effect on cropping system and their impact on crop productivity. The findings revealed that about 45 percent respondents had knowledge on climate change, and knowledgeable households have adopted climate change adaptation strategy against negative effects. Likewise they were more pro-active to perceive weather change pattern and suitable practices in agricultural sector. Most of the weather variables such as temperature, rainfall and hailstorm have been trending towards the undesirable direction. Among farming households, the decrease in productivity, change in harvesting, change in crop variety, and change in sowing time have been perceived and realized by 26.7, 23, 47 and 30 percent respondents, respectively. To adapt to the changing context of climate, adaptation practices such as mulching (13%), hedge row planting (7%), change in crop variety (35%), and change in harvesting time (15%) have been practicing by the farmers with the resultant increase in productivity as revealed for about 30 of percent households. Introduction of new varieties, irrigation facilities and other relevant climate smart technologies are suggested to generate and adapt practices in order to maintain the sustainability of mountainous agricultural system, and for the promotion of livelihoods of farming communities inhabiting in the mountains.

**Key words**: Adaptation, mitigation, perception, temperature

## INTRODUCTION

Climate change is defined as variation which is attributed to human activity that alerts the composition of the global atmosphere and which is in addition to natural climate variability observed over extended period of time (IPCC, 2007). Climate change has been taking place from the origin of the earth as a natural process but in the recent years due to anthropogenic activities the rate of change has been taking place at an increasingly alarming rate. According to IPCC (2014) there has been a tremendous rise in the surface temperature of the earth due to a massive increase in the anthropogenic emissions of greenhouse gases (GHGs), such as $CO_2$, $CH_4$ and $N_2O$ in the atmosphere as a result of the rapid economic and population growth since the mid-twentieth century as compared to the last 800000 years (UNFCCC, 2007). Global warming has been the most evident impact of climate change (UNCTD, 2009). The temperature in the Himalayan and hilly region is rising at a higher rate of 0.08˚C per annum as compared to a rate of 0.04˚C per annum in the Terai region of Nepal (Malla, 2007). The rate of increase in the temperature is found to be even higher than the global average. Nepal is predicted to be one of the most severely affected countries by the impacts of climate change in the years to come (Synnott, 2012).

Along with these shifts in the temperature patterns, there has been a considerable shift in the precipitation patterns of the country. The number of rainy days has decreased with longer drought conditions and erratic rainfall (Malla, 2007). The total annual precipitation has shown an increasing trend over the years, however, with an erratic pattern. There has been less number of rainy days with an increased intensity of rainfall (Malla, 2008). Nepal has been hard hit by the impacts of climate change. Due to changes in the rainfall patterns, the cropping system and production, which are primarily dependent on rainfall, are struck hard. The changes in the hydrograph and water availability during the pre-monsoon, monsoon and post-monsoon seasons are known to have direct impacts in the Nepalese agricultural system (Sharma and Shakya, 2006). These changes contributed to cut back crop production leading to increasing in the problem of food security (ADB, 2009).

* Corresponding author: apsubedi@afu.edu.np

Hills and mountains are proved to be early indicators of global climate change (Singh et al., 2010). Mountain environments are doubtless susceptible to the impacts of global warming as a result of the mix of increased sensitivity to climate change and limited potentialities for species migration to favorable locations create mountains as a "islands". A modification in atmospheric condition will cause it to expand its traditional catchment area extending loss in plant productivity (Rosenzweig et al., 2001). Increase in summer temperatures would favour growth of temperate zone insects resulting in quicker development and extra generations (Porter et al., 1991). High winter temperature probably results into redoubled over-wintering thereby increasing population levels within the following season (Porter et al., 1991).More extreme weather events like droughts and floods likely to be increased which probably lead to pest and disease outbreaks. Drought stress affects plant physiology, inflicting some plants to become more prone to pests and pathogens, particularly once combined with higher temperatures might suppress plant defense mechanism (Rosenzweig et al., 2001). Also due to global warming, dry period is extended and because of that there's a lot of forest fire, and increase in pest and diseases in crops (LFP, 2010).

Change in climate has huge impact on farming and water resources, because of inconvenience in irrigating water for crop production, is hampered as Nepal is dependent on rain fed farming system (Shrestha et al., 1999). Fragile hill based ecosystem of Nepal is more vulnerable to global warming (Lieu & Chen, 2000). To adapt the ever-changing condition of global climate change and its impact, farmers are adopting new practices. In this context, this study was conducted to assess the impact, perception and adaptation strategies in the context of climate change on cropping system as practiced by the local farmers in the mountainous region of Makawanpur. The specific objectives were to assess different cropping practices in the hills; identify the impact of climate change in the cropping system and biodiversity, and document the different innovation strategies practiced by local farmers to cope with the scenario of climate change.

## MATERIALS AND METHODS

This study was conducted in representative hilly VDC, Manahari of Makawanpur. Primary and secondary data relevant to study were collected from various sources. Stratified random sampling was employed to gain a higher degree of precision from selected 2 wards and population was stratified based on socio-economic status considering that it creates heterogeneity in the livelihood to Indigenous farmers, especially on the factors related to the climatic variation. Primary data were collected from field observation in 60 households whereas, secondary data were collected from the record of Community Forest Users Group (CFUGs), District Development Committee (DDC), District Agriculture Development Office (DADO) and other organizations' reports, booklets and journals. Household interview was conducted in the entire sampled household using pre-tested semi-structured interview schedule. Information on climatic phenomena, it's impact on cropping system adopting in the community of indigenous farmers and generally with the oldest and the most experienced person in household affairs were also collected from household survey. A Focal Group Discussion (FGD) was carried out to cross check the information's gathered during household interview.

Data was analyzed using both qualitative and quantitative techniques. Data were entered in SPSS spreadsheet and analysis was carried out using both SPSS and STATA. For qualitative analysis different descriptive analysis were performed and mean, frequency, percentage and Chi-square test were employed to accomplish the objectives of the study.

## RESULTS AND DISCUSSION

### Socio-economic and demographic characteristics

Average age of the respondents in the study areas was 40.25 years which was found higher (41.09 yrs.) among farmers without knowledge on climate change as compared to knowledgeable farmers (39.22yrs). This difference between average age of respondents was found non-significant between two study sub-population (Table 1).

**Table 1. Socio-demographic and economic characteristics of respondents**

| Variables | Overall (N=60) | Knowledge on climate change | | Mean Difference | Chi-square value | P value |
|---|---|---|---|---|---|---|
| | | Yes (n=27) | No (n=33) | | | |
| Age of respondent (yrs.) | 40.25 | 39.22 | 41.09 | -1.86 | -0.461 | 0.647 |
| Economically active member (No.) | 4.23 | 4.48 | 4.03 | 0.45 | 0.855 | 0.396 |
| Land holding (Kattha) | 8.29 | 9.20 | 7.53 | 1.67 | 0.899 | 0.372 |

Out of the 60 respondents, 60 percent were male and remaining 40 percent were female. Similarly, 63 percent of respondents who heard about climate change were male and 57 percent of people who didn't know about climate change were male. This difference was also not significant (Table 2).

**Table 2. Gender of respondents by level of awareness in the study area**

| Gender | Knowledge on climate change | | Overall (N=60) |
|---|---|---|---|
| | Yes (n=27) | No (n=33) | |
| Male | 17 (63.0) | 19 (57.6) | 36 (60.0) |
| Female | 10 (37.0) | 14 (42.4) | 24 (40.0) |
| Chi-squared value = 0.180 | P- value = 0.672 | | |

Note: Figure in parentheses indicates percentage

Perception of respondents on the basis of educational level and their knowledge on climate change seems significant. Out of all the respondents, 50 percent were illiterate, 43.3 percent were only literate and 6.7 percent of whole respondents hold at least school level education. Out of the whole respondents who said they know about climate change, about 44 percent were illiterate, 41 percent were literate and about 15 percent were above school level where as those who were unknown about climate change, 54.5 percent were illiterate and 45.5 percent were literate and none of the respondents who hold above school level degree said they don't know about climate change and it was significant at 10 percent level significant. About 28 percent respondents told they change their occupation in last 10 years. The respondents among whom they know about climate change, 74.1 percent did not changed the occupation in last 10 years and out of them who told they don't know about climate change, about 70 percent respondents did not change their occupation. Hence, occupation change of the population in last 10 years didn't appear significant on the basis of their knowledge on climate change. Out of total respondents, 40 percent said they have food sufficient for 9-12 months period, 28.3 percent respondents said they have food sufficient for 3-6 months, 20 percent have sufficient food for less than 3 months and 11.7 percent of the total respondents have food sufficient for 6-9 months (Table 3). This difference was also significant between two study groups.

**Table 3. Respondents Occupation change and food sufficiency level in study area**

| Occupation change | Knowledge on climate change | | Total (N=60) |
|---|---|---|---|
| | Yes (n=27) | No (n=33) | |
| Yes | 7(25.9) | 10(30.3) | 17(28.3) |
| No | 20(74.1) | 23 (69.7) | 43 (71.7) |
| Chi square value = 0.14 P value = 0.708 | | | |
| **Food sufficiency level** | | | |
| Upto 3 month | 4(14.8) | 8(24.2) | 12(20) |
| 3-6 months | 7 (25.9) | 10 (30.3) | 17 (28.3) |
| 6-9 months | 1 (3.7) | 6 (18.2) | 7 (11.7) |
| 9-12 months | 15 (55.60) | 9 (27.3) | 24 (40) |
| Chi-squared value = 6.39 *P-value = 0.094 | | | |

Note: Figure in parentheses resemble percentage

**Impact of climate change**

Out of the respondents, 30 percent seems to have stable crop productivity since last 10 years and 30 percent of the respondents perceived increase in crop productivity in the same period. Whereas, about 27 percent perceived decrease in productivity (Table 4). Crop productivity depends on numbers of biotic and abiotic factors. But, the objective of this study was to measure the perceived change in productivity due to change in weather variable over a longer period of time. Climatic factors like temperature, solar radiation, rainfall, relative humidity and wind velocity may influence crop growth and productivity either independently or in combination with each other (Ghimire, 2008). Similar mixed results were also assessed in other studies conducted in different environment. Similar to the findings of this study, Aydinalp & Cresser (2008) also noticed variation in crop productivity as a result of changes in climate and weather events and changes in patterns of pests and diseases. Parry & Rosenzweig (1994) found that the climatic variability and change may have an overall negligible effect on total food production as the regional impacts of climate change are likely to be variable with some regions benefitting from the altered climate and other regions adversely affected. Aydinalp & Cresser (2008) predicted geographical shifts in the land areas suitable for cultivation of key staple crops in response to climate change. According to Khanal (2009), there would be negative impacts in the low altitude crops grown in the Terai and foothills from the rising temperature as the temperature is already high there. Bezabih, Chambwera and Stage (2010) found that despite the projected reduction in agricultural productivity, the negative impacts can potentially be quite limited. This is because the time scales involved and the low starting point of the economy leaves ample time for factor substitutability (i.e. replacing reduced land productivity with increased use of capital and labor) and increased overall productivity. This indicates the policies that give farmers opportunity to invest in autonomous climate adaptation, as well as policies that improve the overall performance of the economy, can be as important for reducing the impacts of climate change in the economy as direct government policies for climate adaptation. Similar results were also obtained in India as assessed from a study for effect of random year-to-year variation in weather on agricultural output using a 40 year district level panel data set covering over 200 Indian districts. The study results suggested that climate change is likely to impose significant costs on the Indian economy unless farmers can quickly recognize and adapt to increasing temperatures. Such rapid adaptation may be less plausible in a developing country, where access to information and capital is limited.

**Table 4. Farmer's perception on level of crop productivity in last 10 years based on Climate change knowledge**

| Trend of crop productivity | Knowledge on climate change | | Total (N=60) |
|---|---|---|---|
| | Yes (n=27) | No (n=33) | |
| Increase | 7(25.9) | 11(33.3) | 18(30) |
| Decrease | 8(29.6) | 8(24.2) | 16(26.7) |
| Stable | 9(33.3) | 9(27.3) | 18(30.0) |
| Don't know | 3 (11.1) | 5(15.2) | 8(13.3) |
| Chi-squared value = 0.797 P-value = 0.850 | | | |

Note: Figure in parentheses indicates percentage

Based on the farmers' perception of change in crop harvesting time, 50 percent respondents didn't know whether they had changed their harvesting time or not due to climate change because its dependent on various reasons like time of seed sowing or transplanting, rainfall and its intensity, seed type used but, about 38 percent respondents feel there was change in harvesting time of crop in last 10 years and about 12 percent said there is no change (Table 5).

**Table 5. Distribution of respondents' perception about change in harvesting period**

| Changes in harvesting period | Knowledge on climate change | | Total (N=60) |
|---|---|---|---|
| | Yes (n=27) | No (n=33) | |
| Change | 12(44.4) | 11(33.33) | 23(38.3) |
| No change | 2 (7.4) | 5 (15.2) | 7 (11.7) |
| Don't know | 13 (48.1) | 17 (51.5) | 30(50.0) |
| Chi-squared value = 1.275 | P-value = 0.529 | | |

Note: Figure in parentheses indicates percentage

**Adaptation practices**

Among all, about 47 percent farmer respondents perceived that they did change in crop variety, 30 percent changed in cropping time, 13.3 percent changed in the field pattern, 6.7 percent changed in crop diversity within field and 3.33 percent farmers applied other methods to adapt effect of climate change in the farm. Among respondents who were knowledgeable on climate change, about 59 percent perceive the changed in crop variety, about 26 percent changed in cropping time, 11 percent changed in the field, 3.7 percent changed in crop diversity and none of them say they applied other methods. Whereas, group of non-knowledgeable on climate change, 36.4 percent changed crop variety, 33.33 percent changed in cropping time, 15.2 changed in the field pattern, 9.1 percent changed crop diversity and 6.1 percent applied other available methods in last ten years (Table 6).

**Table 6. Farmers Perception on effect of climate change on agronomic practices**

| Effect of climate change in farm | Knowledge on climate change | | Total (N=60) |
|---|---|---|---|
| | Yes (n=27) | No (n=33) | |
| Change in crop variety | 16(59.3) | 12(36.4) | 28(46.7) |
| Change in cropping time | 7(25.9) | 11 (33.33) | 18 (30.0) |
| Change in the field pattern | 3 (11.1) | 5 (15.2) | 8 (13.3) |
| Change in crop diversity | 1(3.7) | 3 (9.1) | 4 (6.7) |
| Others | 0(0) | 2 (6.1) | 6 (3.33) |
| Chi-squared value= 4.40 | | P -value = 0.354 | |

Note: Figure in parentheses indicates percentage

According to the survey on adaptation practices of high rainfall, 35 percent respondents have changed crop variety to adapt the high rainfall, 30 percent use other various methods, 13.3 percent use mulching, 15 percent change harvesting time and methods and 6.7 percent used hedge row planting. Among climate knowledgeable respondents, 40.7 percent respondents changed crop variety, 25.9 percent used other mixed methods, 14.8 percent changed harvesting time or methods, 11.1 percent used mulching and 7.4 percent used hedge row planting methods to adapt high rainfall (Table 7). Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (UNFCC, 2009). In the same line, there were some local coping and adaptation strategies adapted by communities in response to potential and observed risks and hazards related to climatic and non-climatic factors in study area.

Adaptation practices refer to actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate (Adger, 2007). Various adaptation measures that deal with climate variability and build upon improved land and water management practices have the potential to create resilience to climate change and to enhance water security (FAO, 2011). According to (CSSA, 2011) understand the physiological, genetic, and molecular basis of adaptation to drought, heat, and biotic stresses likely resulting from climate change; translate new knowledge into new agricultural systems that integrate genetic and management technologies.

In reality at macro-level, a wide variety of programs for the agricultural sector's adaptation to climate change are in effect depending on the national and regional conditions. Adaptation measures are classified into five programs: research and development (crop development, meteorological and climate information system, resource management innovation), government programs and insurance (agricultural subsidies, private insurance, resource management program), agricultural production techniques (agricultural production, land utilization, irrigation, cultivation time control), and financial management for farm households (crop insurance, crop future trading, income stabilization program, household income) (Smit & Skinner, 2002). Farmers in the study area have adopted some of the agronomic adaptation strategies like mulching, hedge row planting, change in crop variety, change in harvesting time and other similar. But, farmers were not aware or unable to adapt about role of financial, technological, research and development of aspects in adaptation to climate change in study area.

**Table 7. Farmers perception on adaptation practices to adopt with high rainfall**

| Adaptation practices | Knowledge on climate change | | Total (N=60) |
|---|---|---|---|
| | Yes | No | |
| Mulching | 3(11.1) | 5 (15.2) | 8 (13.3) |
| Hedge row planting | 2 (7.4) | 6 (6.1) | 4 (6.7) |
| Change in crop variety | 11(40.7) | 10(30.3) | 21(35.0) |
| Change in harvesting time | 4 (14.8) | 5 (15.2) | 9 (15.0) |
| Other | 7 (25.9) | 11 (33.3) | 18 (30.0) |
| Chi-squared value=0.95 | | P- value = 0.916 | |

Note: Figure in parentheses indicates percentage

**Perception on trend of change in climatic variables**

Out of total respondent households, about 37 percent perceived increase in total rainfall in last 10 years and equal number of people reported a decrease in rainfall, but 26.7 percent people perceived no change in rainfall in 10 years. On the basis of their knowledge on climate change, it seems quite significant. Among those who are listed knowledgeable on climate change, 48.1 percent respondent said decrease in total rainfall whereas 22.2 percent perceived increment. On the other hand, among those who are listed non-knowledgeable on climate change, 48.5 percent people perceived there is increase in total rainfall, 27.3 percent thought decrease and 24.2 percent people though it's same in last 10 years. According to the survey, on the perception of the farmers, 66.7 percent told average temperature of the area is increased in last ten years which is followed by 18.3 percent responded that there is decrease whereas 15.0 percent perceived that its same over ten years' time. Similarly, among the total respondents surveyed, 35 percent respondents perceived the increase in rainfall intensity in the area in last 10 years where as 38 percent though there is decrease in rainfall intensity and 26.7 percent people though its same.

**Table 8. Farmers' perception on trend of total rainfall, rainfall intensity and temperature**

| Climatic variables | Total rainfall | Knowledge on climate change | | Total (N=60) |
|---|---|---|---|---|
| | | Yes (n=27) | No(n=33) | |
| Total rainfall | Increase | 6 (22.2) | 16 (48.5) | 22 (36.7) |
| | Decrease | 13 (48.1) | 9(27.3) | 22 (36.7) |
| | Same | 8 (29.6) | 8 (24.2) | 16 (26.7) |
| | Chi- squared value = 4.72 * | | P- value = 0.09 | |
| Change in average temperature | Increase | 20 (74.1) | 20 (60.6) | 40 (66.7) |
| | Decrease | 4 (14.8) | 7 (21.2) | 11 (18.3) |
| | Same | 3 (11.1) | 6 (18.2) | 9 (15.0) |
| | Chi Square Value = 1.23 | | P value = 0.541 | |
| Rainfall intensity | Increase | 7 (25.9 ) | 14 (4.4) | 21 (35) |
| | Decrease | 12 (44.4) | 11 (33.3) | 23(38.3) |
| | Same | 8(29.6) | 8 (24.2) | 16 (26.7) |
| | Chi-squared value=1.79 | | P- value= 0.408 | |

Note: Figure in parentheses indicates percentage

Among the respondents surveyed, 38.3 percent perceived there is decrease in flood, 28.3 percent thought there is increase in flood frequency, 16.7 percent though it's same and again 16.7 percent people thought they were unaware about flood frequency. On the basis of their climate change knowledge, their perception of flood frequency was insignificant. Among studied respondents, 51.7 percent people though there is increase in drought frequency and 31.7 percent people thought it's decreasing in last ten years. Similar perception was seen in the drought severity in that area. Perception of respondents on drought on the basis of climate change knowledge seems insignificant.

**Table 9. Farmers perception on flood frequency and drought in study area**

| Climatic variables | Types of change | Knowledge on climate change | | Total (N=60) |
|---|---|---|---|---|
| | | Yes (n=27) | No(n=33) | |
| Flood frequency | Increase | 6 (22.2) | 11 (33.3) | 17 (28.3) |
| | Decrease | 12 (44.4) | 11 (33.3) | 23 (38.3) |
| | Same | 5 (18.5) | 5 (15.2) | 10 (16.7) |
| | Don't know | 4 (14.8) | 6 (18.2) | 10 (16.7) |
| | Chi-squared value = 1.327 | | P- value = 0.723 | |
| Drought frequency | Increase | 12 (44.4) | 19 (57.6) | 31 (51.7) |
| | Decrease | 10 (37) | 9 (27.3) | 19 (31.7) |
| | Same | 3 (11.1) | 1 (3.0) | 4 (6.7) |
| | Don't know | 2 (7.4) | 4 (12.1) | 6 (10.0) |
| | Chi-squared value= 2.72 | | P-value = 0.436 | |
| Drought severity | Increase | 12 (44.4) | 18 (54.5) | 30(50) |
| | Decrease | 8 (29.6) | 9 (27.3) | 17(28.3) |
| | Same | 4 (14.8) | 1 (3.0) | 5 (8.3) |
| | Don't know | 3(11.1) | 5 (15.2) | 8 (13.3) |
| | Chi-squared value= 2.98 | | P-value = 0.39 | |

Note: Figure in parentheses indicates percentage

According to research findings, 38.3 percent people perceived decrease in hail storm frequency and 33.3 percent thought there is increase in hail storm frequency in study area. On hail storm severity, 33.33 percent people though its increasing, 40 percent though its decreasing and 20 percent thought it's same in last 10 years. Perception on hail storm frequency and its severity on the basis of climate change knowledge seems in-significant as given in Table 10. Among the respondents surveyed, 51.7 percent thought there is decrease in dew frequency and 26.7 said it's same in last 10 years. In case of dew severity, 50 percent of respondents though its decrease in dew severity and 26.7 percent thought it's same in last 10 years. Perception on dew frequency and severity on the basis of climate change knowledge is not significant.

**Table 10. Farmers' perception on hailstorm and dew in study area**

| Climatic variables | Type of change | Knowledge on climate change | |
|---|---|---|---|
| | | Yes (n=27) | No(n=33) |
| Hailstorm frequency | Increase | 11( 40.7) | 9 (27.3) |
| | Decrease | 10 (37.0) | 13 (39.4) |
| | Same | 4 (14.8) | 10 (30.3) |
| | Don't know | 2 ( 9.4) | 1 (3.0) |
| | Chi-squared value=2.92 | | P- value=0.403 |
| Hailstorm severity | Increase | 11 (40.7) | 9 (27.3) |
| | Decrease | 10 (37.0) | 14 (42.4) |
| | Same | 4 ( 14.8) | 8 (24.2) |
| | Don't know | 2 (7.4) | 2 (6.1) |
| | Chi-squared value=1.61 | | P- value=0.656 |
| Dew frequency | Increase | 4 (14.8) | 5 (15.2) |
| | Decrease | 15 ( 55.0) | 16 (48.5) |
| | Same | 7 (25.9) | 9 (27.3) |
| | Don't know | 1 (3.7) | 3 (9.1) |
| | Chi-squared value = 0.801 | | P -value= 0.849 |
| Dew severity | Increase | 5 (18.5) | 6 (18.2) |
| | Decrease | 14 (51.9) | 16 (48.5) |
| | Same | 7 (25.9) | 9 (27.3) |
| | Don't know | 1 (3.7) | 2 (6.1) |
| | Chi-squared value= 0.12 | | P- value = 0.976 |

One of the major problems due to climate change is low rainfall which is being copied by farmers with different methods in the research sites. Among the respondents, 28.3 percent used mulching, 13.3 percent used change in variety, 10 percent use change in crop, 3.3 percent used drip irrigation and 45 percent used other mixed methods to cope low rainfall.

**Table 11. Distribution of respondents adopting adaptation strategies for low rainfall in study area**

| How to adapt low rainfall | Knowledge on climate change | | Total (N=60) |
|---|---|---|---|
| | Yes (n=27) | No(n=33) | |
| Drip | 1 (3.7) | 1 (3.0) | 2 (3.3) |
| Mulching | 6 ( 22.2) | 11 (33.3) | 17 (28.3) |
| Change in variety | 5 (18.5) | 3 (9.1) | 8 (13.3) |
| Change in crop | 3 (11.1) | 3 (9.1) | 6 (10.0) |
| Other | 12 (44.4) | 15 (45.5) | 27 (45.0) |
| Chi-squared value= 1.72 | | P-value = 0.787 | |

Note: Figure in parentheses indicates percentage

Climate change has been observed in Nepal in varying level of climates that are prevalent in diversified topography and vegetation. There are impacts of climate changes in Terai (almost tropical region), mid-hills and valley (subtropical region), and mountains and the Himalaya (temperate and tundra regions) of Nepal. A country like Nepal could not explain more than this as the impact of climate changes in the Himalayan region. Because of climate change it is reported untimely start of monsoonal rainfall that resulted rain deficit in the eastern Terai lowlands in 2005/06, reducing crop production by 12.5% nationwide (Malla, 2008). In agriculture, about 10% of agricultural land was left fallow due to rain deficit on the one hand, while on the other hand in the mid- western Terai faced heavy rain with floods, which reduced crop production by 30% (Regmi, 2007).

**Impact of adaptation strategies on crop productivity**

About 50 percent respondents perceived that different adaptation practices used help to increase productivity, 30 percent said it's same and 20 percent didn't know about it or unaware about that. On the basis of knowledge on climate change, among those who said they did know about climate change, 63 percent realized increase in production due to adaptation practices, and 37 percent perceived it remaining same. Among climate non-knowledgeable respondents, 39 percent said there is increase in production due to adaptation practices, 36.4 said they didn't know and 24.2 percent said production remained same in last 10 years though different adaptation practices applied (Table 12).

**Table 12. Effect of adaptation practices on productivity in study area**

| Effect of adaptation practices | Knowledge on climate change | | Total (N=60) |
|---|---|---|---|
| | Yes (n=27) | No(n=33) | |
| Increase | 17(63) | 13 (39) | 30 (50) |
| Remain same | 10 (37) | 8 (24.2) | 18 (30.0) |
| Don't know | 0 (0) | 12 (36.4) | 12 (20.0) |
| Chi squared value = 12.23 ** P-value= 0.2 | | | |

Note: Figure in parentheses indicates percentage

## CONCLUSION

Findings of this study revealed about the existing condition of climate change and its effect on ecosystem, agriculture, and ultimately to people's livelihood in the hilly region of Makawanpur. The effect of climate change is increasing day by day. It is well perceived that location specific studies are essential for particular sector and communities and there is an urgent need to find out the effective adaptation strategies. Thus, there is strong need to enhance understanding on impacts of climate change on agriculture. Studying about the local people and their way of cropping system is also helpful to conserve the indigenous crops and agro-biodiversity. Effect of climate change in last ten years clearly revealed the change in agro-biodiversity and productivity. On the other hand level of production was not severely affected in last ten years mainly due to the adaptation practices against climate change. Introduction of new varieties, developing more irrigation facilities and other relevant climate smart technologies are suggested to generate and adapt practices against climate change for the promotion of livelihoods of farming communities inhabiting in the mountains.

## ACKNOWLEDGEMENTS

This research was funded by DOREX, AFU.

## REFERENCES

ADB. (2009). *Nepal Climate Change Assessment Report*, Asian development Bank, Manila, Philippines.

Adger, W. N. (2001). Scales of governance and environmental justice for adaptation and mitigation of climate change. *Journal of International Development, 13,* 921-931.

Aydinalp, C. and M. S. Cresser. (2008). The effects of global climate change on agriculture. American-Eurasian Journal of Agriculture & Environmental Sciences. 3(5), 672-676.

Bezabih, M. Chambwera, M., & Stage, J. (2010). Climate Change, Total Factor Productivity, and the Tanzanian Economy – A Computable General Equilibrium Analysis. Environment for Development. *Resources for the Future, Discussion Paper Series, June, EfD DP 10-14.*

CSSA. (2011). *Position Statement on Crop Adaptation to Climate Change*. Crop Science Society of America, Madison, WI.

FAO. (2011). FAOSTAT. *Available at http://faostat.fao.org/ site/339/default.aspx* (verified 9 June. 2011). FAO, Rome, Italy.

Ghimire, R. (2008). Resilience of community to climate change through adoption of sloping agriculture land technology and eco-friendly agriculture in Jugedi Khola watershed, Nepal. Geographic Studies and Environment Protection Research. 7: 208-215.

IPCC. (2007). *Climate Change 2007: Impact, adaptations and vulnerability*. The working group II contribution to the Inter-governmental panel on climate change fourth assessment report. Cambridge university press. Cambridge, UK.

IPCC. (2014). *Climate Change 2014: Synthesis Report*. Contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

Khanal, C. R. (2009). Climate change and organic agriculture. *Journal of Agriculture and Environment*, 10:102-104.

LFP. (2010). Participatory tool and technique for assessing climate change impacts and exploring adaptation option: community best tool kit for practitioner, livelihood and forestry programme (LFP), Kathmandu, Nepal.

Lieu, X. & B. Chen. (2000). Climate warming in the Tibetan Plateau during recent decades. *International Journal of Climatology* 20: 1729-1742.

Malla, G. (2007). *Climate change and its impact on agriculture sector in Nepal*. Climate change and human health: Potential impact, vulnerability and adaptation in Nepal.

Malla, G. (2008). Climate Change and Impact on Nepalese Agriculture. *Journal of Agriculture and Environment, Review Paper*.

Porter, J. H., M. L. Parry & T. R. Carter. (1991). The potential effects of climatic change on agricultural insect pests. *Agriculture, Forestry and Meteorology* 57: 221-240.

Rosenzweig, C. and M. C. Parry. (1994). Potential impact of climate change on world food supply. Nature, 367: 133-138. (Available at: www.nature.com/ articles/367133a0).

Rosenzweig, C., A. Iglesias, X. B. Yang, P. R. Epstein & E. Chivian. (2001). Climate change and extreme weather events: Implications for food production, plant diseases, and pests. *Global Change and Human Health* 2: 90-104.

Sharma, R. J. & N. M. Shakya. (2006). Hydrological changes and its impact on water resources of Bagmati watershed, Nepal. *Journal of Hydrology* 327: 315-322.

Shrestha, A. B., C. P. Wake, P. A. Mayewski & J. E. Dibb. (1999). Maximum temperature and trends in the Himalaya and its vicinity: An analysis based on temperature records from Nepal from period 1971-94. *Journal of Climate* 12: 2775-2787.

Singh, B.K., Bardgett, R.D., Smith, P., & Reay, D.S. (2010) Microorganisms and climate change: terrestrial feedbacks and mitigation options. *Nature Rev* 8:779-790.

Smith, B., Burton. I., Klein, R. J. T., & Street, R. (1999).*The science of adaptation: framework for assessment mitigation.* Adaptation strategies for climate change, 4: 1299-213.

Synnott, P. (2012). Climate change, agriculture and food security in Nepal: Developing adaptation strategies and cultivating resilience, Nepal.

UNCTD. (2009). Climate change regime: Developing country interests in climate change action and the implications for a post-2012. United Nations Conference on Trade and Development, Geneva, Switzerland.

UNFCC. (2007). Climate change: impacts, vulnerabilities and adaptation in developing countries. Available online at: www.unfccc.int/files/essential_background/ background_publications_htmlpdf/ application/txt/pub_07_impacts.pdf Retrieved on 12 December 2015.

UNFCC. (2009). *Climate change: Impacts, vulnerabilities & adaptation in developing countries.* Retrieved from UNFCC: Climate Change Regime