International Journal of Biological Innovations

Available online: http://ijbi.org.in | http://www.gesa.org.in/journals.php

DOI: https://doi.org/10.46505/IJBI.2020.2107

Research Article

E-ISSN: 2582-1032

CLIMATE CHANGE AND PRACTICES OF FARMERS' TO MAINTAIN RICE YIELD: A CASE STUDY

Amar Chandra Mandal and Om Prakash Singh*

Department of Agricultural Extension
Agriculture and Forestry University, Nepal
**Corresponding author:* opsingh@afu.edu.np

Received: 25.04.2020 Accepted: 18.05.2020 Published: 21.05.2020

Abstract: A survey was conducted during December 2019 to March 2020 in the Siraha district of Nepal to assess farmers' perception on climate change and identifications of local practices to maintain the yield of rice production. Total 60 samples were purposively selected from the study site. During interaction and interview, the opinion of 75- 80% formers was that temperature increases, rainfall duration and its frequency decreases due to the global warming. About 33.33% farmers experience was an increase in flooding hazard due to increase in rainfall intensity during the rainy season in Siraha and its vicinity. The majority of respondents perceived increased in weed and pest (65%) and new weed (30%) and new pest (26.7%) infestation due to climate change. About 18% respondents had a clear knowledge of climate change. The major source of information was self-experiences (80%) and organization (20%). The major climate change adaptation practices adopted by farmers were the use of drought-resistant varieties (11.67%), flood-resistant varieties (13.33%) and early maturing crops (15%). Crop insurance is one of the adaptation practices to climate change. The study showed that 63.33 % of the respondents know about crop insurance policy but none of the respondents have done crop insurance on different crops. The increase in disease and pest infestation is major problems of farmers. The focus group discussion and key informant study showed that the farmers were positive to adopt climate change adaptation strategies. So, Government and policymakers should focus on climate-resilient adaptation strategies formulation for rice cultivation through intensive research and extension package. Adoption of different resistant varieties and technological adoption like zero tillage, application of irrigation, and training related to adoption techniques should be done.

Keywords: Climate change, Global warming, Perception, Rainfall, Rice production.

INTRODUCTION

Climate change and global warming are a great concern of today as they affect the natural ecosystem. Climate change refers to variations in the global climate or regional climate over a long time period. Increase in concentration of greenhouse gases (GHGs) mainly CO2, N2O and CH4 in the atmosphere due to natural as well as

anthropogenic factors is causing climate change (IPCC, 2007) affecting both the sustainable and unsustainable agriculture, ecological balance, human health and survival, forestry, widespread biodiversity, aquatic, terrestrial and mountain ecosystem which has been burning issue of discussion and debate in recent decades. Humans should understand the levels and values of biodiversity (Verma 2016) as the genetic diversity acts as buffer in biodiversity (Verma 2017a). There is a necessity of ecological balance for widespread biodiversity (Verma 2017b). Unsustainable agriculture has multiple effects (Verma 2017c) and disturbs the ecological balance (Verma 2018a). The ecological balance is an indispensable need for human survival (Verma 2018b).

Exponential increase in carbon dioxide (CO2) concentration, which contributes more than 80% of total GHG emission, causes greenhouse effects (Mala, 2008). Nepal's contribution to the global GHG emission is 0.025% (Oli and Shrestha, 2009). Climate change is an emerging environmental challenge, which has been considered through several basic indicators such as increased temperature, variability and uncertainty of precipitation. Extreme weather condition such as heat waves, drought, floods, erratic and inconsistent rainfall, change in crop production pattern, rise in sea level, polar ice and glacier melting, increase in an infestation of disease and pest are some of the incidences likely to happen due to climate change (IPCC, 2007). An impact on the environment due to the present shutdown to break the spread-chain of COVID-19 pandemic is not the sustainable approach because it is short term change.

Climate is one of the major determinants for agricultural production and productivity. Temperature, solar radiation, rainfall, soil moisture, and CO2 concentration are all important climatic variables that determine agricultural productivity. It is a major concern about the impact of climate change on the agricultural system as agriculture is highly vulnerable to climate change, which is a more complex and not linear relationship. The impact of climate change as witnessed in recent times has adversely affected agriculture in various ways. The inclusive and sustainable development cannot be achieved without focusing on agriculture sector. The sustainable development has direct relation with environmental ethics (Verma, 2019). Sometimes, environmental ethics need to be redefined (Verma, 2017d). Higher temperature beyond optimum range eventually reduce crop yield due to higher respiration and increased developmental rates while encouraging the proliferation of disease, pest, and weed. The atmospheric temperature in Nepal has increased by 1.8°C during the last 30 years from 1975 to 2006 (Synnott, 2012) and the average temperature increased by 0.06°C per annum (Maraseni, 2012) variation and uncertainty of rainfall increase lead to crop failure. Moreover, the overall climate change impact on the agriculture sector is expected to be negative even though there may be a positive effect on some crops in some regions of the world, threatening global food security (Mala, 2008).

Nepal is a small mountainous landlocked country of South Asia with an area of 147, 181 sq km. It is the fourth most vulnerable country for climate change according to new Climate Change Vulnerability Index (CCVI) (Maplecroft, 2010). About 1.9 million people are vulnerable and 10 million exposed to increased risk due to climate change in Nepal (MoE, 2010). Nepal is an agrarian country and the contribution of the agriculture sector to the Nepalese economy has been noteworthy. The agriculture sector accounts for 33% of total Gross Domestic Product (GDP) and 65.6% of Nepal's population is engaged in agriculture (MoAD, 2012). It is largely rain-fed and over 50% of Nepalese farmers are smallholders cultivating less than 0.5 ha (CBS, 2011). Rice is the major and most prestigious food crop in Nepal. It is grown in a diverse environment from the tropical plain region to the foot of the mountain up to the highest elevation (3050 msl). It contributes nearly 20 % of the agricultural gross domestic product (AGDP) and provides more than 50 % of the total calorie requirement of the Nepalese people (MoAD, 2014).

The objective of this study was to assess the changes in climatic variables like temperature, rainfall, water recharge/precipitation, farmers' perception of climate change and identifications of local practices to maintain the yield of rice production in changing climatic condition also in Siraha, Nepal.

MATERIALS AND METHODS

Primary data were collected from a field survey of a sample size of 60 households. The households were selected randomly and triangulated the data conducting one Focus Group Discussion (FGD) in each village also verified by KII (Key Informant Interview/Survey) with District Agriculture Development Office (DADO), ASC (Agriculture Service Centre) and personnel. The collected data were coded, tabulated and analyzed by using Statistical Package for Social Science (SPSS), MS Excel and STATA.

Primary data were collected by administering the questionnaire survey, focus group discussion, key informant interview, and direct observation. Secondary data related to climate were obtained from DHM, data related to rice production obtained from DoA, DADO of Siraha.

RESULTS AND DISCUSSION

(A) Socio-economic and demographic information of the respondents:

Population characteristics of respondents by age group:

Identification of the respondents according to the age group is very important because old age persons have more felt experience about climate change trends and they are the better source of the required information. In this study, out of the 60 respondents, 37(61.67%) majority was in the range of 35-60 years followed by the age group below 35 (33.33%) and above 60 years (5%) as shown in Table 1.

Table1: Distribution of respondent by age group.

Age group	Frequency	Percent
Below 35	20	33.33
35-60	37	61.67
Above 60	3	5
Total	60	100

Sex of the respondents:

Most of the respondents of this study were males (65%) and 35% were females. Details are shown below in Table 2.

Table 2: Distribution of respondents by sex.

Sex of respondent	Frequency	Percent
Female	21	35
Male	39	65
Total	60	100

The educational level of respondents:

Education plays a vital role in the socio-cultural and economic changes in society. To assess the educational status of respondents, it has been grouped in five categories, as illiterate (who cannot read and write), literate (who gain informal education and can only read and write), secondary (up to ten), higher secondary (up to twelve) and graduate/university level. Most of the

respondents were found to be illiterate (35%) followed by secondary and higher secondary (21.67%), literate (18.33%), and university (3.33%) as shown in Table 3. Educated people can get many ideas from other places of the same situation, which could be internalized in their own climatic situation.

Table 3: Distribution of respondents by education level.

Education level	Frequency	Percent
Illiterate	21	35
Literate	11	18.33
Secondary	13	21.67
Higher secondary	13	21.67
University	2	3.33
Total	60	100

(B) Household and farm characteristics in the study area:

Ethnicity of the respondent's household:
These households were categorized into two categories such as indigenous/ ethnic/Janajati and Yadav. The majority of the respondents were Yadav followed by Aadibasi/Janajati. Out of 60 respondents, 58.33% were Yadav followed by 41.67% Aadibasi/Janajati. The distribution of respondents in the study area is presented in Table 4.

Table 4: Distribution of survey household by ethnicity.

Ethnicity	Frequency	Percent
Indigenous/ ethnic, Janajati	25	41.67
Yadav	35	58.33
Total	60	100

Primary occupation of the respondent:
Occupation of local community people reflect the nature of micro-economy of any locality and various commercial, business as well as employment opportunity in the area and also determines the well-being of living standard. The table below shows that majority of the households' primary occupation was agriculture (66.67%) followed by remittance (28.33). The percentage of households involved in the business was 3.33% followed by services 1.67% as shown in Table 5.

Table 5: Primary occupation of the household.

Occupation	Frequency	Percent
Agriculture	40	66.67
Business	2	3.33
Services	1	1.67
Remittances	17	28.33
Total	60	100

Distribution of economically active population:
The age of the family members was categorized into three classes *namely*, less than 15 years, 15 to 60 years (economically active population) and more than 60 years as shown in Table 6. It was found that the majority of the respondents (49.65%) were in an economically active age group.

Table 6: Distribution of surveyed household population by age group.

Age group	Frequency	Percent
< 15	176	41.6
15 – 60	210	49.65
> 60	37	8.75
Total	423	100

Average size of land holding and rice land holding:
The average size of landholding was 1.417 ha in the study area (Table 7) with a minimum of 0.167 ha and a maximum of 3.33 ha in total and the average size of rice cultivating land was 1.21 ha with minimum of 0.167 ha and maximum of 2.67 ha in total.

Table 7: Average size of land holding of respondents.

Land holding (ha)	Minimum	Maximum	Mean
Total cultivated land area	0.167	3.33	1.417
Total rice cultivated land area	0.167	2.67	1.21

(C) Farmer's perception of climate change:
Awareness of respondent on climate change in the study area: The frequency of extreme weather events such as drought, flooding, heat stress, landslide, hailstorm, and snow fall has been increasing (MoPE, 2004). As per this study, 3.33 percentages of the respondents found more clearly aware of climate change, 15 % of respondents clearly and 81.67 % had little knowledge of climate change as shown in Table 8.

Table 8: Awareness of respondents of the study area on climate change.

Awareness	Frequency	Percent
More clearly	2	3.33
Clearly	9	15
A little bit	49	81.67
Total	60	100

Source of information:
During the assessment, farmers' expressed their response about climate change, directly and indirectly, they relate it with their past experience, feeling and knowledge on rainfall, pattern, temperature and drought as compared to past. Respondents obtained information and experience on climate change by media (43.43%) followed by self-experience (36.36%), from local leaders and neighbors (13.13%) and organization (7.07%) as shown in Figure 1.

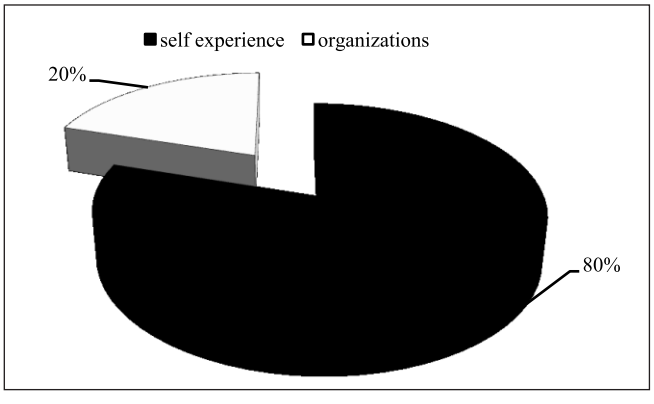

Figure 1: Source of information on climate change.

Perception of changing temperature and rainfall: There is a gradual increase in atmospheric temperature in different ecological zones of the Eastern development region of Nepal (Manandhar, 2009). Most of the respondents (86.7%) felt the increase in temperature as compared to the past 10 years. 93.33% of the respondents felt the increase in hotter days as shown in table 9.

Table 9: Change in microclimate as perceived by respondents.

Response	Increased	Decreased	Not felt
Temperature	52 (86.7)	0	8 (13.6)
Rainfall frequency	0	46 (76.67)	14 (23.33)
Rainfall duration	3 (5)	48 (80)	9 (15)
Rainfall intensity	47 (78.33)	1 (1.67)	12 (20)
Flooding frequency	20 (33.33)	7 (11.67)	33 (55)
Flooding intensity	23 (38.33)	3 (5)	34 (56.67)
Hotter days	56 (93.33)	1 (1.67)	3 (5)
Source of recharge	0	53 (88.33)	7 (11.67)

Figures in the parenthesis indicate percentage.

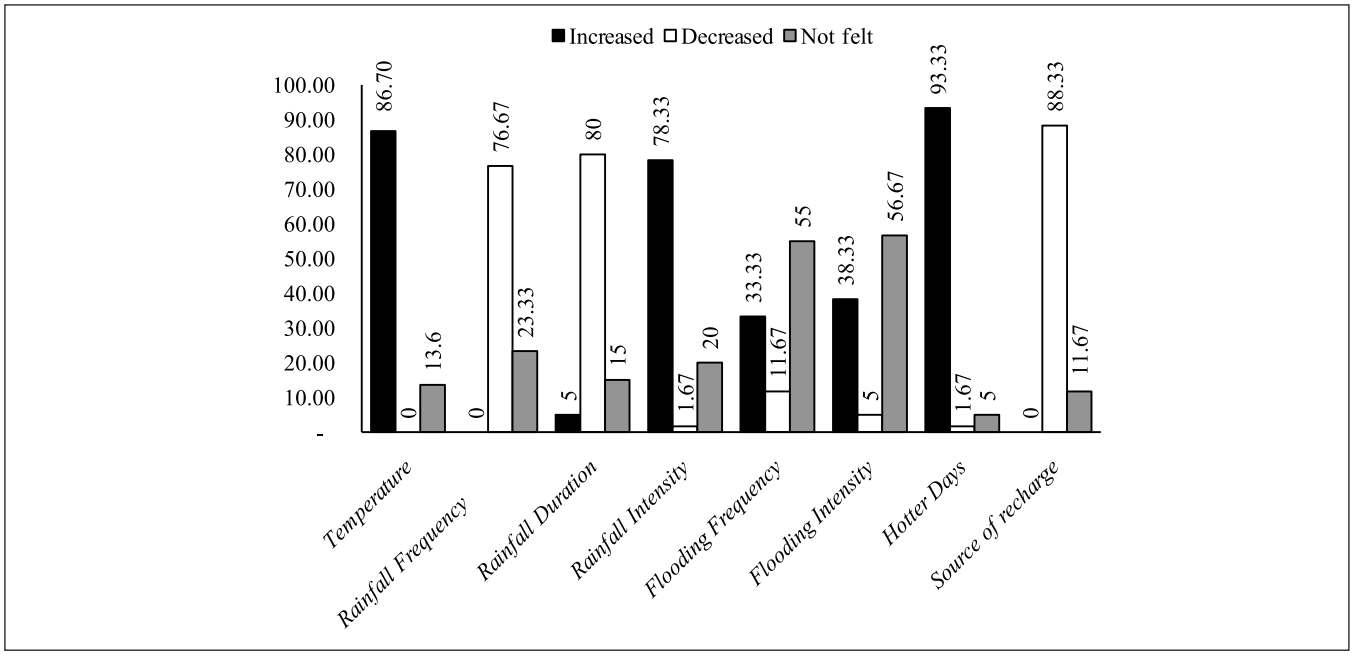

Figure 2: Respondent perception on microclimate in the study area

Farmers under study perceived that there was a decrease in precipitation as compared to the past 10 years. The majority (76.67%) of respondents reported a decline in rainfall frequency, rainfall duration (80%) but increased rainfall intensity (78.33%). However, 33.33% of respondents experience increased in frequency of flood as compared to the past 10 years in the study area whereas, 55% of respondents did not felt flood problems in their area because of being higher ground level in the vicinity of the study area as shown in Figure 2. An increase in heavy rainfall generally found to be occurring in most places, even when mean precipitation is not increasing (Trenberth, 2011).

Perception on the occurrence of climatic hazards (Risk):

The study explored that the drought hazard experienced more (95%) in the study area

followed by floods (55%). Flood hazard is the same in the area of 40% of respondents as they did not experience flood problem because of being comparatively high altitude of the landscape (Table 10).

Table 10: Respondents perception on climatic hazards.

Climatic hazards (risk)	Respondents perception	
Flood hazards (risk)	Increased	33 (55)
	Decreased	3 (5)
	Same	24 (40)
	Increased	57 (95)
Drought hazards (risk)	Decreased	0
	Same	3 (5)

Figures in the parenthesis indicate percentage

Respondent's experience on rice cultivation practices as compared to the past ten year and present time:

Cultivation practices of rice experienced by farmers can be used to evaluate both climatic and non-climate factors affecting the production and productivity of rice. Comparing the experience of farmers on rice transplanting and harvesting time, drought duration, insect pest infestation, weed infestation, and yield variation ten years ago before and now is found to be changing. All of the respondents (100%) had transplanted rice 3-4 weeks later than previous due to the absence of irrigation facilities and 90% of respondents accepted that its harvesting time too has been shifted late than before. While only 10% response came that it's harvesting time is the same due to the substitution of early maturating rice varieties. However, one very interesting and contradictory result came in existence through this study that despite all odds of appearing present climatic situation, 78.3% of respondents revealed that the yield is maintained or increased than past 10 years. This might be due to the use of quality seed, improved varieties and better cultural practices. The study revealed that 65% of the respondents experienced higher weed and insect pest infestation and 30% experienced new weed and 26.7% experienced new pest infestation as shown in Table 11.

Table 11: Respondents experience on rice cultivation practices comparing before ten years and now.

Rice cultivation practices as compared to before 10 years	Respondents experience	Total
Transplanting time	Earlier Late Same	0 60 (100)
Harvesting time	Earlier Late Same	 54 (90) 6 (10)
Rice yield	Higher Low Same	47 (78.3) 3 (5) 10 (16.7)
Weed infestation	Higher Lower	39 (65) 3 (5)
Pest infestation	New Higher Lower. New	18 (30) 39 (65) 5 (8.3) 16 (26.7)

Figures in the parenthesis indicate percentage

Farmers' adaptation practices to changing climate on rice production:

A majority (76.67%) of the respondents used improved rice variety Sonamansuli followed by Lalka basmati 20%. The study found an increase in disease, pest and weed infestation in the present context as compared to past ten years (DADO). Farmers of study area just started adopting different drought-resistant, flood-resistant rice varieties to cope with the climate change adversities. Regarding intervention of new initiative by the farmers themselves to fight against climatic change conditions, about 11.67 percent of farmers used drought resistant rice variety Sukkha dhan-3. About 13.33 percent farmers use flood resistant variety; Swarna sub-1, and 15% use early maturing rice variety Hardinath-1. The study showed that 100 percent of the respondents practiced manual methods of weed control and chemical method for pest control. About 17% of respondents have used green manuring in their field and 15% have used DSR cultivation method. The study explored that only 63.33% of respondent were acknowledged about crop insurance but none of them have brought in actual practices of crop insurance for any crop or livestock's as shown in Table 12.

Table 12: Farmers adaptation practices on rice production.

Adoption practices	**Respondents experience**	**Total**
Improved variety	Sona Mansuli Lalka Basmati	46 (76.67) 12 (20)
Use of drought resistant variety	No use Sukha-3	53 (88.33) 7 (11.67)
Use of flood tolerant	No use Swarnasub-1	52 (86.67) 8 (13.33)
Use of early maturing	No use Hardinath-1	51 (85) 9 (15)
Weed management	Manually Herbicide Others	60 (100) 0 0
Pest management	Chemical Ipm Organic	60 (100) 0 0
DSR method	Use No use	9 (15) 51 (85)
Use of green manuring crops	Use No use	10 (16.67) 50 (83.33)
Know about crop insurance	Yes No	38 (63.33) 22 (36.67)

Figures in the parenthesis indicate percentage

Changes in rice varieties in the study area:

Local landraces of many crops were lost in the study area. Farmers said that they had lost the long duration rice varieties. The long duration rice varieties require longer vegetative growth period for obtaining a good yield, due to the late onset of monsoon they were not able to transplant the rice variety on right time and in the later stage of crop growth there was no adequate moisture in the field which consequently leads to lower crop yield. Farmers recognized that local landraces varieties were more susceptible to disease insect and had low productivity. Farmers adopted improved crop varieties instead of local landraces to obtain more yield (Table 13).

Table 13: Different varieties of rice used in the study area.

Before 10 years		Present	
Local landraces	**Improved and hybrid**	**Local landraces**	**Hybrid and improved**
Kariyakamod	Sona Mansuli	Basmati	Sonamansuli
Jasawa	KanchiMansuli	Kariyakamod	Sukha rice-3
Palasha	Jira Mansuli	Harinakker	Lalka basmati
Harinakker	Ramdhan		Sabitri
Khemati	Mansuli		Hardinath-1
Ghusari	Rambilash		Ramdhan
Basmati	Sabitri		Swarnasub-1
Latsar	Rampur mansuli		Radha-4
Ghumakheraha	Radha		Kanchimansuli
	Parwal		

According to farmers, there are various reasons behind the change in rice varieties. Farmers have started to cultivate different varieties due to their different varietal characteristics. Some of the farmers said that they started to cultivate hybrid varieties for its better yield; even it requires more water and fertilizers. Farmers of the study area reported that the rice variety Sonamansuli has a short stem which is enough to withstand water pressure during the flood. Radha-4 was cultivated in own land as it requires less water and to some extent; it is drought tolerant rice variety. Some of the farmers in the study area have started to cultivate drought tolerant rice variety Sukha dhan-3, flood tolerant variety swarnasub-1 and early maturing variety Hardinath-1.

CONCLUSION

Most of the farmers in the study area perceived climate change; explicitly in terms of change in rainfall pattern, rainfall duration, rainfall intensity, rainfall frequency, the commencement of monsoon, increase in climatic hazard and summer temperature in terms of warmness. Commonly, drought led to low crop yield, especially in the rain-fed rice farming system. The recurring flood causing damage and loss of standing rice crop in the field itself by burring due to soil sedimentation and an increase in pest infestation.

The present study was carried out to assess the farmers' perception of climate change and identification of local practices to balance the rice yield in the response of changing climate. Agriculture including livestock was a major occupation of the household. Most of the respondents had only a little awareness of climate change and the majority source of information was from their self-experience. There were increasing trends of disease and pest infestation assessed as perceived by farmers. The increase in disease, pest infestation is a major problem for farmers. The variation in precipitation in the study area causes flood and drought occurred during rice production leads to a reduction in production.

Farmers were practicing and counting it through different coping and adaptation strategies in their farm based experiences. But there should be the promotion of local and indigenous adaptation practices followed by farmers with the use of local skills and resources which are economically feasible ecologically sound and environmentally acceptable. A change in climatic condition was affecting the crop rotation and normal cropping calendar as compared to the past by the farmers. Changes in cropping calendar hinder the crop growth leading poor yields. Farmers used a range of adaptation strategies to cope and adapt to climate effects. The strategies used for adaptation included afforestation, change in planting dates, switching to irrigation farming, construction of irrigation channel, plastic pond, water harvesting tank, practicing mulching, shifting to the

cropping system, crop diversification and engagement in non-farming activities. Despite being willing to use the coping and adaptation strategies, most of the smallholder farmers faced challenges such as lack of capital, adaptation knowledge and water for irrigation, when trying to adopt the adaptation strategies.

REFERENCES

1. **CBS** (2011). Statistical year book Nepal. Central Bureau of Statistics, National Planning Commission, Kathmandu, Nepal.
2. **IPCC** (2007). Climate Change 2007: Solomon S. D., Qin M., Manning Z., Chen M., Marquis K., Averyt M., Tignor and Miller H.L. (eds.). The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 996p.
3. **Malla G.** (2008). Climate change and its impact on Nepalese agriculture. *The Journal of Nepalese Agriculture*. 9(1): 62-71.
4. **Manandhar S.** (2009). Perception and adaptation to climate change by farmers in different ecological zones of the western development region of Nepal. Thesis, M.Sc. Asian Institute of Technology (AIT), School of Environment Resources and Development, Thailand.
5. **Maplecroft** (2010). Big economies of the future - Bangladesh, India, Philippines, Vietnam and Pakistan-most at risk from climate change www.maplecroft.com
6. **Maraseni T.N.** (2012). Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal. *Environmental science & policy*. 21: 24-34.
7. **MoAD** (2012). Statistical Information on Nepalese Agriculture (2011/2012), Government of Nepal, Ministry of Agricultural Development, Agri-Business Promotion and Statistics Section, Singha Durbar, Kathmandu, Nepal.\
8. **MoAD** (2014). Statistical Information on Nepalese Agriculture (2013/2014), Government of Nepal, Ministry of Agricultural Development, Agri-Business Promotion and Statistics Section, Singha Durbar, Kathmandu, Nepal.
9. **MoE** (2010). National Adaptation Programme of Action (NAPA). Government of Nepal, Ministry of Environment, Singha Darbar, Kathmandu.
10. **MoPE** (2004). Initial National Communication to the Conference of Convention on Climate Change, Ministry of Population and Environment, Kathmandu.
11. **Oli B.N. and Shrestha Kumud** (2009). Carbon Status in Forests of Nepal: An Overview. *Journal of Forest and Livelihood*. 8(1):62-66.
12. **Synnott P.** (2012). Developing Adaptation Strategies and Cultivating Resilience, Report prepared for Mercy Corps Nepal.
13. **Trenberth K.E.** (2011). Changes in precipitation with climate change. *Climate Research*. 47(1-2): 123-138.
14. **Verma A.K.** (2016): Biodiversity: Its Different Levels and Values. *International Journal on Environmental Sciences*. 7(2): 143-145.
15. **Verma A.K.** (2017a): Genetic Diversity as Buffer in Biodiversity. *Indian Journal of Biology*. 4(1): 61-63. DOI: http://dx.doi.org/10.21088/ijb.2394.1391.4117.9
16. **Verma A.K.** (2017b): Necessity of Ecological Balance for Widespread Biodiversity. *Indian Journal of Biology*. 4(2): 158-160. DOI: http://dx.doi.org/10.21088/ijb.2394.1391.4217.15.
17. **Verma A.K.** (2017c). Multiple effects of Unsustainable Agriculture. *International Journal on Agricultural Sciences*. 8(1): 24-26.
18. **Verma A.K.** (2017d). Environmental Ethics: Need to Rethink. *International Journal on Environmental Sciences*. 8(1): 7-9.
19. **Verma A.K.** (2018a): Unsustainable Agriculture, Environmental Ethics and Ecological Balance. *HortFlora Research Spectrum*. 7 (3): 239-241.
20. **Verma A.K.** (2018b). Ecological Balance: An Indispensable Need for Human Survival. *Journal of Experimental Zoology India*. 21 (1): 407-409.
21. **Verma A.K.** (2019). Sustainable Development and Environmental Ethics. *International Journal on Environmental Sciences*. 10 (1): 1-5.