Journal of Agricultural Extension and Rural Development Vol. 5(3), pp. 42-49, March 2013
Available online at http:// academicjournals.org/JAERD
DOI: 10.5897/JAERD12.072
ISSN 2141-2154 ©2013 Academic Journals

Full Length Research Paper

Impacts of climate change on marginal community and bio-diversity in Terai, Nepal

R. A. Mandal[1]*, Bechu K. V. Yadav[2], I. C. Dutta[3], P. K. Jha[4], S. B. Karmacharya[5], K. K. Yadav[6], S. Haque[7] and A. Shrestha[8]

[1]Tribhuvan University, Kirtipur, Kathmandu, Nepal.
[2]Department of Forests, Nepal.
[3]TU Service Commission, Nepal
[4]Nepal Agricultural Research Council (NARC), Nepal.
[5]Trichandra College, Nepal.
[6]Food and Agriculture Organization (FAO), Nepal.
[7]Institute of Forestry (IOF), Hetauda, Nepal.
[8]Netherlands Development Organisation, Nepal.

Accepted 12 October, 2012

This paper aims at exploring the impacts of climate change on the marginal communities and the status of silvo-agriculture species. Mahottary district of Nepal was selected for this study in 2012. A pertinent questionnaire was used to determine the impacts of climate change. The key respondents were interviewed and workshops organized at three different levels to triangulate the information. Stratified random sampling was applied to collect the bio-physical data. The results showed a shift in flowering and ripening seasons of agriculture crops. The associate species of *Shorea robusta* were at threat. Those species were abundant in the past, but rarely found nowadays. The values of Shannon Weinner and Simpson indices were 2.53 and 0.86 respectively in 2005 and 2.34 and 0.85 respectively in January, 2012 showing the impacts of climate change on forest species. Bees that make hive on *Bombax ceiba* were not found and the marginal communities were affected. Similarly, Terai indigenous communities and Dalits were found to have been affected because of insufficient fish in the paddy fields. Frogs and storks were scarcely found in the farmlands. Extreme drought, untimely floods and mass-wasting have been damaging the wealth and health in the locality.

Key words: Dalits, Terai indigenous, impacts, climate change, forest biodiversity.

INTRODUCTION

Abundant scientific evidences support that climate change creates very serious risks globally, and it demands an urgent global response to address the issues. United Nations Framework Convention on Climate Change (UNFCCC) was the first important initiative to take actions for stabilizing the issues of climate change (UNFCCC, 1997). The Clean Development Mechanism (CDM) under Kyoto protocol is one of them (Gundimeda, 2004) but it does not include the management of natural forest though it can significantly contribute to reduce emission by about 17.4% through restoring the degraded forest and halting the deforestation as Reducing Emission from Deforestation and Forest Degradation (Bali Roadmap, 2007). Reducing emissions from deforestation and forest degradation (REDD)+ came into existence as an advance resolution in climate change system through forest enhancement (plantation and regeneration management), sustainable management of forests and forest conservation (Skutsch and Van Lakee, 2009).

The Earth could warm by 3°C this century but even with a temperature rise of 1.5 to 2.5°C approximately 20 to 30% of plant and animal species assessed so far are likely to be at increased risk of extinction (Cruz et al.,

*Corresponding author. E-mail: ram.mandal@gmail.com.

2007; Hossain and Marinova, 2010). Climate modeling indicates temperature increases in the Asia/Pacific region in the order of 0.5 to 2°C by 2030 and 1 to 7°C by 2070 (Winkler, 2005). If we ignore the issues of climate change, it will be harmful to all living beings and surroundings. The result provided by the AR4 of IPCC showed that, it could be warmer by 0.04°C in winter and 0.25 to 0.3°C in summer and precipitation of the whole country is expected to increase in range of 15 to 20% in comparison to the past century (IPCC, 2007) in Nepal. The study done by using Global Circulation Models (GCM) challenged IPCC projection and indicated that there might be increase in temperature from 0.5 to 2.0°C by 2030 and wide range of changes in precipitation in monsoon -14 to +40% by 2030 because Nepal is a landlocked country (NCVST, 2009).

Nepal harbors around three percent and one percent of the world's floral and faunal species, respectively (MoFSC, 2002) because of variation in altitude from 60 m (Terai) to 8848 m (Mount Everest), temperature and rainfall but these flora and fauna are seriously affected because of increasing temperature and irregularity in rainfall (Gross, 2002). The temperature has been increased by 0.09ºC in Himalayas (Shrestha et al., 2012) and by 0.04ºC in the Terai (Plain) which are imparting adverse impacts on forest bio-diversity, agriculture and human beings. Indeed, several studies are carried out associated with impacts of climate change in Himalayan region (Bajracharya et al., 2007) but very limited studies are done in Terai which harbors high range of forest ecosystems, stores a lot of food grain and provides settlements for 48% of people (Pokhrel and Jha, 2007).

Mahottary district of Terai is one of the most affected areas where climatic disasters like floods, erosion, landslides, extreme cold and drought are common and obviously consequences are on forest diversity, agriculture and caused can be observed but what are these impacts and how are they affecting local communities are essential part of the study. Therefore, the study undertaken to assess the impacts of climate change on marginal community (Terai indigenous community: Bin, Malaha, Tharu and untouchable castes called Dalits: Musahar, Dhankar) as well as on different sectors like forest biodiversity and agriculture based on people's perception, climatic data and field observation.

MATERIALS AND METHODS

Research site

Mahottary district was selected for study site because no any study about the impacts of climate change has done before in this district. This district lies in 26° 36' North to 28°10' North and 85°41' East to 85° 57' East. Terai and Chure have tropical and subtropical climate. The temperature ranges between 20 and 25°C and average annual rainfall has been recorded between 1100 and 3500 mm. However, rainfall and temperature varies every year. As shown in Figure 1, Banke-Maraha CFM was selected to collect the bio-physical data, and Laxminia and Bharatpur VDCs were selected to collect the socioeconomic data.

Sampling design

The stratified random sampling was applied to collect the bio-physical data. Bio-physical data of 2005 of Banke-Maraha forest was available from district forest office, Mahottary. So, this Banke-Maraha collaborative forest was purposively selected so that impacts of climate change on forest bio-diversity can be compared. To collect the socio-economic data, 10% sample intensity (Groves et al., 1992), that is, 42 households (22 from Laxminia and 20 from Bharatpur) were chosen to carry out the interview with senior citizens from Indigenous and Dalits households. Similarly, 11 key respondents, that is, teachers, official staff, college lecturers and media people were interviewed. Moreover, workshops were organized at three different levels; they were for forestry staff and professionals, collaborative forest management executive committee and marginal community. These workshops had main focus to discuss answers obtained from the interview as well as pre-developed checklists. Moreover, people's perception about the abundance of forest and NTFPs species was also collected during socioeconomic data collection.

Data collection and analysis

Stratified random sampling was used to collect biophysical data from total of 30 sample plots of 5 m × 2 m size (Moore et al., 2003). Among them, 2 plots were taken from *Acaia catechu- Dalbergia sissoo* stratum, 3 from forest nearby roadside, 3 from forest nearby village and 22 from *Shorea robusta* mix forest stratum. Moreover, data of temperature and rainfall were collected from department of hydrology and meteorology. Data related to landslides, river bank slides, floods and erosion were documented. These data were collected from secondary sources like web search of old newspapers, ministry of home affairs and district development committee.

A simple and descriptive statistical analysis was applied to analyze socio-economic, rainfall and temperature data while bio-physical data were analyzed using the bio-diversity Shannon Weinner (H) and Simpson indices (D) using following formulae:

$$H = -\sum_{i=1}^{s}(pi)(\ln pi)$$

and

$$D = \sum_{i=1}^{s}\frac{n(n-1)}{N(N-1)}$$

RESULTS AND DISCUSSION

Variation in annual rainfall

It is essential to describe the variation in rainfall and temperature, the experience of marginal communities about the local climate, what they feel presently before exploring the perception of people regarding the impacts of climate change and the types of disasters they have experienced in their locality.

Annual rainfall between 1980 and 2010 showed great variation (Figure 2). It was seen that in the year 1987 and

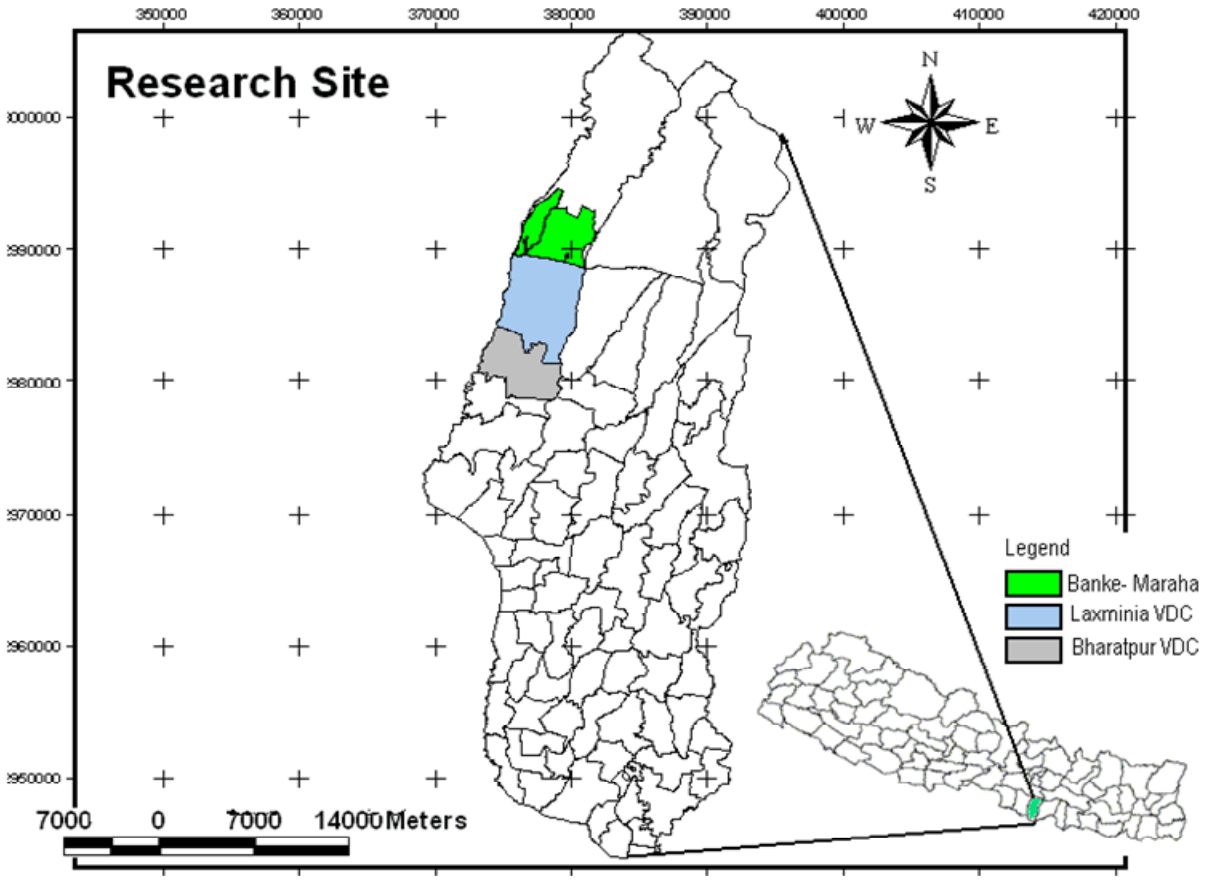

Figure 1. Map of the study area.

1988, the highest annual rainfall that is, 2388.7 and 2058.8 mm were recorded respectively. Since then, the trend has been declining.

The remarkable fact is that there was high intensity of rainfall in 2 to 3 months which resulted in water hazards. As shown in Figure 3, there was high intensity of rainfall in July from 1981 to 2003. After that, the hazardous month was shifted to August which affected farmers' agricultural calendar. There was very little rainfall in April after 2005 which, the local people assumed was pre-monsoon rain.

Increasing temperature

There were some differences in temperature between 1981 and 2010 (Figure 4). About 0.038°C increase in annual temperature was found. However, there was no significant relationship between year and temperature.

People's perception of impacts of climate change

Respondents agreed that there had been changes in climatic conditions in Mahottary. There is a shift in the present rainfall seasons and intensity as compared to the past 20 to 25 years. Similarly, people lamented that the Shreepanchami (January) festival which marked the beginning of the winter rain which was appropriate time for sowing wheat grain and Ram Nawami (April) festival that indicated the start of summer rain when paddy seed was sown no longer exist (Table 1). Respondents added that summer months are extremely hot while winter seasons are very cold; with frost which was common in January, currently being experienced in December. There has been a paradigm shift regarding local climate which are obviously related to global warming and climate change. Kantipur newspaper (2012) highlighted the death of 5 people due to extreme cold in Mahottary district in 2012 and these are mostly from poor Dalit and indigenous community.

Impacts of climate change on indigenous community and Dalits

Indigenous people like Bin and Malaha, who had enough opportunities of fishing in paddy farms during August and September in the past, are now suffering from their business. They guessed the quantity of fishes by hearing

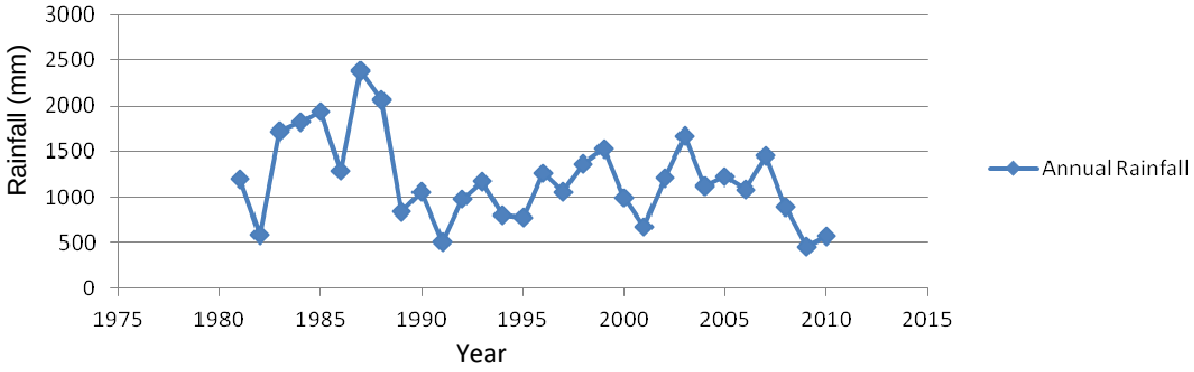

Figure 2. Variation in annual rainfall.

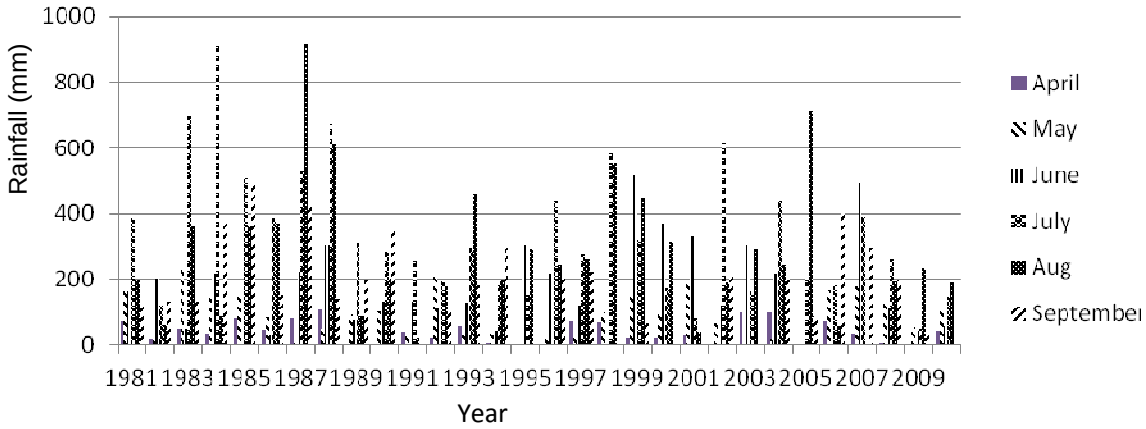

Figure 3. Variation in mean monthly rainfall.

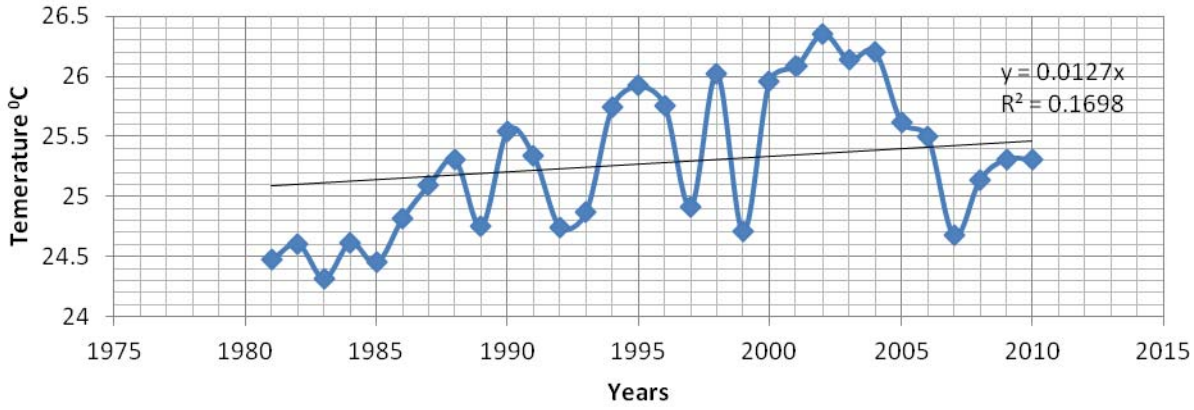

Figure 4. Variation in temperature in Mahottary.

the sound of frogs croaking and presence of storks but they do not have these symbols these days. Similar chain effect was observed on food habits of Terai Dalits like Mushahar who catch mouse in the field as well. They enjoyed catching rats in the field after harvesting paddy in December but they have not such opportunities now-a-days; there is no more rats in the paddy fields. In addition, Dhankar is other Terai Dalits who like to collect the leaves of *Bauhinia vahlii* in order to prepare leaf plates to generate income from their sales. They shared that the *B. vahlii* was abundantly found in the forest, but nowadays it is very rare, affecting their business. Apart

Table 1. Comparison of current events with the past.

Past scenario (20-25) years ago	Present scenario
A lot of rain for long duration	High intensity of rainfall for short period of time
The summer rain started from the end of March or first week of April (Ram Nawami) to sow the paddy seed and winter rain started at the end of December (Shreepanchami festival) for wheat sowing	Unreliable rainfall pattern. Now farmers have to depend upon other sources of water to sow paddy and wheat
Chatta festival (in beginning of October), people burn fire on the bank of pond to escape from cold	It is not so cold in October
Minimal cold in January	Severe cold in January
It was raining in December and no frost	No rain in December but frost occurs
Frost was seen in February and March	Frost and very cold earlier in December
It was not so hot even in May and June	It is very hot in May and June

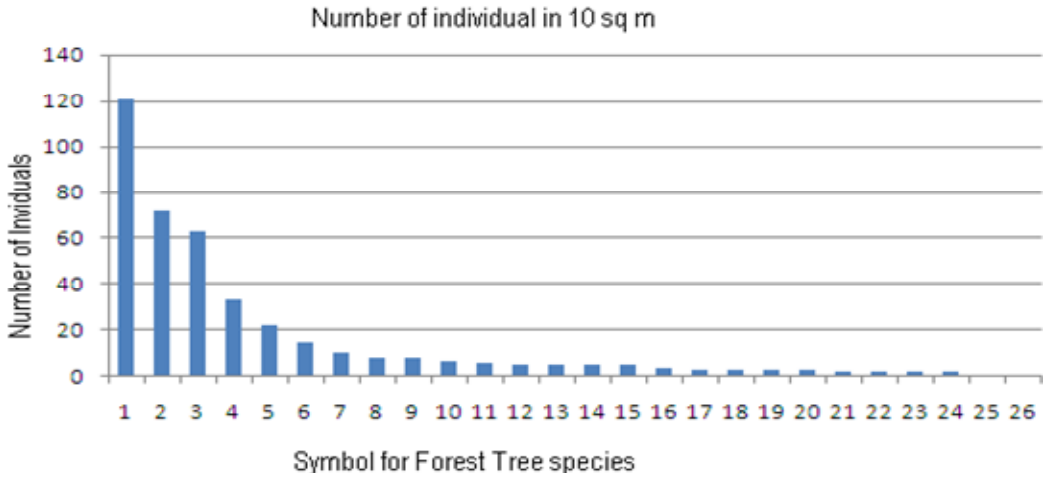

Figure 5. Species ranking according to abundance in 2012.

from this, decreased number of *Bombax ceiba* has affected bee-hive making on the branches which in turn has reduced the pollination process of mustard in the surrounding farms. Increased temperatures and variation in rainfall have created favorable conditions for the insects and pests that affect farm yields. This results in increased use of insecticides and pesticides by farmers, which ultimately damages lives of aquatic animals like frog, snakes and fishes.

Impacts of climate change on forest vegetation, wildlife and agro-crops

The results on the impacts of climate change on forest biodiversity can be mainly grouped into four different categories: Forest tree species; non-timber forest products (NTFPs); wild birds and animals and others.

Impacts on forest tree species

As shown in Figures 5 and 6, *Shorea robusta* is the dominant species in Banke- Maraha collaborative forest in 2005 and also in 2012. Then, very less valuable species *Sapium insigne* and *Terminalia tomentosa* occupied second and third rank respectively in 2012 as compared to *T. tomentosa's* second position in 2005 (Table 2). Some species such as *Desmodium oojeinense, Gmelina arborea* and *Anthoceplus chinensis* were in high threat in 2005 and these species were not found now in this forest. Moreover, it was found that *Schleichera trijuga*, *Adina cordifolia*, *Terminalia belerica, Terminalia chebula* and *Dalbergia sissoo* were in high threat in both mentioned years.

The biodiversity index values slightly differed between 2005 and 2012. The Shannon Weinner and Simpson indexes were 2.53 and 0.86, respectively in 2005 which

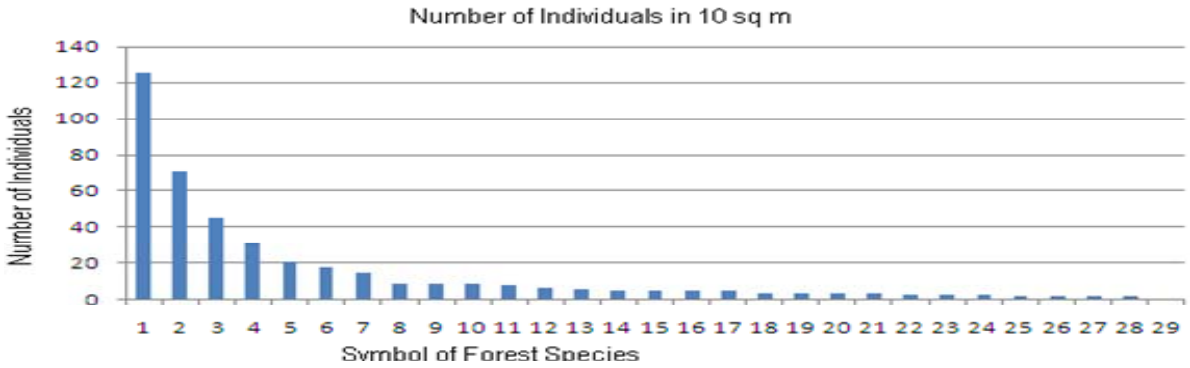

Figure 6. Species ranking according to abundance in 2005.

Table 2. Ranking of species in 2005 and 2012.

Local name	Botanical name	Number of Individuals in 100 m^2		Spp. ranking	
		2005	2012	2005	2012
Sal	*Shorea robusta*	125	121	1	1
Asna	*Terminalia tomentisa*	71	63	2	3
Botdhairo	*Lagerstroemia parviflora*	45	33	3	4
Khirro	*Sapium insigne*	31	72	4	2
Sindure	*Mallotus philipinensis*	21	22	5	5
Satisal	*Dalbergia latifolia*	18	15	6	6
Raj briksha	*Cassia fistula*	15	10	7	7
Aule	*Croton roxburghii*	9	8	8	8
Jamun	*Eugenia jambolana*	9	8	9	9
Siris	*Albizzia procera*	9	6	10	11
Banjhi	*Anogeisus latifolia*	8	7	11	10
Odal	*Sterculia villosa*	7	5	12	12
Kushum	*Schleichera trijuga*	6	5	13	13
Khayar	*Acacia catechu*	5	3	14	17
Amala	*Phyllanthus embelica*	5	5	15	14
Tantari	*Dillenia pantaguana*	5	5	16	15
Sissoo	*Dalbergia sissoo*	5	3	17	18
Karma	*Adina cordifolia*	4	4	18	16
Semal	*Bombax ceiba*	4	2	19	21
Chatiwan	*Alstonia scholaris*	4	1	20	25
Sandan	*Desmidium oojeinense*	4		21	
Barro	*Terminalia belerica*	3	3	22	19
Kumbhi	*Coreyo arborea*	3	3	23	20
Gamhari	*Gmelina arborea*	3		24	
Harro	*Terminalia chebula*	2	2	25	22
Bhalayo	*Semecarpus onacardium*	2	2	26	23
Bael	*Aegle marmelous*	2	2	27	24
Kadam	*Anthocephalus chinensis*	2		28	
Gayo	*Bridelia retusa*	1	1	29	26

were slightly less, 2.34 and 0.85 respectively in 2012. Thus it showed there was variation in biodiversity in the two different periods. The t-test in Shannon Weinner index of these two periods showed that t calculated, 2.18 is greater than t-tabulated, 1.64 at 5% significant interval. This showed the variation in biodiversity is clear between 2005 and 2012.

Jha (2007) has mentioned that *Shorea robusta* would

be converted to mix *S. robusta* forest in Terai due to climate change by increasing of double CO_2. Moreover, in a study done by Sapkota et al. (2009) in Hill, *S. robusta* forest showed that Shannon Weinner index and Simpson Index are near to value of 2.42 and 0.64, respectively. The values of Shannon Weinner and Simpson indices were very close to the values of the year 2005. The differences in biodiversity indices were due to long term impacts of climate change.

Impacts on non-timber forest products (NTFPs)

NTFPs businessman shared that they had three store-rooms for keeping NTFPs at Bardibas, Mahottary and Khayarmara, but now they do not have any more. They added that about 10 persons were engaged in NTFPs collection and trading business for 6 months in the past (10 years ago) but nowadays only 2 to 4 persons are being involved. Wild Asparagus (*Asparagus racemosus*), Shikakai (*Acacia concinna*) and Pipla (*Piper longum*) plants were the sources of income of NTFPs collectors and businessmen, but their quantity is very less in the forest as compared to the past (10-15 years ago). Similarly, poor people who have business to collect *Eulaliopsis binata* and *Bauhiniaa vahlii* shared that they have to spend the whole day to collect one load (30 kg) of these products. Ecologists assume that 10% of the flowering plants in India are under different degrees of threat (Jha, 2007). This study is supported by the study done by Initial National Communication (INC) using Holdridge model which predicted there might be only 12 types of species under doubling CO_2 climatic condition while, Nepal has 15 types of vegetation under existing CO_2 climatic condition (MoPE, 2004).

Impacts on wild birds and animals

The birds like storks which live on fishes are not seen seeking meal in the paddy fields in rainy season. They are only found on the bank of the rivers. Similarly, birds like vultures are rarely found these days because they like to perch on branch of *B. ceiba* and this tree is very scarcely found in the forest. Farmers shared that doves were abundantly found in wheat fields because they use to eat wheat grains, but nowadays they are rarely seen. So, these are common phenomena about the impact of climate change on wild birds. Similarly, the farmers shared that wild animals like deer, wild boar, blue sheep and hog deer used to come to their fields and severely damage their crops, but there are no any signsof these wild animals since the last 20 years.

Impacts on agriculture sector

Local farmers shared that they felt there is a shift in seasons of panicle initiation, flowering, milking stage and crop maturity period for a week or more week. Farmers shared that generally they used to sow paddy seeds in their farm in the first week of June but presently they start sowing in second and third week of June. They added that monsoon is very late these days, by last week of June or first week of July. So, all activities of paddy cultivation are shifted accordingly. Apart from these, farmers have realized that rice and other agriculture products like vegetables are not so tasty these days. It may be due to excessive use of insecticides and pesticides.

Nepal Agriculture Research Council (NARC) had carried out studies on the impacts of climate change on some cereal crops of Nepal and indicated that there might be impacts on season of flowering, milking and ripening of maize, wheat and rice. Hence, there is a shifting paradigm in cropping season. Additionally, there might be a possibility in increase in yield of rice by 21%, wheat by 60% and maize by 12% under double CO_2 condition (MoEST, 2007).

Other effects of climate change

It was found that there were severe floods in 2011 and many houses were damaged and people were affected In Jaleshwar Municipality. Similarly, flood damaged half dozen of offices in July, 2010 and 2007 and in September, 2006. Twelve people died and more than 500 houses damaged by floods; transportation was closed for two weeks from Janakpur to Jaleshwar town. Nepal is a disaster hot-spot country in the world because of serious events of flood, erosion and landslide. The records of 1971 and 2006 showed 2864 and 3899 death tolls due to flood and landslide respectively. Nepal is in the seventh position in the world (MoHA, 2009).

CONCLUSION AND RECOMMENDATION

In conclusion, *G. arborea*, *Dalbergia latifolia*, *Schleichera oleosa*, *A. cordifolia*, *T. chebula*, *T. belerica* and *Phyllanthus emblica* are in threat in the forest due to the impacts of climate change. A total of 17 people lost their lives through disasters in Mahottary district: Twelve (12) persons died from the ravages of floods in 2012, while five (5) persons died from extreme cold conditions during the first quarter of 2012. People are adopting some adaptation measures to counteract the impacts of climate change therefore; further studies in this regard should be emphasized to determine how people have combated this menace of climate change.

REFERENCES

Bajracharya SR, Mool PK, Shrestha BR (2007). Impact of climate change on Himalayan glaciers and glacial lakes case studies on

GLOF and associated hazards in Nepal and Bhutan. ICIMOD, Nepal.
Bali Roadmap (2007). Summary of the thirteenth conference of parties to the on framework convention on climate change and third meeting of parties to the Kyoto Protocol. Retrieved January 14, 2012, from http://www.iisd.ca/vol12/enb1235.
Cruz RV, Harasawa H, Lal M, Wu S, Anokhin Y, Punsalmaa B, Honda Y, Jafari M, Li C, Huu NN (2007). Climate change 2007: Impacts, adaptation and vulnerability. Fourth assessment report of the intergovernmental panel on climate change. Cambridge: Cambridge University press. pp. 469-506.
Gundimeda H (2004). How 'sustainable' is the 'sustainable development objective' of CDM in developing countries like India? Forest Policy Econ. 6(3-4):329-343
Gross J (2002).The severe impact of climate change on developing countries. Med. Global Survival. 7(2):215-225
Groves RMS, Cialdini RB, Couper MP (1992). Understanding the decision to participate in a survey. Public opin. Q. 56:475-495.
Hossain A, Marinova D (2010). Climate change rhetoric in Bangladesh: A cruse or A blessing. Rajshahi university J. Environ. Sci.1:1-12.
Jha PK (2007). Forest and biodiversity in South Asia: An overview. Environment and agriculture, biodiversity, agriculture and pollution in South Asia. ISBN 99933-327-1-2
IPCC (2007). Climate change: Synthesis report. Intergovernmental panel for climate change.
Kantipur (2012). Twelve people died due to extreme cold in Mahottary, Terai. News published in Kantipur daily newspaper on 29 December, 2012. Kathmandu, Nepal.
MoEST (2007). National capacity self- assessment for global environment management. Ministry of environment science and technology, Kathmandu, Nepal.
MoFSC (2002). Nepal biodiversity strategy. Ministry of forests and soil conservation. Government of Nepal.
MoHA (2009). Nepal disaster report 2009. The hazardscape and vulnerability. Ministry of home affairs. Government of Nepal.
MoPE (2004). Initial national communication of Nepal under United nations framework convention on climate change. Ministry of environment and population and environment, Kathmandu, Nepal.
Moore SDd, McCabe PG (2003). Introduction to the practice of statistics" M.H. Freeman and company, New York, Prude University.
NCVST (2009). Vulnerability through the eyes of vulnerable: climate change induced uncertainties and Nepal's development predicaments. Institute for social and environmental transition Nepal (ISET-N) and Institute for social and environmental transition Nepal (ISET-Boulder Colorado) for Nepal climate vulnerability study team (NCVST)
Pokhrel CP Jha PK (2007). Sustainable use of biological resources: An review, sustainable use of biological resources in Nepal. Ecological society, Kathmandu, Nepal. ISBN 9789937-2-2781-0
Sapkota IP, Mulualem T, Odén PC (2009). Tree diversity and regeneration of community- managed Bhabar lowland and Hill Sal forests in central region of Nepal. PhD dissertation Swedish University of Agricultural Sciences Southern Swedish forest research centre, Alnarp Sweden.
Skutsch M, Van Laake P (2009). REDD+ as Multi-level governance in-The-Making. Energy Environ. 19(6):831-844.
Shrestha UB, Gautam S, Bawa KS (2012). Widespread climate change in the Himalayas and associated changes in local ecosystems. PLoS ONE 7(5):1-10.
UNFCCC (1997): United Nations framework convention on climate change. Retrieved date; 2012, May11.from http://unfccc.int/resource/ccsites/senegal/conven.htm#art1
Winkler H (2005). Climate change and developing countries. South Afr. J. Sci. 101:355-364