International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 7, Issue 7 -2020

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2020.07.07.001

Impact of climate change, its factor, effects and adaptation measures on different area of Arghakhanchi District, Nepal

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Abstract

Climate change is currently one of the greatest threats to forest conservation and livelihood security of forest users. A case study entitled Impact of climate change, its factor, effects and adaptation measures on different area of Arghakhanchi District, Nepal ". The main objective of the study was to understand people's perceptions on climate change and its impact on local environment, main factor of causing the change and explore the strategies adapted by local people to cope with climate change impacts on their livelihoods and find out the contribution of community forest on adopting different adaptation strategies by CFUG members. Primary information was collected from household survey and focus group discussion, key informant interview and direct observation, and secondary data was extracted from internet, different journals and organizations related to climate change, its impacts and adaptation measures and factor of climate change i.e Forest fire was determined by using MODIS data. The data were analyzed using statistical tools and computer programs like MS excel, SPSS, arc GIS etc and interpreted in main text with table, figure and charts.

The result of the study shows that there was increase in temperature and decrease in rainfall has been felt by the respondents and also been validated by climatic data analysis. In addition, 64% of the total male respondents and 67% of the total female respondents stated that the number of disease and pest has highly increased in agriculture crops. Similarly, 31% of the total respondents have felt change in monsoon pattern, while 32% of the total respondents suffered from forest fire, 19% from flash flooding and 18% from drought in the study areas. The result showed the average 22 fire occurrence with 14,807.19 ha forest was burnt throughout the year. Temperature greater than 33°c, with slope higher than 35% having less than 1000mfrom road and settlement area has been found to be high risk. Overall, results show that, the trends of forest fire incidence found to be increasing. To cope with these problems, CFUG has conducted training, demonstration tour, and programs focusing to the poor, women and disadvantaged groups for increasing awareness on climate change and its adaptation measures such as check dam construction to control gully and increasing awareness on off-farm income generating activities such as ecotourism, to grow off-seasonal vegetables under plastic tunnels. A key conclusion coming out of this review is that climate change is not only an issue of international concern but is now a local level problem in Nepal.

Keywords: Climatic hazards, MODIS DATA, people's perception, CFUGs etc.

Introduction

Existence of life and vegetation on earth is the result of favorable climate and the availability of freshwater. limate on the earth is influenced by several processes and interactions not only in the earth and its surroundings. Climate change is no longer a subject of theoretical meteorology, but is a real issue affecting almost all the lives and activities on the earth. It refers to the variation in the earth global climate or in regional climate over time. But for the United Nation Framework Convention on Climate Change (UNFCCC), climate change means "all change in climate, directly or indirectly attributed to human activity that alters the composition of global atmosphere and which is in addition to natural climate variability observed over comparable time period" (UNFCCC, 1992, p4).

Climate change is now recognized as one of the most serious challenges facing the world – its people, the environment and its economies. It is believed that most global warming we can now observe is attributable to emissions of" (greenhouse gas)" GHGs. Climate change results due to emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization that vary in solar energy, temperature and precipitation. Climate change and biodiversity loss are more challenging issues that we face today. Both are complex and cross-cutting issues, which affect nearly all human activity (European Union, 2013). Climate change is a global phenomenon. There is growing international consensus about its occurrence; for instance average global air temperature rise by around 0.6˚c over the twentieth century and the 1998 was the warmest year since reliable, widespread instrumental measurement become available in the late 19th century (htpp://en.wikipedia.org).

Nepal climate is influenced by Himalayan mountain range and south Asian monsoon. The climate is categorized into four distinct season; pre-monsoon (March-May), monsoon (JuneSeptember), post-monsoon (October-November) and winter (December-February). Annual rainfall is approximately 1600 mm. The monsoon rain is most abundant in the eastern and gradually decreases as it moves southeast. The temperature trend increases from north to south and decreases with altitude (MOE, 2010). The most vulnerable population to climate change and variability have been rural communities with few resources to cope with extreme weather events like landslides, erosion, and drought (IPCC 2007) particularly, in the mountain and flooding, sedimentation as well as drought in the low land regions of Nepal. The climate change impacts at household level in this region remains fragmented and inadequate to support the development of planned evidence-based adaptation strategies.

Community forestry (CF) is an institutional innovation of empowering local communities in managing forest resources for their benefit. Community level of forest management helps in income generating activities on one hand while in other hand regulating ecosystem, downstream settlements benefits from watershed conservation, carbon sequestration and aesthetic values as in forms of Environmental Services (ES). The community forest of Nepal has higher potentiality for REDD+ (Reduce Emissions from deforestation and forest degradation) and / or PES (Payment for Environmental Services) mechanisms. The successful implementation of these mechanisms help to conserve the forest and can contribute to rural development and poverty reduction which ultimately increase the capacity of people to adapt to climate change (Bishwokarma, 2012). Here is no any study on climate change impacts and adaptation in community forest user group of Arghakhanchi district, and therefore, this study is more important and essential for assessing the effects of climate change on CFUG members of Community Forest Users Group, and adaptation used to cope with these impacts. Thus, community forest (CF) is a holistic approach to mitigate climate change and improve livelihood of local people.

Research Methodology

The study was carried out in six community forest including (3municipalities and 3rural municipalities) of Arghakhanchi district. It was extended with $28^0$00'1.80''N latitude and $83^0$14'28. 80'' Elongitude. Arghakhanchi district lies between 305m to 2515 m above mean sea level. The district can be broadly divided into two physiographic regions i.e. 68%Mahabharat hills and 32%Churia hills. Because of the topological structure, the Churia hills made mostly of soft lime stones and the Mahabharat region made of Phyllite, Schist, Quartzite, limestone.

Hot season exists between March to June with the temperature up to 40°C. This season is the fire occurring season. Monsoon i.e. rainy season starts from July to September. The average rainfall in the district is 2,200 mm. Cold season exists between December to February with the temperature decreases up to6.5°C.Forest covers 62.05% of the total land area

of the district. Majority of the forest area is dominated by Sal (*Shorearobusta*),forest. Saj (*Terminalia elliptica*), Bajh (*Quercus leucotrichophora*), Katush (*Castanopsistribuliodes*), Rhododendron (*Rhododendron ferrugineum*), Uttis (*Alnusnepalensis*), Chuire (*Aesandrabutyracea*), Koiralo (*Bauhinia variegata*), etc.are also available in district.Major forest types found in Arghakhanchi district are Hill Sal forest, Chir pine forest and Chir pine broad leaved mixed forest .Chilaune, Katus, Assna, Guras, Karma,Jamun are scattered in patches all over the district which was shown in (Fig 1 and Table 1).

Figure 1: Map of study area

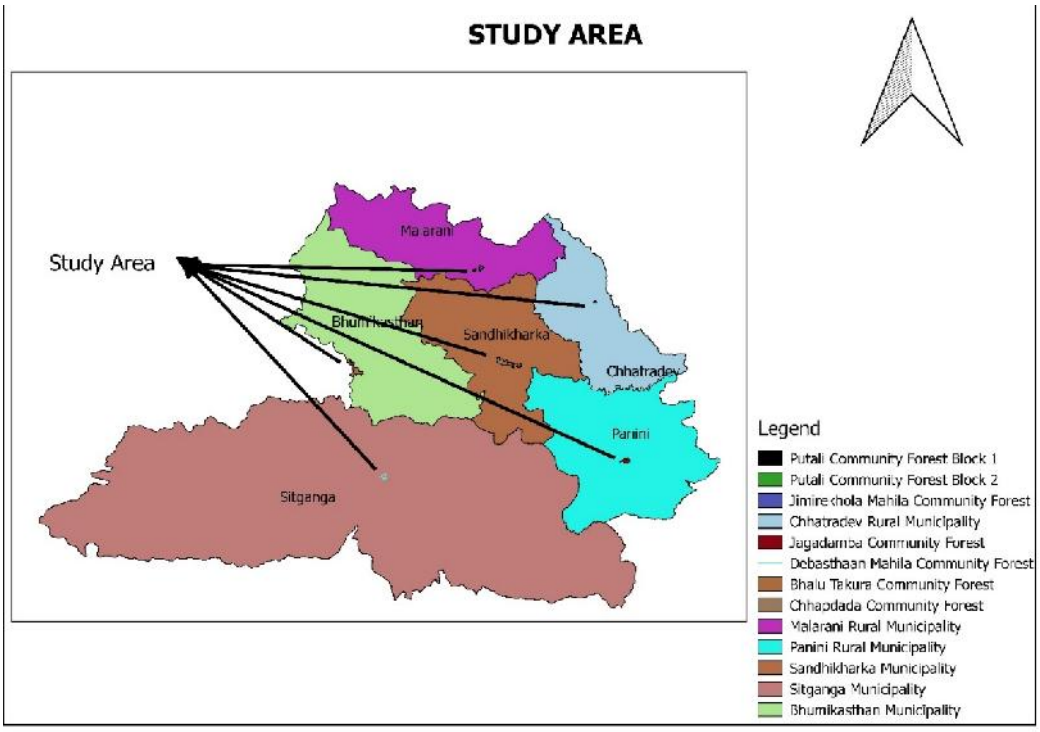

Table 1: Data of CF

Name of CF	No. of Household	Female	Male	Total	Area (ha.)
Jagadamda	66	176	180	356	25.28
Jamirekhola mahela	72	198	213	411	3.39
Bhalutakura	179	453	509	962	69.76
Devesthan Mahela	56	181	198	379	14.25
Putali	118	320	339	659	17.02
Chapdada	136	353	359	712	67.87

Primary Data collection

A. Meeting with CF executive committee

A meeting was organized with executive committee members of six CFUG. During the meeting, all executive members were oriented about the study scope and consent was taken from all of them. Thereafter, they expressed commitment of support during the study. From this meeting, forest areas, forest users, floral and faunal species, management activities, benefit sharing and sampling household related information were also recorded.

B. Household survey

Schedule was developed, tested to administer to achieve the research objectives. Before administrating the instrument, the changes were done for sequential arrangement of question and language clarity. After correction of research instrument, main study was begun. Out of 627 household of six CF altogether 125 households were chosen from different economic strata and conducted the household level interview. Stratified random sampling method was used to select the respondent by fixing 20% sample intensity. For household level interview, tested set of structured and semi-structured schedule was used. The schedule mainly focuses on people's understanding on climate change, adaptation strategies gained by locals and CF support on climate change adaptation. To understand the perspectives on climate change, gender, economic group and diverse educational group were considered in household level interview.

C. Key informant interview

4 key informant interviews were conducted and DFO office, Sub divisional Forest office, old age people, teachers, local leaders, forest dependent and related entrepreneurs and CFUG committee members were taken as the key informants of study. From these key informant's consultation, impact of climate change in local level, its extent, local level strategies and contribution of community forestry were found out.

D. Focus group discussion

Twelve focus group discussion (two in each Cf) was carried out including CFUGS members, local representatives with medium and poor economic class people. Other discussions were conducted with different groups of people like old aged people, disadvantaged group and women group about the research issue-climate change and its indicators which provided chance to disadvantaged people and women to express their views.

E. Direct observation

Direct observation was done during the research specially to triangulate the information gathered in group discussion and questionnaire survey.

Secondary Data Collection:

Secondary data required for the study was collected from the relevant sources like published and unpublished literatures like reports, newsletter and journals from internet, library and operational plan and other minute book of CFUG. Meteorological data of temperature and precipitation of district was also carried out.

Factor Responsible for climate change

Fire sensitive or risk zonation: Factor of climate change fire incident was determined as the main for this Kernel density model was used to find out the high, medium and low risk or sensitive zone of the district. It is necessary to estimate density to know where the fire incidence is more concentrated. Kernel density calculates magnitude per unit area from point using kernel function to fit smoothly tapered surface to each point.

Fire risk modeling involved several steps: Several studies have proposed the integration of variables into a single fire model (Chuvieco and Congalton, 1989; Hernandez et al., 2006; Carrão et al., 2003; and Jaiswal et al., 2002). Several types of factors and parameters are required for forest fire risk zone modeling. In delineating forest fire risk zone mapping, all seven thematic layers of parameters such as slope, landcover, aspect, distance from roads, distance to settlements, and elevation. Chuvieco and Congalton (1989) suggest a hierarchical scheme of fire rating which was followed in this study. Layers of importance from highest to lowest were as follow: land cover, vegetation, slope, aspect, temperature, Proximity to roads, proximity to settlements and elevation (Chuvieco and Congalton,1989).

Table 2: Variables in forest fire risk zone modeling, their weights, ratings and fire occurrence from 2002 to 2018 AD.

Variables and its class						
Land Cover	Temp ^{0}C	Slope (%)	Distance to Road (m)	Proximityto Settlement(m)	Elevation (m)	Aspect
Broad leaved Closed Forest *(1)	>33*(1)	>35*(1)	<10000*(1)	<1000*(1)	<1000*(1)	South*(1)
Broadleaved Open Forest*(2)	31-33*(2)	25-35*(2)	1000-1500 *(2)	1000-1500 *(2)	1000-1500*(2)	South west and south east*(2)
Grassland*(3)	30-31 *(3)	15-25*(3)	1500-2000*(3)	1500-2000*(3)	1500-2000 *(3)	West and East*(3)
Shrubland*(4)	28-30 *(4)	5-15*(4)	2000-2500*(4)	2000-2500*(4)	>2000*(5)	North west and North east*(4)
Barren Land*(5)	<28*(5)	<5*(5)	>2500*(5)	>2500*(5)		North*(5)

*Parantheses indicates fire rating classes. They are Very high,high, medium, low and very low(1,2,3,4,5).

Data Analysis

All collected data were analyzed using qualitative and quantitative data analysis techniques. People's perception was verified by analyzing 25 years' data of temperature and precipitation Data processing, analysis, interpretation of the information collected through household survey and interview was done using SPSS and MS-Excel. Climatic data collected from meteorology department was used for trend analysis of temperature and precipitation pattern and finally, social data was linked to technical data viz. precipitation and rainfall.

Least Square curve fitting technique was used to find linear trend in the data. The linear trend between the time series data(y) and time (t) is given in the equation $y=a+bt$ where, y=temperature or rainfall, t=time (year) "a" and "b" are constant estimated by the principal of least square. Five point Likert was used to rate the people's opinion where weighted mean was used to interpret the people's perception.

Independent chi-square was used to test the hypothesis i.e. Ho: *there is no significant difference on reported among the different strata of respondents*.

An area where CF has contributed on adaption was classified into three categories based on percentage of respondents agreed. The categories were for High contribution (50%-100%) Low contribution (1%- 50%),and for Zero contribution (0%).

Factor responsible for climate change i.e fire was determined by using the MODIS data.

Results and Discussion

This section presents the information about the respondents, people's perception on climate change, impact of climate change on study area, adaptive measures adopted by respondents and contribution of CF on adopting the adaptive measures against climate change.

People's Perception on Change in Temperature

Temperature was one of the major variables relevant to climate change. Local people on study area were experiencing a change in seasonal temperature as compared to previous years. For the query on do they feel increase in temperature in their locality 100% of the respondents answered yes? About 13% of the total respondents answered that the change rate was very high, 40% answered high, 13% answered medium, 17% of the total respondents answered low and rest 17% answered very low.

For summer temperature, 65% of the total respondents answered there was change in summer temperature and 35% answered there was not any change in summer temperature. Out of 65% respondents answered there was change in summer temperature 48% answered that the summer temperature has been increasing and 17% answered that it has been decreasing. Likewise, for the query on winter temperature 96% of the total respondents answered that they feel change in winter temperature and 4% answered they didn't feel any change in winter temperature. Out of the individual who answered there was change in winter temperature 48% answered winter temperature has been increasing and 52% answered that it has being decreasing.

People's Perception on Change in Precipitation

Precipitation was another variable which indicate the change in climate. Precipitation as an indicator of climate change includes four main sub-factors: shifting of the rainy season, decrease in winter rainfall and snowfall patterns, uncertainty of intensity of rainfall and snowfall patterns (Bishwokarma, 2009). For there research question on change in summer rainfall i.e. do you feel change in summer rainfall 95.65% (22 out of 23 numbers) of the total respondents answered yes and 4.35% (Only 1 out 23) of the total respondents answered that there was no any change. Out of 95.65% of the total respondents answered yes, 4% of respondents answered that the summer rainfall has been increasing and 92% of respondents answered that the summer rainfall has been decreasing.

Similarly, 96% of the total respondents answered that there was change in winter rainfall and only 4% answered there was not any change in winter rainfall (Figure 6). Out of 96% answered there was change in winter rainfall all respondents said that winter rainfall has been decreasing compared with last 5-10 years.

Major Areas Affected by Climate Change

Forestry Sector

Increase in insect, pest and diseases and change in NTFP collection

Weighted mean of male and female were 3.3 and 4.3 indicated the incidence of insect, pest and disease in forest has been same as before and increased respectively (Table 2). Here the average weighted mean for sex was 3.8 indicating the incident of insect, pest and disease in forest was increasing. Here the response based on sex does not differ significantly as the level of significance was below 0.05 which was shown in Table 3 and in Table 4.

Table 3: Increase in pests, insects and disease

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	18.2	0	27.3	36.4	18.2	3.3	7.78	NSD
	Female	0	0	8.3	50	41.7	4.3		
	Average	18.2	0	17.8	43.2	29.9	3.8		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level

Table 4: Change in NTFP collection

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	0	18.2	81.8	0	0	2.8	0.012	NSD
	Female	0	16.7	83.3	0	0	2.8		
	Average	0	17.45	82.55	0	0	2.8		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level

Availability of grazing and species composition of forest

Here, average weighted mean for sex was 1.6 represented the rate of grazing has decreased. There was no significant difference in response of people based on sex. Respondents replied that the rate of grazing in forest area has reduced because of formation of conversion of forest to CF and also due to reduction on trend of animal husbandry shown in Table 5.

Weighted mean for male was 3.2 and that for female was 2.6 with average weighted mean of 2.9, all of them indicating the species composition of forest was same as before. There was significant difference in response of people based on sex as shown in Table 6.

Table 5: Availability of grazing

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	72.7	18.2	9.1	0	0	1.3	5.454	NSD
	Female	41.4	8.3	50	0	0	2		
	Average	57.2	13.25	29.55	0	0	1.6		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level]

Table 6: Species composition of forest

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	0	0	72.7	27.3	0	3.2	9.301	SD
	Female	8.3	16.7	75	0	0	2.6		
	Average	4.15	8.35	73.85	0	0	2.9		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level]

Key informants have stated that new varieties of fast growing tree species have been planted on forest which has resulted change in composition of species in forest area.

Vulnerable and susceptible areas in CF

Weighted mean of male was 3.4 and that of female was 2.9 with average weighted mean for sex being 3.1, all of them indicated that the vulnerable and susceptible areas of forest have been same as before. There was significant difference in response of people based on sex as shown in Table 7 .

Table 7: Vulnerable and susceptible areas in CF

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	0	0	72.7	9.1	18.2	3.4	10.4	SD
	Female	0	33.3	41.7	25	0	2.9		
	Average								

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level]

Agriculture Sector

Early flowering and fruiting and change in seed quality

Weighted mean for both male and female was 2.8 indicated the early flowering and fruiting was same as before. As the level of significance is above 0.05 of respondents there was no significant difference in the response of people depending on sex of respondents as shown in Table 8 .

Table 8: Early flowering and fruiting

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	0	36.4	45.5	18.2	0	2.8	1.12	NSD
	Female	0	41.7	25	25	0	2.8		
	Average	0	39.05	35.25	21.6	0	2.8		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level

Crop storage time and increase of disease and pest in agricultural crops

With the average weighted mean of 2.0 for male and 1.8 for female both indicated the crop storage time has decreased. Here, the average weighted mean for sex was 1.9 which indicated the crop storage time has decreased. The response of respondents do not differed significantly sex wise as shown in Table 9.

The weighted mean of 3.5 for male and 4.2 for female and average weighted mean of 3.8 also indicated the number of disease and pest has highly increased in agricultural field. There was no significant difference in response of people based on both sex and economic strata as shown in Table 10.

Table 9: Change in crop storage period

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	0	96.9	9.1	0	0	2	3.352	NSD
	Female	25	66.7	8.3	0	0	1.8		
	Average	12.5	80.3	8.7	0	0	1.9		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level]

Table 10: Increase of disease and pest in agricultural crops

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	0	36.4	45.5	18.2	0	2.8	1.12	NSD
	Female	0	41.7	25	25	0	2.8		
	Average	0	33.05	35.25	21.6	0	2.8		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level]

Respondents of the study area reported that the number of insects, pests and diseases in both agricultural field and forest has been increased. Common insects and pests seen before were gradually disappearing and new species of insects were observed. They reported that both new and old species of insects has been seen in huge number in hot days of summer season.

Water Sector

Change in water level and status of watershed areas

Weighted mean for male was calculated to be 1.6 and for female was 2.3 both representing the water level has decreased. The average weighted mean for sex was 1.9 which shows that the water level has decreased. There was no significant difference in response of respondents on statement based on sex as shown in Table 11.

Weighted mean of male was 2 and that of female was 2.7 indicating the watershed areas have decreased and same as before respectively. Hence, with the average weighted mean of 2.3 for sex shows that the number of watershed areas has decreased. There was significant difference in response based on sex as shown in Table 12.

Table 11: Change in water level

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	36.4	63.6	0	0	0	1.6	6.613	NSD
	Female	16.7	41.7	33.3	8.3	0	2.3		
	Average	26.55	52.65	16.65	4.15	0	1.9		

[SD= Significantly differ at 0.05 level, NSD= Not signiAvailability of drinking water

Table 12: Status of watershed

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	9.1	81.8	9.1	0	0	2	14.661	SD
	Female	8.3	16.7	75	0	0	2.7		
	Average	8.7	49.2	42	0	0	2.3		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level]

Biodiversity Sector

Status of wild animals and population of weed species

Weighted mean for male was 3.8 indicating the no of wildlife has increased and that of female was 7.7 indicating the number of wild animals there was same as before. Hence with the average weighted mean of 3.2 for sex wise it shows that the number of wild animal in study area has increased than before. There was no significant difference in response of people base on sex and economic strata as shown in Table 13.

Weighted mean of male was 2.3 indicating the population of weed species has decreased and of female was 2.8 indicating the population was same as before. Hence, average weighted mean depending on the sex of respondent was 2.5 indicated the weed species was same as before. There was no significant difference in response of people based on sex as shown in Table 14.

Table 13: status of wild animals

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	0	9.1	9.1	72.7	9.1	3.8	10.842	NSD
	Female	8.3	33.3	33.3	25	0	2.7		
	Average	4.15	21.2	21.2	48	4.5	3.2		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level]

Table 14: Population of weed species

Respondent Category		Respondent (%)					Mean	X^2	SD/NSD
		Highly Decreased	Decreased	Same as Before	Increased	Highly Increased	Weighted		
Sex	Male	9.1	81.8	9.1	0	0	2	14.661	SD
	Female	8.3	16.7	75	0	0	2.7		
	Average	8.7	49.2	42	0	0	2.3		

[SD= Significantly differ at 0.05 level, NSD= Not significantly differ at 0.05 level]

Factor responsible for climate change i.e. Fire

Year wise fire incidents and Month wise fire incidents

Temporal changes of fire frequency for the Arghakhanchi district were investigated on a monthly and yearly basis from 2002-2018. From feature classes created, it was possible to obtain data on the number of fires per month in the Arghakhanchi district since 2002-2018 AD. The Monthly changes were studied for each year. The annual fire occurrence during the recent 17 years is shown in Fig 2 and 3. Fig 4 shows that forest fires left historically very higher fire incidents in 2016 which is about 121 in numbers. Normally fires occurred in 5 different years in 2009, 2010, 2012 , 2014 and 2016 contributes 35,37,46,41,121 numbers respectively which is about 77.56% of the total fire incidents in District. In 2002 only a single fire occurrence was observed.

Month wise fire incidents

There was a large variation in the monthly pattern of fire occurrence; with April being the most significant having highest numbers of fire. The figure 9 shows that two months April and May are the peak months of fire occurrence in the district while March has significantly few fires than January and June and the remaining months have no fire occurrence, however the district has not seen fire in the months Febrary, July, August, September, October and November.

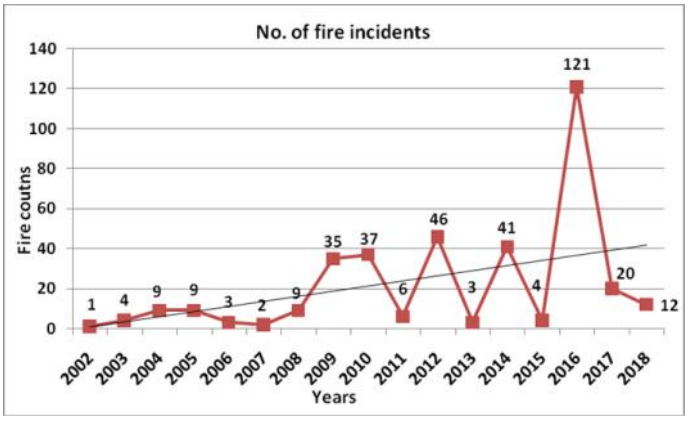

Figure 3: Year wise fire incidents in District

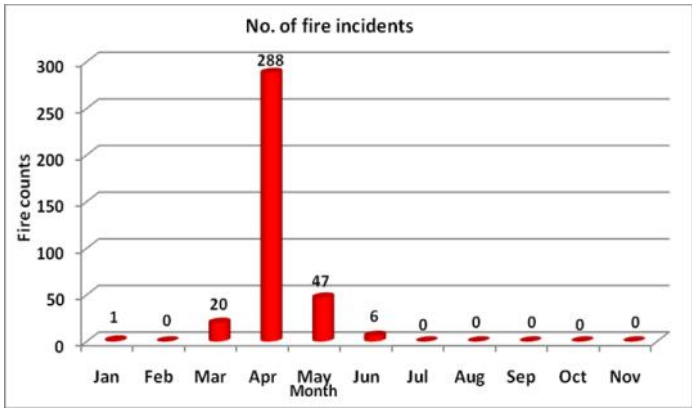

Figure 4: Fire occurrence per month

Forest Fire Incident in Different Land Classes: From Figure 18, Result shows that, Forest fires occur higher in broadleaved closed forest followed by broadleaved open forest. Out of 362 fire incident in District, about 168 fire was observed in broadleaved closed forest, 95 fire was observed in broadleaved open forest. Grassland account about 89 fire, which is followed by needle leaved open forest which is 6 in number. Agriculture and shrub land account 1 in number. This is because the tropical broadleaved forest experiences heavy leaf fall during summer (i.e. March–June) which results in the accumulation of a large amount of leaf litter, fuelling frequent and prolonged occurrences of fire during summer.

Forest Fire Incident in Topographic Features and based onelevation: The results show that a large no of fire were incident in southern aspect which is 77 in numbers which is followed by south east and south west which is 55 in number.

Higher number of forest fires occurred in area range below 1000m elevation. About 81.76% of the fires were recorded in the areas below the elevation of 1000m, whereas 18.23% of the incidences occurred in areas from 1000m to 2000 m . 0% of forest fire occurred above 2000m (msl). Hence comparatively lower elevation has more prone to forest fire than higher elevation which is shown in fig 5 and 6.

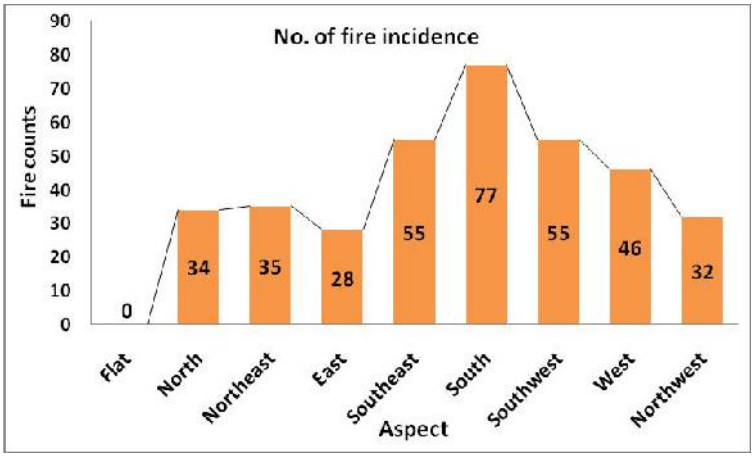

Figure 5: Fire occurrence in aspect

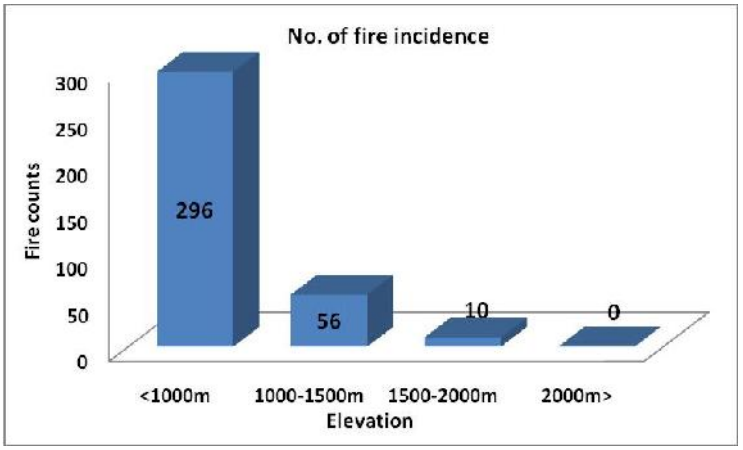

Figure 6: Fire occurred based on elevation

Forest fire incident in Slope And based on Temperature: Result shows that, Number of fire incidents received higher in slope greater than 35% degree and Very less number of fires occurred in slope less than 5%. Hence, Forest fire is more in upslope than lower slope.

Climatic Factor Temperature: Temperature is one of the main factor causing the forest fire. With the increases in temperature number of fire incidents increases. Temperature range greater than 33°C is more prone to fire ,which records about 106 in number. With decreases in temp. no of fire also reduced and less than 28°c, fire records about 4 in number which are shown in figure 7 and 8.

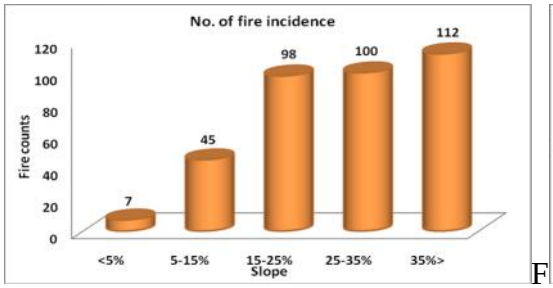

Figure 7: Fire occurrence distribution in slope

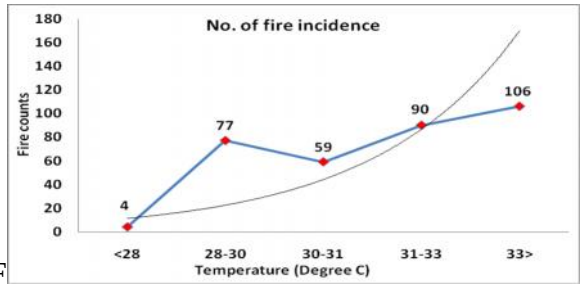

Figure 8: Fire occurrence with temperature

Conclusion

Although the number of insects and pests has been increased in forest area other impacts of climate change has been felt less in forest sector. The availability of NTFPs and fodder has increased; composition of species on forest area has been same as before, vulnerable and susceptible areas of forest has decreased.

Increase in number of disease, pests and insects, change in flowering and fruiting time, decrease in seed quality, and decrease in crops storage time were the major impacts felt by people in agricultural sector. Shift in monsoon pattern and irregularity in rainfall were felt by people, which has direct impacts on water sector and forests with increase in number of weed species and invasive species especially *Lantana camera* (banmara) on forest areas.

Conversion of forest into community forest has resulted in protection and proper management of forest. Community forest user group has conducted training, demonstration tour, and programs focusing to disadvantaged group for increasing awareness among people on issues related to environment and climate change and check dam construction to control gully and increasing awareness on off-farm income generating activities such as ecotourism.

Other adaptive measures taken by people were autonomous and spontaneous. The use of the chemical fertilizer has improved the production is felt by the local and tunnel farming was in practice to generate household income.

Research states that, higher number of forest fires occurred in area range below1000m elevation. About 81.76% of the fires were recorded in the areas below the elevation of 1000m, whereas 18.23% of the incidences occurred in areas from 1000m to 2000 m (Fig.20). 0% of forest fire occurred above 2000m (msl). Hence comparatively lower elevation has more prone to forest fire than higher elevation which coincides with previous study conducted by Matin et al 2017. Elevation has straight relation with temperature which also motivates forest fire (Rothermel, 1983; Rothermel, 1991, Yakabu et al., (2015).

Result shows that, Number of fire incidents received higher in slope greater than 35% degree and Very less number of fires occurred in slope less than 5%. Hence, Forest fire is more in upslope than lower slope which is similar with previous study conducted by Adab et al., (2011).

The large no of fire were incident in southern aspect which is 77 in numbers which is followed by south east and south west which is 55 in number. Southern aspect experiences more sunlight resulting higher temperature but low fuel moisture and humidity. This creates the vegetation becomes parched on south facing slope than north facing slope while the east aspect receives more ultraviolet and direct sunlight hence it dries faster (Anderson 1982; Prasad et al., 2008). Because of that, drier fuels are more exposed to ignition (Noonan, 2003; Iwan et al., 2004). In addition, earlier in the day, east aspects get more ultraviolet and direct sunlight than west aspect. Consequently, east aspects become drier faster (Anderson, 1982 cited from Adab et al., 2012)..Hence, my result signifies that South facing aspect is more susceptible to forest fire which coincides with previous study conducted by Ghimire,2014.

Temperature is one of the main factor causing the forest fire. With the increases in temperature number of fire incidents increases .Temperature range greater than 33°c is more prone to fire, which records about 106 in number. With decreases in temp. no of fire also reduced and less than 28°c, fire records about 4 in number which is similar to Matin et al., (2017). It has been suggested that higher the temperature higher is the risk of forest fire. (Hussien et al., 2008; Farukh et al., 2009; Miller et al., 2012; Khanal, 2015; Matin et al., 2017).

Result shows that, Forest fire occurs higher while settlement distance is in below 1000 m and very low while settlement distance is greater than 2500m. About 80.90% of forest fire occurred in below1000 m, 10.50% while settlement distance is in between1000-1500m and 0.60%when settlement distance is greater than 2500m. While making the fire risk zone it was predicted that the distance near to habitat for 1000m. The same happened to the Hussien et al., (2008) where he argues that people usually know that forest fire is illegal hence to avoid charges they would rather start away from the settlement because they will know that no one will see them. Hence, my result signifies that, forest fire decrease with increase of distance from settlement which is consistent with previous study conducted by Saklani, 2008.

Result shows that the distance near to road is more vulnerable for forest fire which records about 43%,21% incident in area with distance of 1000-1500m and 8% incidence in area greater than 2500m.which is similar with the research conducted by Hussien et al., (2008) In addition. Matin et al., (2017) stated that 40% of fires were recorded within the range of 1km in Nepal. Keeley and Fotheringham (2003) also cited that anthropogenic ignitions occurs frequently along the road corridors and other areas where human activity is high.

It is concluded that increase in temperature and decrease in rainfall has been felt by the respondents which have also been validated by climatic data analysis. The mean maximum temperature of the study areas was increasing by 0.0257°C per year, and the amount of rainfall was in decreasing trend with the rate of 35.34mm per year.

Although the number of insects and pests has been increased in forest area other impacts of climate change has been felt less in forest sector. The availability of NTFPs and fodder has increased; composition of species on forest area has been same as before, vulnerable and susceptible areas of forest has decreased.

Increase in number of disease, pests and insects, change in flowering and fruiting time, decrease in seed quality, and decrease in crops storage time were the major impacts felt by people in agricultural sector. Shift in monsoon pattern and irregularity in rainfall were felt by people, which has direct impacts on water sector and forests with increase in number of weed species and invasive species especially *Lantana camera* (banmara) on forest areas.

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Other adaptive measures taken by people were autonomous and spontaneous. The use of the chemical fertilizer has improved the production is felt by the local and tunnel farming was in practice to generate household income.

Recommendations

Based on the limited study area and time frame, following recommendations have been made.

Further research in wide geographical location and large time frame can provide the actual figure of climate change, its impacts and adaptive measures in Nepal.

Use of resistant variety of crops and hybrid seeds were the adaptive measures adapted by majority of people but there was no contribution of CF in this sector, therefore possible CF support on the sector other than forest should be identified and implemented.

As there is less adaptation measures used by the locals to overcome the risk of climate change impact so other adaptation like water harvesting technique should be trained to the locals.

Though local felt the use of chemical fertilizer useful for the high production, further research in the agriculture field is needed to analysis the actual effect made by the chemical fertilizer to the soil.

Acknowledgments

We are indebted towards REDD Implementaton center babarmahal, Kathmnadu for providing opportunity to carry out this research. We are extremely grateful to sir Dr. Ram Asheswar Mandal, Dr. Him lal Shrestha for their valuable suggestions and guidance in the preparation of this report. We would like to express my heartfelt gratitude to all the staffs of School of Environmental Science and Management, college, my friends and seniors for all the help and coordination extended in bringing out the report on time.

Forest Officers and staff of Divisional Forest office, Arghakhanchi who in spite of their busy schedule provided help and invaluable guidance during field work and report preparation are highly acknowledged

We extremely thankful to our friend Rajendra Rijal, Bhuwan Budthapa, Sangita Bashyal, Aastha Bhattarai who provided an enormous help during field work. I am thankful to various members of different CFs for their support.

Declaration of Interest Statement:

Declaration

The piece of work entitled "Impact of climate change, its factor, effects and adaptation measures on different area of Arghakhanchi District, Nepal" is our own work, except wherever acknowledged. We have not submitted it or any of its part to any other university for publication. There is no conflict of interest among authors for publication.

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DOI:10.22192/ijarbs.2020.07.07.001	

How to cite this article:
Satish Bhusal, Sangita Bashyal, Prabesh Adhikari. (2020). Impact of climate change, its factor, effects and adaptation measures on different area of Arghakhanchi District, Nepal. Int. J. Adv. Res. Biol. Sci. 7(7): 1-14.
DOI: http://dx.doi.org/10.22192/ijarbs.2020.07.07.001