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People's perception of climate change impacts and their adaptation practices in Khotokha valley, Wangdue, Bhutan

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Climate change is expected to have serious environmental, economic, and social impacts in mountainous regions worldwide. Rural communities that depend on farming, livestock rearing and natural resources for their livelihoods are likely to be affected by its adverse impacts. This study was carried out to understand one community's perceptions and experiences of climate change and to assess the people's use of forest resources and possible implications for climate change adaptation. The study was conducted through semi-structured questionnaires. The entire population of 67 households was surveyed for the study. The household data were analyzed using descriptive statistics, frequency and inferential statistical tests, namely, parametric t-test and chi- square. The study revealed that a majority of people in the community (79 %) were aware of climate change. Over ninety per cent of the local people depend mainly on cultivation of potato and rearing livestock for their livelihood. The results indicated that climate change and variability have affected the lives of the local people who have developed adaptation strategies in their own way to cope with it. Local people cited impacts including reduced precipitation and an irregular rainfall pattern, which affects potato cultivation and winter fodder production. Production has also been affected by an increased in insect pests. Additionally, new invasive/weed species are reported to be colonizing the pasture land, preventing the regeneration of preferred grass species for grazing. Use of forest products such as fuel wood, flag post, fencing post and litter in particular, have decreased because of available alternatives. Over eighty per cent of those interviewed the need of government support.

Keywords: Adaptation, Agriculture, Climate change, Livestock, Resource use

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It is anticipated that climate change will have serious environmental, economic, and social impacts in mountain regions. Rural communities that depend on the use of natural resources for their livelihoods are likely to suffer from its adverse impacts of climate change[1]. The Himalayan region is also experiencing critical problems often relating to climate change such as poverty, environmental degradation, natural resources depletion, shortage of water resource and desertification[2]. Climatic variability in these mountain ecosystems along with livelihoods of the rural communities is likely to be further threatened[3]. Among the most vulnerable to climate change are rural communities with few resources to cope with extreme weather events causing landslides, erosion, and drought[3]. Assessment of potential climate change impacts on the livelihoods of these communities is critically important for their survival.

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Bhutan is considered to be one of the more successful countries in the world with regard to environmental conservation. The constitution of the Kingdom of Bhutan states that at least 60 % of its forest cover should be maintained at all times (RGOB, 2008)[4] and hitherto the country has maintained more than 70 % of the land area under forest and more than 50 % of its area is under protected forest, which is one of the key strategies for maintaining forest cover and protecting wildlife species[5]. Forest conservation supports livelihoods of the rural communities and mitigates climate change by sequestering carbon and reducing soil erosion. Besides harvesting timber for local consumption, these communities utilize forest products for agriculture where more than 60 % of the population depends on farming and livestock rearing for earning cash income[5]. These activities remove forest resources with a consequent reduction of carbon stocks. Most of the farmers are not aware

about the proper utilization of forest resources, nor are they familiar with the impacts of farming on forest biomass that ultimately affect carbon sequestration capacity of forests (Locatelli, 2010)[6] and reduce climate change adaptation. Moreover, the total amount of timber being harvested through various management systems is not well documented.

Forests in Bhutan are managed through state and community management systems. In state management systems, forests are categorized as management units, protected areas and watershed management systems, while community forests are managed by adjacent communities. Natural resources, particularly the forest resources, play an important role for the livelihood of the people and the country[7].

The climate change mitigation and adaptation policies of Bhutan relate directly and indirectly to climate change through the programs of sustainable forest management, biodiversity conservation, watershed management and water source protection[8]. These policies reflect the perspectives of specific programs[9]. However, evidenced-based climate change policies are fewer, and these policies and strategies need further strengthening to be more effective.

It is reported that, temperatures are likely to increase more in high mountain areas than elsewhere[10]. Glaciers and snowfields will recede and may even disappear, reducing Bhutan's dry season water resources[8]. This will affect irrigation and drinking water supplies and make hydroelectricity less reliable (ibid). In addition, receding glaciers often leave behind expanding glacier lakes that can outburst causing catastrophic floods. Global climate change will also likely shift monsoon precipitation patterns in ways that will threaten Bhutan's current agricultural practices, infrastructure, and bio-diversity, especially in the mountain regions where migration of species is physically restricted[11]. In order to improve the resilience of rural households and communities' resilience against climate change, there is a need for understanding of these risks. Therefore, the objective of this study was to assess one community's perceptions of climate change, climate variability, and building community resilience through sustainable natural use along with implications for climate change adaptation.

Methods

Study area

Our study area, the Khotokha region, located in central Bhutan, has a broad valley in the middle with the surrounding hills rising in moderate slopes, with occasional steep areas in some parts. The elevation of the area ranges from 1900 m at the bottom of the valley to 3785 m at the ridge top (Fig. 1).

The lands of Khotokha are found to be reasonably workable with almost 70 % of the total area having a slope at or below 35 %. The population in the area depends on farming as the main source of their livelihood[12].

The sale of potatoes contributes nearly 90 % of the area's income and the sales of livestock products and vegetables contribute the rest.

The people also depend on forest resources for timber, cattle bedding and non-wood forest products (NWFPs) to support their livelihood. More than fifty per cent of the households are illiterate, although every household has children going to school at present.

Data collection

Information on perceptions, responses to and local knowledge of climate change, its impact on farming and adaptive strategies applied by the households was gathered through personal interviews, field observations and secondary data.

Household survey: We employed was a census approach (100 % households), where all the households were considered for the interviews. Out of 75 households in total, 67 participated in the interview. In each case, the head of each family was interviewed as it was assumed that he/she was most aware of the issues. A semi-structured questionnaire was used to ask interviewees whether they have noticed long-term changes in climate and/or change in

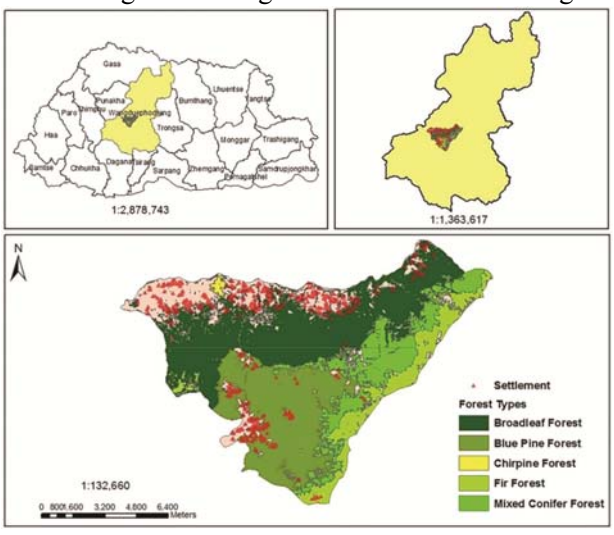

Fig.1 — Study map

the status of the area's natural resources over the years. As well as the household survey, informal discussions were also held to identify other situations that have lead to changes in the livelihoods of the community. Before the data collection was conducted, people were well informed on the research to be carried out.

Secondary data: Secondary data on policy, programs and activities regarding climate-related risk management and adaptation practices were also collected from government reports. Climate data from 1996 to 2012 were obtained from the nearest metrological station (Nobding meteorological station).

Data analysis

Data collected from the household surveys were analyzed using the Statistical Package for Social Science (SPSS) software and Microsoft excel. Descriptive statistics such as frequency, and t-test were used to compare climate change impacts and adaptation strategies in the study area. Qualitative information such as farmers' perceptions regarding climate change was analyzed using frequencies and percentages which were subjected to the chi-square test of independence.

Results and discussion

Climate change and its impact

Climate change has become a serious issue seen to have negative impacts on the rural livelihoods through a range of associated changes taking place, such as, rise in temperature, erratic rainfall and prolonged dry spells.

The study revealed that 79 % of the interview respondents perceived an effect of climate change on their daily activities, while 14 % were uncertain (Fig. 2a), although they could understand the concept of climate change and potential impacts. Most of the respondents (44.4 %) indentified changes in forest composition, rainfall and temperature as taking place within recent years, while 37 % cited changes including flowering time, rainfall patterns and temperature which is attributed to climate change. However, 15 % of respondents had no clear idea about what changes were taking place. In total (85 %) of the surveyed households indicated a perceived increase in average temperatures and decrease in rainfall amounts (Fig. 2b). They also reported experiencing unpredictable rainfall patterns, especially over the past 10 yrs.

A particular incident fresh on the mind of the respondents was an untimely and unexpected rainfall during 2015, at the time of potato harvest which destroyed most of the crop. Usually, the potato harvest takes place during the months of October and November with favorable weather. Although some farmers were unable to link what they were experiencing to climatic change, they, nonetheless, employ adaptation strategies. For example, they harvest and store water in drums or tanks for use during times of water scarcity.

Campbell *et al.* (2009)[13] reported that climate change is likely to impact species and biodiversity mainly through changes in distribution and composition status of forests as a result of changes in mean temperatures and rainfall patterns. According to Wangda & Ohsawa (2010)[14], there is a probability that the upper limit of evergreen broad-leaf species would shift from 2900 m (current) to higher altitudes in the future.

Long term climatic (Tempeature & Rainfall) data analysis of from 1996 to 2012 revealed that the maximum temperature appears to be rising at a rate of 0.079 ^{0}C annually, while the minimum is decreasing at an annual rate of 0.209 ^{0}C. Likewise, rainfall data for the same period showed a trend of 0.125 mm decrease yearly. Similar finding was reported from a previous study in the Himalayan Hindu-kush

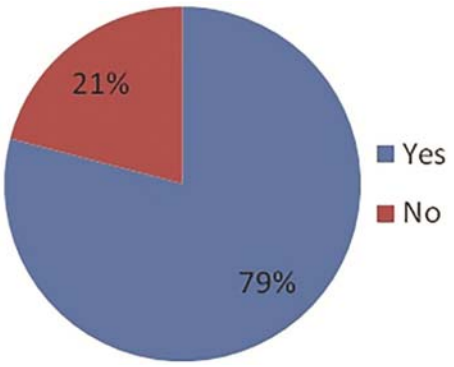

Fig. 2a — Perception on climate change

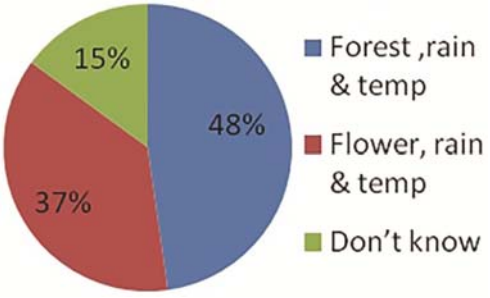

Fig. 2b — Changes observed by interviewee

mountain region that the mean temperature is increasing at the rate of 0.06 ^{0}C per year and that the raise in temperature was greater at higher altitude[15].

Rainfall, however, was reported as unpredictable and erratic[15]. Thus, local farmers' observations are in line with meteorological data regarding climatic variability. The observations and climatic data analysis agree with farmers' perceptions of an ongoing rise in maximum temperatures and decrease in rainfall. However, people's perception on increasing the minimum temperature every year did not coincide with decreasing trend of minimum temperatures of the meteorological data (Figs 3&4).

Impact of Climate Change on rural farming

All the respondents expressed that the climatic changes they observed affect their farming activities. The main impact highlighted by local farmers was low crop production. The Fig. 5a shows that low production was attributed to lack of rain, presence of insect pest, and unwanted weed invasion. To overcome this problem, 29.9 % and 26.9 % of the respondents sought to irrigate crops and spray insecticide, respectively, while 43.2 % of the respondents had no ideas or strategies to overcome the adverse impacts they experienced (Fig. 5b).

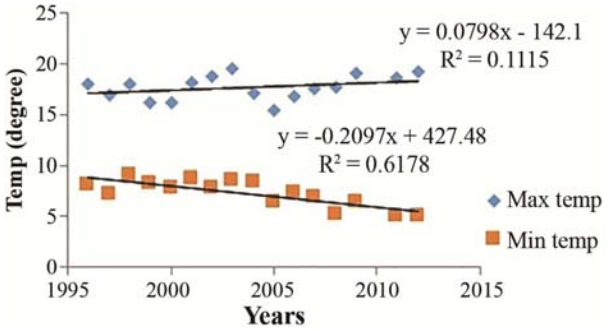

Fig. 3 — Trend of max and min temperature

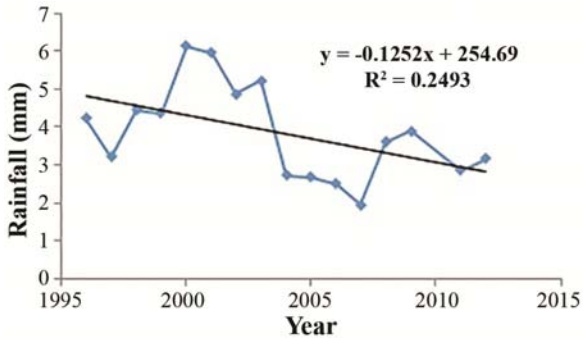

Fig. 4 — Rainfall trend

Local people reported that climatic conditions have affected their daily activities and their livelihoods. One example given was that invasive plant species were becoming prevalent and widespread, threating to dominate the local native species. Moreover, invasive species in agriculture hamper the growth of potatoes (main income source) and vegetables. The weeds were also found to dominate the fodder grasses available for the livestock, which was identified as main reason for shortage of fodder resulting in a reduction of livestock products. Chettri *et al.* (2010)[16] noted that the changes in temperature and precipitation would lead to further increases in atmospheric greenhouse gases which in turn would lead to lower yields, higher prevalence of insect pest, and ultimately, disappearance of some of native species. Similarly, Tse-ring *et al.* (2010)[17], reported that high altitude grassland would be the most sensitive to the climate change in terms of temperature rise and erratic precipitation. This will undoubtedly have serious implications for the livelihoods of people depending on livestock grazing in these areas.

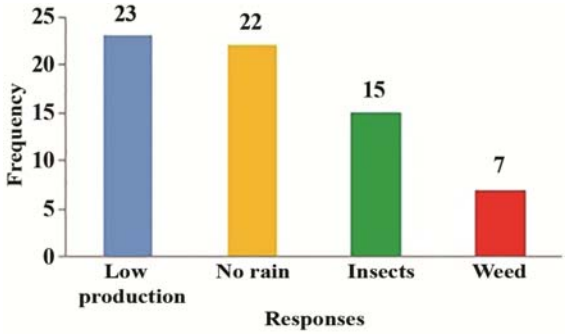

Fig. 5a — Result of climate change

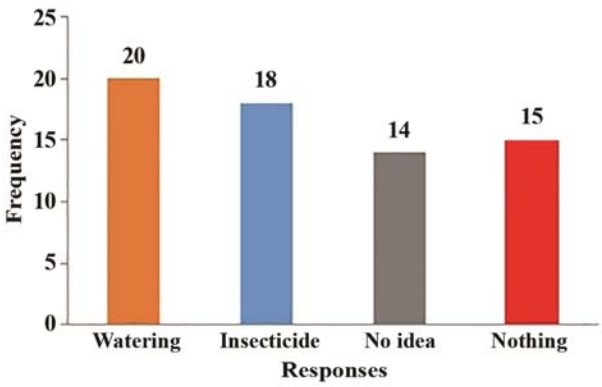

Fig. 5b — Option practiced

Besides the changes indicated above, local people have also noticed immense changes in their surroundings within the last few years. These include loss of snow cover on mountains which used to be covered with snow throughout the year, but now are bare for much of the time. In many cases, anecdotal evidence from local people confirms findings from recent scientific studies, particularly about shrinking snow cover and retreating glaciers[1].

Gitay *et al.* (2002)[18] and Chettri *et al.* (2010)[15] reported that there was a decrease of snow cover by about 10 % on average in the northern hemisphere by the late 1960s. Also, a comparison of Landsat MSS images taken from 1973 to 1979 and Landsat ETM+ images from 1999 to 2000 indicated a decrease in snow cover in the eastern Himalayas by 24.6 % between these time periods. Although, there are no records of data and observations for analysis on snow cover to show trends in Bhutan, changes in snowfall pattern and frequency have been experienced by a majority of the people living in study area.

For small, developing countries like Bhutan, availability of resources and building adaptive capacity are of utmost importance. It is reported that there were no government or non-government organizations working on documenting or mitigating the impacts of climate change for the community in the study area. Hence, government intervention is necessary at this stage to assist local people in coping with climate change and mitigate its adverse effects.

A survey (2010) carried out on four eco-floristic zones in Bhutan showed that, understanding of climate change and its impacts among the local people was found to be generally poor. The survey also highlighted that there were limited adaptation measures opted by the respondents. However, changes such as rise in temperature, erratic rainfall, and snowfall pattern shifts were observed by a majority of the respondents. IPCC (2014)[19] reported that the impact of climate change will be adverse in the developing countries with resource poor communities having very limited adaptive capacity and preparedness. Bhutan is one of the least developed country (Sovacool *et al.,* 2012)[20] and the effect of climate change is already visible in agriculture[20].

According to SAPA (2016)[9], The Renewable Natural Resources Sector Adaptation Plan of Action, the effort to address effects of climate change on agriculture and food security is inadequate. In forest and biodiversity, the knowledge of the state of forest, ecosystems and ecosystem services in the context of climate change is very limited. An inventory of water resources has been conducted but the information is very basic. Meteorological data like temperature, rainfall and humidity are limited to less than two decades which is not sufficient to correlate with the changes taking place.

Forest resources use

Bhutan is a predominantly agricultural country practicing traditional mixed farming, mainly for subsistence. The agricultural sector, consisting of crop farming, horticulture and livestock constitutes more than 69 % of the total population. Crop farming, livestock rearing and the use of forest products are integral to the farming systems that have been practiced for a long time. Although agriculture is one of the most important sectors of the Bhutanese economy, its contribution to GDP declined from 26 % in 2001 to 25 % in 2003 and 19 % in 2008[21,22].

Forests are also an important component of the Bhutanese farming system as farmers obtain a variety of products and services from forests, such as leaf litter for animal bedding and for the production of organic manure[23]. Forests also provide timber and fuel wood as well as NWFPs such as mushrooms and edible ferns to supplement local diets of local individuals and provide a source of cash income. There is a concern that climate change will impact the production of both NWFPs and timber from the forests of Bhutan.

The average quantity of current timber demand was observed to be 6.45 ± .255 in number, which is approximately double of the future demand by the people as predicted: 3.81 ± .107. Yet, Parametric paired t-test showed that the average quantity/household (HH) of timber produced over 5 yrs has decreased by 2.64 numbers which is statistically significant ($t = 9.8$, $p < .01$). Similarly, the quantity of wood and forest products such as fire wood, flag post, fencing post (No) and cattle bedding (kg) have been determined as 4.93 ± .281, 20.46 ± 1.31, 27.9 ± 1.28 and 961.18 ± 83.161, respectively over 5 yrs of time period. Parametric paired t-tests showed that the average quantity/HH/5yrs consumed for each of the above forest products has decreased by 1.52, 20.46, 27.99 and 961, respectively, which is statistically significant ($t = 5.9$, 2.7, 3.4 and 2.1,

Table 1 — Current and future timber demand (field survey, 2015-2016)

Category	Average quantity (No)/HH/5 yrs			
	Current	Future	Mean±SD	Paired t-test
Timber (no)	6.45	3.81	2.64±0.87	9.8**
Fire wood (no)	6.45	4.93	1.52±1.42	5.9**
Flag post (no)	23.87	20.46	3.40±7.03	2.7**
Fencing post (no)	30.00	27.99	2.01±8.21	3.4**
Cattle bedding (kg)	1123.88	961.19	162.68±672.84	2.1**

**Significant at $p < .01$
Source: Field survey (author)

$p < .01$, respectively) (Table 1). The reason for the decrease in demand of forest products could be due the completion of most the construction in the area and also other available options. A similar study carried out by Chhetri & Lexer (2011)[24] in Punakha, Bhutan on current and future demand for forest resources supports this finding, where demand have decreased compared to the current use. The noted decrease in the use of forest products is likely due to the Government's policy of encouraging people to minimize their use of timber and look for more viable alternatives in keeping the forest intact and helping in climate regulation. For instance, the government has encouraged people to use string flags with fewer poles rather than erecting 108 poles for various religious purposes. Moreover, supply of rural house building timber is strictly regulated by the Forest and Nature Conservation Rules[25]. A maximum of ten trees may be initially supplied to a household for construction; subsequently, they are entitled to additional timber only after 25 yrs. Other forms of timber such as flag posts and fencing posts may be supplied based on the actual requirement after field verification by the concerned authority. This is done to curb the illegal activities which may harm the forest resources and to make the public aware of the importance of natural resources and responsible citizenship.

To decrease firewood consumption in cooking and heating, the government has provided with 95 % of households with electricity, including 100 units each of free electricity to rural households. Recently, the government also initiated an improved cooking stove (part of its Climate Change Programme) to minimize the use of firewood and subsequently reduce greenhouse gas emissions. Unlike traditional stoves, this stoves consumes less firewood and also emits smoke through a chimney, which is good from a health perspective[26].

People are encouraged to use living fences, which greatly reduces the use of poles from the forest for fencing and also helps in carbon sequestration in line with the government's vision to combat climate change, and to remain a carbon neutral country. The government has also encouraged the farmers to rear improved varieties of cows (requiring fewer cows to produce the same volume of milk as the local varieties). According to a study carried out by WCD (2015)[27], during the period from 2012 to 2017 there was an increase in improved cattle from 24.1 to 27.4 % while the original local cattle decreased from 79.9 to 72.6 %, respectively. This reduction of livestock will greatly reduce the volume of leaf litter collected from the forest, which will improve moisture retention as well as carbon accumulation and retention.

The overall decreased dependency on the local biological resources will help immensely help in Bhutan's conversation efforts, enhancing the mitigation and adaptation measures through increasing carbon sequestration and moisture retention, mitigating rising temperatures and reducing erosion. The respondents in general perceived an importance of their community forests and most preferred to be involved in their management. Currently, they are not given this option, as forests are managed by the government for timber production. Allowing people to engage in managing the forests themselves as true community forests could prove to be a valuable alternative and would improve the livelihoods of the people depending on forest resources in the face of climate change.

Out of the 67 households surveyed, most (71.6 %) are engaged in NWFP collection. The main purpose of the collection is for domestic consumption. The amounts of NWFPs collected by individual households in a year have been presented in Table 2. Of the NWFPs collected by the HHs only a small amount (7.5 %) was sold in the local market. The respondents reported that availability of mushroom in the forest has decreased compared to previous years. This is mainly attributed to disturbances due to logging activities as per the communities' view. They also conveyed that mushroom and other forms of NWFPs occurred less in the conifer forest than in the broad-leaved forest. It was observed that, people residing closer to the forest were engaged in mushroom collection. People dry the mushrooms and use them during the times of vegetable shortage. Such practices encourage the people for adapting to food scarcity due to climate change.

Table 2 — NWFP

Variable	Quantity (kg/hh/yr)		
	Average±SE	Minimum	Maximum
NWFP collection	2.30±.402	0	15
NWFP consumed	2.08±.374	0	15
NWFP sold	0.24±.111	0	5

Source: Field survey (author)

Adaptation measures

Although we found that some kind of adaptive measures are practiced in response to climate change impacts at the community level, these are often short term rather than long term actions. In fact, most of the coping activities followed by local people were in response to the immediate changes they had experienced. Most of the respondents were not aware of the longer term impacts of climate change and its variability although they were experiencing them.

The assortment of potential adaptive responses available to human societies is quite large, although many of these are purely technological, managerial or policy based[3]. However, adaptation options practiced in the study area was found to be very limited. Different types of adaptation measures are practiced, e.g., feeding animals with improved feed (*Karma* feed) available in the market and irrigating farms with tap water in the absence of rain water. However, these measures were not necessarily due directly to the perceived climate change. Farmers reported that degradation of the pasture lands and low grass production has led to reduced livestock numbers.

Non-parametric χ-test of independent of attributes (Table 3) showed that there was an association between education and the response regarding the use of adaptation measures in the study area. This was statistically significant ($\chi^2 = 7.890$, $p < .01$), which means that literate people were more likely to adapt to climate change than uneducated people. A similar test showed that there was a statistically significant ($\chi^2 = 4.323$, $p < .05$) association of livestock rearing with improved and local cattle holding category. The association between number of family members per household and adaptation practices was also found to be statistically significant ($\chi^2 = 4.233$, $p < .05$). These results indicate that literate people are more aware of the changes taking place and more able adapt to the changes to some extent. For instance, households having more members were enabled to engage in collection of fodder and perform other activities.

Table 3 — Adaptation practices

Variables	Category	Adaptation responses (frequency and percentage)		
		Yes	No	χ^2 - value
Education	Illiterate	10 (32.3)	21 (67.7)	7.890**
	Literate	24 (66.7)	12 (33.3)	
	Pooled value	34 (50.7)	33 (49.3)	
Livestock	Local cow	13 (38.2)	21 (61.8)	4.323*
	Improved cow	21 (63.6)	12 (36.4)	
	Pooled value	34 (50.7)	33 (49.3)	
Members	Below average	13 (40.6)	19 (59.4)	4.233*
	Above average	23 (65.7)	12 (34.3)	
	Pooled value	36 (53.7)	31 (46.3)	

** Significant at $p < .01$, * Significant at $p < .05$
Source: Field survey (author)

According to (Panday, 2013)[28] rearing livestock is an important source of income to the rural population. Livestock rearing involves the collection of fodder from forests and agricultural fields, and grazing in forests lands which may have negative influence on the forest resources[28].

In the agriculture sector, people responded that government intervention is critical for adaptation to climate change through supply of improved varieties of seeds, construction of irrigation channels and electric fencing for protection of crops and livestock from wild animals. Therefore, it has become imperative to look at the possible adaptation programs at the community level to address unexpected changes occurring as experienced by the community at an early stage. Some respondents reported that the hardships faced in agriculture and animal husbandry were forcing people, especially the young generation, to change their occupation from farming to business, or to migrate from their villages in search of off-farm jobs.

Conclusion

Variations in temperature and precipitation patterns have impacts on various aspects of local life worldwide. People in our community-based study in rural Bhutan reported that the impacts they experienced were more adverse than positive. Bhutan practices subsistence agricultural farming. Livestock are an important source of food, and supplemental cash income through sale of their products. The majority of the people living in the study area are farmers and their main sources of livelihood are from agriculture and livestock. The local communities use the natural resources in the study area in line with the Forest and Nature Conservation Rules and

Regulations. They depend both directly and indirectly on available natural resources for food (non-wood forest products), timber, firewood, flag post, fencing pole and cattle bedding. Farmer interviewed in the study area were able to recognize that temperatures have increased, snowfall has decreased, and that the rainfall pattern has become more erratic. The study also found that people with higher incomes are better able to adopt adaptation practices. For example, people with higher incomes opted for improved varieties of cows and used feed purchased from the market rather than relying on local fodder. Empowering communities with information on the impacts of climate change, technological skills, education and employment is crucial to overcome vulnerability. More in-depth research is, therefore, necessary to further identify and document climate change impacts and develop appropriate and effective adaptation strategies. The findings of this study provide a clear direction for future research and for development planning and adaptation management programs in the region. Such a research could develop adaptation strategies or highlight mechanisms that are already being implemented by the local people in response to climate change.

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