Assessing vulnerability and adaptation strategies of forest dependent people to climate change in the Mid-hills of Nepal

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Climate change is now recognized as one of the most serious challenges facing the world– its people, the environment and its economies. Rural people are more vulnerable to the effects of climate change due to its high dependence on climate-sensitive sectors like glaciers, agriculture and forestry, and its low financial adaptive capacity. This study was carried out with the aim of assessing and documenting vulnerability and adaptation strategies of forest-dependent people to climate change effects in Mid-hills of Nepal. Primary data were collected from household survey, interview with key informants, and focused group discussion. The results showed that the average annual rainfall was decreasing at the rate of 18.02 mm whereas the average annual mean temperature was increasing at the rate of 0.07°c per year. The major climatic hazards, of the study area, identified were long drought and landslide. The chi-square test shows that the poor forest-dependent people are more vulnerable to long drought, landslide and floods as compared to the rich rural people. Indigenous adaptation practices such as cultivation of vegetables and other crops that are less susceptible to droughts, and rearing of hybrid-varieties of livestock are mostly used to cope with climate change impacts. The results indicate that 15% of the respondents have changed their cropping pattern from paddy to off-seasonal vegetables crops because of more income from vegetable farming. Raising awareness and sharing information as well as increasing income from farming among the locals by applying new technologies should be done in order to build their capacity to cope with climate change impact.

Key words: Vulnerability, livelihood, adaptation, climatic hazard, impacts

Climate change refers to a "statistically significant variation either in the mean state of the climate or in its variability which may be due to natural process or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC, 2001). There has been an unprecedented warming trend during the 20th century. The average temperature of the earth's surface has risen by 0.74°C since the late 1900s (IPCC, 2007). The present average global surface temperature of 15°C is nearly 0.6°C higher than it was 100 years ago. Most of the increase is because of the consequences of human activities. A further increase of 1.5–6.0°C is projected by the year 2100. The average atmospheric CO_2 concentration has increased from 280 ppm in 1,850 to 365 ppm at present, and could exceed up to 700 ppm by the end of the present century, if emissions continue to rise at the current rates (IPCC, 2001).

Climate change is now recognized as one of the most serious challenges facing the world and its people, the environment and its economies. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) has mentioned that global warming is mostly due to man-made emissions of Green House Gases (GHGs), mostly CO_2. It is believed that most global warming that we can now observe is attributable to emissions of GHGs that result from human activities, in the land use changes such as deforestation particularly in the developing countries, and the burning of fossil-fuels specifically in the developed countries. There is consensus among many scientists that the anthropogenic cause of increment of GHGs in the atmosphere is the main cause of the climate changes incidences experienced (Louman *et al.*, 2009). Global GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) emissions due to human activities

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have grown since the pre- industrial time with increase of 70% between 1970s and 2004 (IPCC, 2007).

Vulnerability is the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate. The IPCC has defined vulnerability as "a measure of system's susceptibility to climate change, which is a function of the system's exposure, sensitivity and adaptive capacity". The capacity to adapt to climate hazards and stress depends on a country's wealth, resources and governance. The Himalayan region is one of the most vulnerable regions to climate change in the world, not only because of more rapid increase in temperature but also due to the inhabitants being among world's poorest groups. Adaptation to climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to changes in the climate system (Smit *et al.*, 2000). Furthermore, it is argued that human and natural systems will, to some extent, adapt autonomously, and that planned adaptation can supplement autonomous adaptation.

Nepal as a part of the globe cannot remain untouched to this global change. Although Nepal is responsible for only about 0.025% of the total annual greenhouse gas emissions of the world (Karki, 2007), the nation is now experiencing the increasing trends and the associated effects of climate change. Various studies have shown that the impacts of climate change are evident on forests, water resources, agriculture and other sectors in Nepal. Observed data indicates consistent warming and rise in maximum temperature at an annual rate of 0.04–0.06ºC (GoN/MoE, 2010). A report published by the Department of Hydrology and Meteorology shows that the temperature in Nepal is increasing at the rate of 0.06°C, on an average, per annum (DHM, 2008). Between 1977 and 1994, the nation's average temperature rose at the rate of 0.03-0.06°C per annum, with a higher rate in the mountains than in the lowlands (Shrestha *et al.*, 1999). Another report of the Government of Nepal based on an analysis of the temperature recorded between 1981 and 1998, shows an increase of 0.41°C per decade (MoPE, 2004). The temperature in the Himalayas, however, is increasing at the faster rate than that in the lower lands. On the other hand, there is no distinct trend regarding precipitation changes in Nepal. Observations show that the high-rainfall-regions and seasons are experiencing increase in rainfall and are getting wetter, whereas the low-rainfall-regions and seasons are experiencing decrease in rainfall and are getting drier (MoPE, 2004). Besides, extremes in monsoon have also been observed in the recent years. The meteorological station at Nepalgunj in Western Nepal recorded the ever highest rainfall of 336.9 mm within 24 hours on August 27, 2006 (SOHAM, 2006).

Developing countries are more vulnerable to the effects of climate change due to their high dependence on climate-sensitive sectors like glaciers, agriculture and forestry, and their low financial adaptive capacity (Karki, 2007). Countries like Nepal are more susceptible to the climate change and its impacts due to their limited capacity to cope with hazards associated with the changes in climate (Kates, 2000). The ongoing climatic changes which are projected to occur in the future are likely to occur in the different sectors like, water resources (that include glacial fluctuation, hydrological regime and GLOF), agriculture sector, flora and fauna, health sector and livelihood (MoEST, 2008). Forest and water resources, the major natural resources of Nepal, are at the forefront of climate change vulnerability (PAN, 2009). Because of the climate change and rising temperatures, Nepal could face the drier phases during the dry seasons with wetter monsoon (as much as three times the current level of rainfall) with chances of flood and landslides during the rainy season with subsequent impacts on agriculture, forestry and livelihoods (Alan and Regmi, 2005).

Nepal is one of the most vulnerable countries from the view point of climate change. This phenomenon of climate change has directly affected upon the natural resources like land, water and forest resources. Those people who directly depend on these resources, particularly forest resources, are becoming more vulnerable day by day. While there is much anecdotal evidence of climate change, no comprehensive studies have yet been conducted on vulnerability and adaptation strategies of forest-dependent people. Studies on vulnerability of the local livelihoods and adaptation strategies can provide basis for the concepts and methods for assessing

climate change impacts, vulnerability and adaptation. This study is focused on how the rural forest-dependent people perceive and understand climate change in their local context, what class and level of people are more vulnerable, and what major adaptation strategies are adopted by the rural forest-dependent people to cope with climate change impacts in the Mid-hills of Nepal.

Materials and methods

Study area

The study was carried out in Khanchikot Village Development Committee (VDC) of Arghakhanchi district, Nepal. Khanchikot VDC is located on the southern belt of the district (Figure 1). The altitudinal range of the VDC varies from 1,000 m to 2,500 m above the mean sea level, and so climate also varies from sub-tropical in the south to temperate in the north. The total area of the VDC is 1563.1 ha of which forest is the major land use type (61.22%) followed by cultivated land (26.55%), shrub (11.45%) and others (0.78%) (DFO, 2010). The total population of the VDC is 4,091 with 69.15% Brahmin/Chhetri, 21.7% Dalit and 9.16% Janajati (KVDC, 2010).

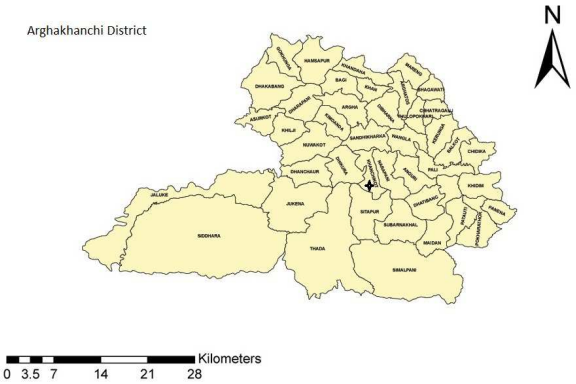

Fig. 1: MAP showing the study area

Sampling design and data collection

Altogether, 55 forest-dependent households (HHs), which is about 11% of the total HHs within the Khanchikot VDC, were taken as samples for the study purpose. In each ward of the VDC, economic-classes (rich, medium and poor) were identified using participatory well-being ranking method to analyze the degree of vulnerability on the basis of the economic status of the respondents. The major variables used for well-being ranking were physical, human, social, financial and natural capitals.

In vulnerability analysis, the conceptual framework provided in the third assessment report of the IPCC, 2007 was used, where vulnerability of a system has been defined as a function of three elements *viz*. i) exposure to climate change effects, ii) sensitivity and iii) adaptive capacity. Mathematically, vulnerability is expressed as:

$V = f$ (exposure, sensitivity and adaptive capacity) …….. (1)

Major climatic hazards of the study area were identified on the basis of the people's exposure on their livelihood assets (physical, biological, financial, human and social capitals) to adapt with the climate change effects, through discussions with the key informants, community forest users, farmers and community leaders. Climatic hazards were further ranked on the basis of their exposure and sensitivity on five capitals and their adaptive capacity to adapt these climatic hazards. The following hypothesis was made to analyze the vulnerability of different economic status of the respondents.

H_0: Different levels of vulnerability due to major climatic hazards are not associated with economic status of the rural people.

H_1: Different levels of vulnerability due to major climatic hazards are associated with economic status of the rural people.

The primary data were solicited through reconnaissance survey, key informants interview, formal and informal discussion, household survey and direct observation while the secondary data were collected through review of literature available in the form of journal articles, thesis, publications and websites.

The climatic data (temperature and rainfall) of the VDC between 1978 and 2009 were acquired from the Department of Hydrology and Meteorology, Kathmandu. The maximum and minimum monthly temperatures as well as the mean monthly rainfall data were used as the major indicators of climate change in the study area.

Microsoft Excel 2007 was used to analyze the temperature and rainfall data. On the other hand, the qualitative data were analyzed using Chi-Square Test.

Results and discussion

Socio-economic status of the respondents

Altogether, 55 HHs of the VDC were selected for the purpose of the study, of which 53% of the HHs belonged to Brahimin/Chhetri, 25% to Dalit and 22% to Janajati as shown in figure 2. Out of the total HHs sampled, 14% were rich, 22% were of middle-class and the rest 64% were poor as shown in figure 3. Majority of these HHs were engaged in agricultural activities.

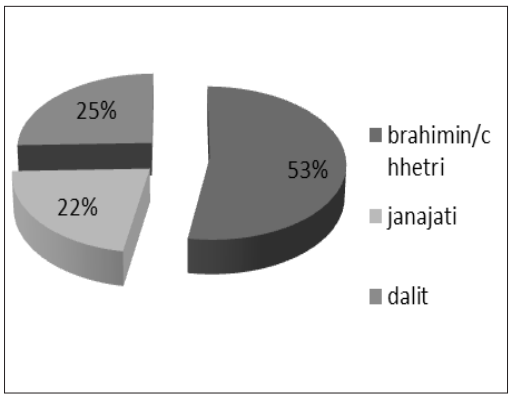

Fig. 2: Ethinicity of the respondents

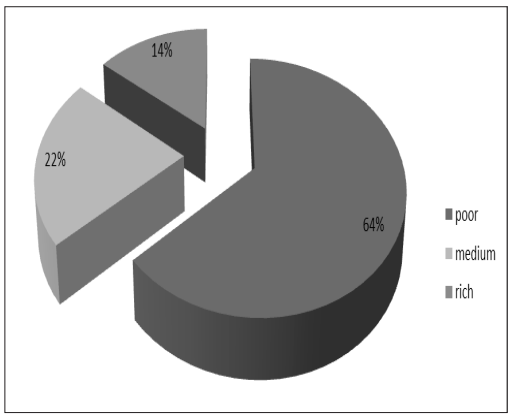

Fig. 3: Wealth being status of the respondents

Analysis of climatic variables

Analysis of temperature data

Change (increase or decrease) in temperature of any area is a direct indicator of climate change in the area. For the purpose of this study, the monthly maximum and minimum temperature data of the last 31 years (1978–2009) were used. The linear trend line (Figure 4) shows that the mean annual temperature over the last 31 years was in increasing trend at the rate of 0.07°C per annum, a slightly higher than the national average of 0.06°C per annum, with the highest temperature of over 18°C recorded in the year 2002.

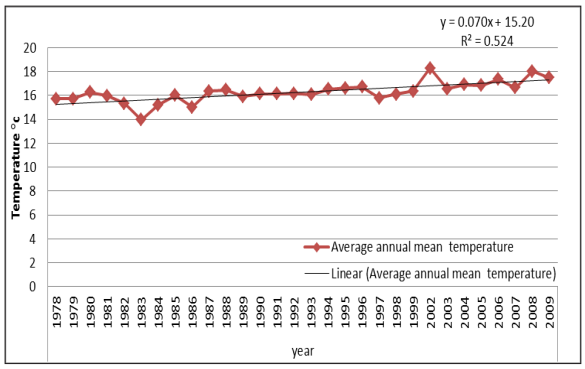

Fig. 4: Average annual mean temperature (1978–2009)

Considering 1978 as the base year (when the average annual temperature was 15.78°C), Figure 5 below indicates the increasing trend of temperature during the period of 1978–2009 with the average decade temperatures of 15.82°C, 15.91°C and 17.10°C during 1979–1988, 1989–1999 and 2000–2009 respectively with the highest increment of 17.1°C in the last decade i.e. in 2000–2009.

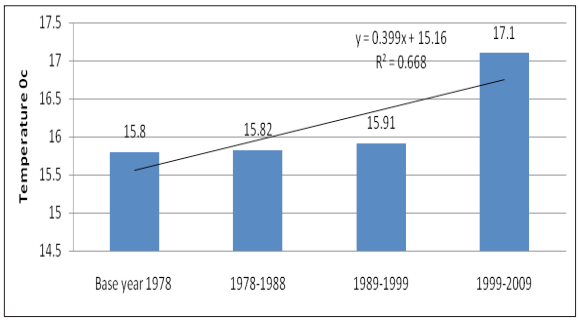

Fig. 5: Mean decade temperature and its trend

Analysis of rainfall data

Rainfall is another major factor to indicate climate change in any area. The annual rainfall data of the last 30 years (1978–2008) were taken for the study. The average annual rainfall over the past 30 years shows its decreasing trend with erratic pattern (R^2 = 0.12) at the rate of 18.02 mm per annum during the period (Figure 6).

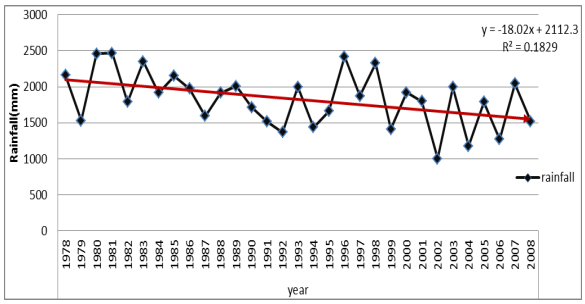

Fig. 6: Average annual rainfall and its trend (1978–2008)

Rainfall data were analyzed on the seasonal basis like winter (December–February), spring (March–May), summer (June–August) and autumn (September–November) during the three decades. The result showed that the average rainfall on the seasonal basis was also in decreasing trend except for the spring season as shown in Figure 7.

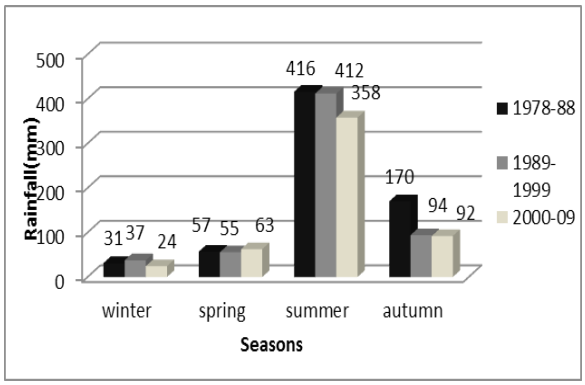

Fig. 7: Average seasonal rainfall in decades

Vulnerabilities of forest dependent peoples to major climatic hazards

The major climatic hazards of the study area were identified in a participatory way i.e. on the basis of the people's exposure and sensitivity to these hazards. The major climatic hazards as reported by them were- long drought and landslide.

Long drought impact and vulnerability

According to the local people's experiences, the cases of droughts in the study area were in increasing trend. According to them, most of the droughts cases were experienced when there were needs of rainwater. One third of the respondents expressed that the long drought has directly affected upon the germination and growth of the forest species leading to the unavailability of some preferred fodder species in the study area. Besides, the water levels in various water sources such as natural springs and wells were also found to have gone down year by year. There had been scarcity of water, especially during the period of- seedbed preparation, flowering stage of the paddy, irrigating wheat and other winter crops. It was found that frequent droughts had destroyed and eroded the social assets, the very means for adaptation. Similar was the case observed in the Mid-hills of Dhading district where natural springs, wells and other water sources had dried since the last 7-8 years due to decreased amount of rainfall to recharge these sources (SAGUN, 2009).

When frequency and intensity of climatic hazard increase, poor communities are left with no time to recover from previous impacts through either asset accumulation or acquiring skills and knowledge necessary for adapting to future climate changes. Consequently, they are subjected to continuous hunger and deeper vicious circle of poverty and vulnerability. This shows that rural forest-dependent people are highly vulnerable to long drought. However, the degree of vulnerability varies according to the economic class of people. The results of this study reveals that poor forest-dependent households are highly vulnerable to long drought as compared to the well-off rural people ($\chi^2 = 16.69$ with 4 d.f. at 5% level of significance, is significant).

Landslide impact and vulnerability

It was found that erratic rain, floods, droughts and other natural calamities were the common phenomenon in the study area, and the local people experienced such unusual situations for more than 15 years in the past. Same case was reported by Shrestha *et al.* (2000) that all the national as well as the regional precipitation series showed significant variability on annual and decadal time scales. These situations invite new fear and trauma. When a community is hit by natural calamities, all of its social institutions (local clubs, ethnic or cultural groups, educational institutions, health care center etc.) are likely to be affected.

The landslides have affected livestock, agriculture, land, crop and mobility of the people. The landslide has occurred in sloppy and fragile forest land. Households near to the unstable slopes and fragile area are highly vulnerable to landslides. This VDC is situated on the

steep topography making it more vulnerable to landslide. Around 70% of the forest-dependent HHs live in fragile, steep and marginal lands. The local infrastructures like health post, VDC office, post office and secondary school are also vulnerable to landslide and to some context floods too due to their spatial arrangement. This shows that locals are at higher degree of vulnerability due to landslide. However, the degree varies with the different economic classes. Local indicators were developed for these criteria in a participatory manner. The chi-square test has verified that the degree of vulnerability was higher in the poor forest-dependent HHs than the well-off HHs (χ^2 = 12.31 with 4 d.f at 5% level of significance, is significant).

Adaptation strategies

Though, people have poor knowledge on the technical matters of climate change, they have shown several evidences, which demonstrate that they have perceived, felt and experienced its effects. The major adaptation strategies adopted in different sectors are as follows:

Agriculture and forest resources

In order to escape from continuous crop failure owing to unusual rain and frequent droughts, people are forced to seek some alternatives. For instance, some people have been trying to reduce their paddy lands and introduce vegetables, other than crops, that are less susceptible to droughts in additional land. The results revealed that 15% of the respondents had changed their cropping pattern from paddy to off-seasonal vegetables crops because of more income from vegetables farming. People were not willing to change from their traditional agricultural practices to off-seasonal agricultural practices, but the changing climate had forced them to do so. For instance, late cultivation of paddy hampered the cultivation season of wheat and mustard. On the other hand, people used to transplant hybrid-paddy quiet earlier, otherwise it would be affected by insecticides and pests. The results showed that 30% of the forest dependent-households had started to raise the fodder species in their agricultural lands due to unavailability of fodder species in the nearby forest. Some of the households also use biogas as an alternative to firewood. Much of the significant adaptation practices are still based on the indigenous knowledge and technology that needs to be enhanced.

Livestock rearing

With the changing pattern of climate, 20% of the households had started to raise the improved variety of livestock instead of the local variety. Hybrid and improved varieties of cow and buffalo are common emphasizing milk production. More milk yielding livestock are popular as selling milk is quite easier due to market development and reasonable price. With the continuous flood, the river banks look like desserts. Now, people have group approach to reclaim the degraded lands for fodder promotion, income generation activities through cash crops and community plantation through community forestry approach.

Water resources

The traditional water ponds are getting lost gradually. According to the respondents, 2 water ponds were lost in the recent year. Some ponds had problem of siltation while others are either encroached or have dried up. But now with the implication made by the absence of traditional ponds, people are building awareness on the importance of traditional ponds. Through the initiation of community forest user groups, peoples are engaged in the conservation and maintenance of water ponds to harvest monsoon rain and also to be used by their cattle for consuming water and taking bath.

Landslide

Khanchikot VDC is highly vulnerable to landslide due to its steep topography, human settlement on fragile lands and lack of infrastructure for pre-warning. Ward No. 2, 8 and 9 are more vulnerable to landslide. To deal with the problem of landslide, the locals have started to construct check dam with gabions and bamboos, and gabion spurs along the ravines and streams.

Conclusion

Based on the meteorological data, it was found that both the minimum and the maximum temperatures in the study area were found to be in the increasing trend with 0.092ºC and 0.05ºC per year respectively. In addition, rainfall pattern in the study area was irregular with decreasing pattern every year at the rate of 18.02 mm/ year. The results of the study revealed that the

climate change had severely affected upon the rural households. The study area was exposed to different climatic hazards like long drought, landslide, floods, forest fire, and pest and disease outburst in the forest. Long drought was identified as the most threatening hazard among all the climatic hazards. Landslide was identified as the second most threatening climatic hazard in the study area. This study explored that the locals were vulnerable to long drought. However, the degree of vulnerability differs among the different economic classes. This study concludes that the poor people are in higher degree of vulnerability than the well-off rural people to different climatic hazards. Majority of the respondents were not found to have adopted proper adaptation practices to cope with these climatic hazards. Some of the respondents were found to have changed their cropping pattern and planted hybrid variety of crops. The locals were found to have been using indigenous practices in agriculture, livestock rearing and forest resource management. But these indigenous practices are short-term solution for sustainable resource management and for coping with the adverse effects of climatic hazards. Raising awareness and sharing information with technology as well as increasing farm income among the locals should be done to build their capacity to cope with the impact of climate change. Improved agriculture technology, training and awareness to farmers, initiating mixed cropping pattern, improved and drought-resistant varieties of crops must be introduced to cope with the effects of climate change. Furthermore, preparation and execution of local adaptation plans integrating with the local development activities cannot be overlooked.

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