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Local people's perception on Climate Change, its impact and adaptation practices in Himalaya to Terai regions of Nepal

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Abstract: *The study showed that average temperature has increased from 0.6 to 0.98^0 C over the last 30 years and precipitation is characterized by large inter-annual variability with substantial decrease in amount over the last five years. The annual temperature increasing trend followed 0.055>0.0455>0.035>0.02 ^{0}C yr^{-1} from Middle Mountain, Siwlik, Himalayan and Teari regions respectively. More than 80 percent HHs responded that they have perceived increased temperature and expressed low amount snowfall in High mountain and rainfall in Mid mountain and Terai region over the last five years. Low amount of snow fall in the Himalayan region affected to the Nomad groups due low grass available to feed their livestock. Furthermore, local collector reported that there was lower availability of the medicinal plant such as Nirmasi and Jimbu due to low precipitation in the High mountain region. Similarly, more than 75 % respondent explored that monsoon has started one or two weeks later and increased the more number of drought days in the Mid-mountain and Terai. Study found that there was also decreased in water sources, ground water, and increased siltation and sedimentation in the downstream Terai region. Furthermore, change in flowering and fruiting time in some species, increased invade species like Agerative spp, Lantana camera in the farm land as well as forest land.*

Adaptation measures such as use of water source, community forest management, planting trees and grasses in the farm land, crop diversification were practiced by local people in their farm land as well as communal land. Natural resource degradation, poverty are already severe problems in this region, and there will be more severe problems in future if present scenario continues, particularly because small farmers do not have adequate resources to adopt to cope with CC impact. Study showed that Mid-mountain region is less vulnerable through climate change than other regions. Furthermore, no any policies and programs have been formulated for adaptation strateragy in this region. It is suggested that policy and program should formulate holistic approach and develop low cost technology for adaption to CC impact and improve livelihood of the local communities.

Keywords: Extreme events, livelihood, rainfall, temperature, variability, vulnerability.

Introduction

Climate change is expected to have serious environmental, economic, and social impacts on South Asia in particular, where rural farmers whose livelihoods depend on the use of natural resources are likely to bear the brunt of its adverse impacts (ICIMOD, 2009). The region is also confronted by issues like poverty, environmental degradation, natural resources depletion, shrinking water resources; desertification and climate change (Schid, 2008). Climatic variability in this fragile ecosystem and nature based livelihood system of the rural communities has further threatened the livelihood of the local people.

IPCC (2007) has listed three key sectors, food and fiber, land degradation and biodiversity as the most vulnerable to climate change in the South Asian region. 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. Assessing the potential climate change impacts and economic analysis are urgently needed for the survival of these rural communities.

Nepal's share in climate change is negligibly small. The population of Nepal is less than 0.4% of the world population and is responsible for only about 0.025% of annual greenhouse gas emissions (NAPA\MOE, 2009). However, Nepal is highly vulnerable to climate change impacts. Temperatures are likely to increase more in high mountain areas than elsewhere (Shrestha et. al. 1999). Glaciers and snowfields will recede and may even disappear, reducing Nepal's dry season water resources. This will affect irrigation and drinking water supply and hydroelectricity will be less reliable. In addition, receding glaciers often leave behind growing glacier lakes that can break through terminal moraines causing catastrophic floods. Global climate change will also likely shift monsoon precipitation patterns in ways that will threaten Nepal's current agricultural practices, infrastructure, bio-diversity, especially in mountain regions where migration of species is physically restricted (Regmi et al. 2009).In order to improve the ability of communities and households to adjust to ongoing and future climate change, we need improved understanding of the risk they are facing. Estimating possible future adaptation is essential to climate change impact and vulnerability assessment. Therefore, assessing the potential climate change impacts on livelihood are urgently needed for the survival of these rural communities.

Objectives of the Study

1. To evaluate long-term climate data (on precipitation and temperature) in order to determine variation in climate at different altitudinal regions of Nepal.

2. To understand farmers' perception and experience of climate change.

3. To identify the impact and adaptive measures being taken to maintain farmers' farming and livelihood in different regions (Himalaya to Terai region) of Nepal.

Research Methodology

Study Area

Study was conducted along a north-south transect of the Narayani Basin, a major tributary of the Ganga river. This transect runs from the Trans-Himalayan to lowland southern regions (Upper-Mustang (Trans-Himalayan region near Tibet-China region, High mountain, Mid-mountain and Lowland Terai (near India border) (Figure 1) of Nepal. Data were collected from each site at different altitudes (3,500 m, 2,500 m, 1,500 m and 150 m) which covers the range of the high altitude to lowland regions of Nepal. The study area is one of the most suitable in which to study climate change impacts and adaptation practices through different communities and ethnic groups from Himalayan to the lowland Terai regions.

Data collection

Studies on perceptions, responses and local knowledge of climate variability, impact on farming and adaptive strategies at the household and community levels were gathered through field observations, personal interviews, key informants interviews as well as consultation with institutions and community based organizations. Semi-structured questionnaire was used to ask farmers whether they have noticed long-term changes in mean temperature, mean precipitation, extreme climatic events, and change in natural resources over the past 30 years. Rainfall and temperature data (1979 – 2008) were collected from Department of Hydrology and Meteorology, Government of Nepal. Secondary sources of data about policy, programs and activities regarding climate-related risk management, and adaptation practices were also collected from different government agencies.

Data analysis

Data collected from both meteorological stations and HH survey were analyzed by using the Statistical Package for Social Science (SPSS) version 16 software and Microsoft excel. Statistical tests such as time series; regression, mean comparison were used to compare impact of climate change on different groups of adaptation strategies in different regions. Qualitative information such as farmers' experiences regarding climate change and adaptation measures taken on their farmland collected from key informants interviews and local level institution were analyzed manually, both by the researcher and in conjunction with the villagers, and interpreted in relevant chapters to complement and supplement the quantitative information collected from household interviews and the meteorological stations. Finally, data were compared different regions by performing an impact assessment and evaluating adaptation practices in their farming as well as livelihood strategy.

Result and discussion

Climatic variability and Meteorological data analysis

The climate of the area can be characterized as cold desert temperate to subtropical and tropical climate. The climate is subalpine, and had a maximum and minimum temperature of 26.8°C and 9.9°C in July and 10.7°C and - 5.8 °C in November in the Trans Himalayan region. The whole area remains under snow for 4 – 5 months from November to March. Total annual rainfall is less than 200 mm and more than half of the total precipitation occurs as snow during the winter months (DHM, 2007). Whereas, subtropical climate found in the Mid-Mountain region. The minimum and maximum temperature recorded from 4.8 to 25 ^{0}C with more than 4000 mm rainfall annually. Similarly, in Tearai and Siwalik region maximum temperature recorded more than 38^{0}C during the summer and average annual rainfall recorded more than 1900 mm.

Long-term temperature data analysis (1979-2008)

The temperature data from different region (High Mountain to Terai region) between 1979 and 2008 showed a warming trend. During the period of 30 years, the mean annual temperature has increased by 0.03^{o}C yr^{-1} (Table 1). Though this warming trend is in line with the mean annual maximum temperature estimated by Shrestha, et al. (1999), it is higher than global average increased given by IPCC (2007). Average seasonal temperature data analysis showed more prominent rising of temperature in winter ranges from 0.05°C in Middle Mountain to 0.02 ^{0}C in Terai region yr^{-1} (Table 1), which clearly indicates the warming trend in winter is more as compared to summer seasons. The annual temperature increasing trend followed 0.055>0.0455>0.035>0.02^{0}C yr^{-1} from Middle Mountain, Siwlik, Himalayan and Teari regions respectively.

Precipitation data analysis

The recorded data on rainfall from 1979 to 2008 showed large inter annual variability, with highest rainfall in middle mountain region (5441 mm) to lowest in the Trans-Himalayan region (179.4). More than 80 percent of the annual downpour was found to occur during Monsoon season only (Table 2). However, during the last few years (2000 to 2006), there was a substantial decrease in the amount of rainfall especially in monsoon followed by increasing downpour in the consecutive years.

The monsoon rainfall is mainly of an orographic nature, resulting in distinct variations in rainfall with elevation between the southern slopes of the Himalayas and the rain shadow areas on the Tibetan Plateau (Mei'e, 1985). On the meso-scale, the impact of climate is mainly due to local topographic characteristics (Chalise, 2001); with dry inner valleys receiving much less rainfall than the adjacent mountain slopes as a result of the lee effect. This suggests that the currently measured rainfall, which is mainly based on measurements of rainfall in the valley bottoms, may not be representative for the area, and the use of these data results in significant underestimates.

Local people response to climate change

Majority of the local people (more than 75 %) were responded that they have experiences change in climate with increasing temperature (Figure 2) in all ecological regions. Additionally, more than 80 % of the respondents were reported rainfall variability with untimely, late monsoon start, no winter rain and high intensity pattern with short periods (Table 3). Furthermore, they have been experiencing an unpredictable rainfall patterns over the past 10 years. Almost 70 percent respondents said that the incidents of drought have been increasing and link it with the untimely and unusual rainfall patterns over the past few years in both study sites (upstream and downstream) (Figure 3). Additionally, Trans-Himalayan communities reported that there used to be good snow fall in high altitude area, before it could be up to 2 to 2.5 feet. But, lately snowfall is only negligible in last 3-4 years. Furthermore, local people have also noticed spectacular changes in their surroundings in the last couple of decades; hillsides that once used to be covered in snow throughout the year are now bare and dry. In many cases, stories from local people confirm findings from recent scientific studies, particularly about shrinking snow cover and retreating glaciers (ICIMOD, 2009). Stream flow and spring characteristics have changed dramatically in recent years, making it challenging to manage water supplies.

Local peoples' perceptions on changing climate and major impacts

People responded that climate change has both positive and negative impact on rural livelihood. Some farmers in Mustang, in the Jomsong (district head quarter), reported that the changed climate has positive impact in the agriculture farming. Farmers are growing new vegetables such as cauliflower, cabbage, chili, tomato and cucumber, which used to need greenhouses to survive. Local fruits have better sizes and tastes.

Agriculture is the mainstay in the study area and more than 90% people follow traditional cultivation practices that rely on seasonal rain water. Erratic rainfall patterns, contributing to soil erosion, landslides in the upstream and flooding and sedimentation in the downstream sites, which resulted loss of soil fertility, and decreased crop yields as well as crop damage. Though drinking water has increased due to availability of water storage tanks and water pipes, local people said that they were facing more drought periods resulting decrease in natural springs and irrigation water (Table 3). Key informant reported that there were drastically decreased Millet, Black gram and Mustard production over the last 4 years in the Mid-mountain and Siwalik region. This may affect agriculture production, and subsequently food security. In Trans-Himalayan region, Nomad groups and livestock farming has found negative impact through climatic variability at Upper Mustang (Lomanthang). Most highland communities depend on cattle and sheep farming and, therefore, have serious concerns over the declining production of grass in the Himalayan grasslands. This is mainly due to moisture deficiencies resulting from reduced snow deposits. Furthermore, local people noticed that there was less availability of medicinal plants (Nirmasi, Jimbu) (Table 3). It might be due to climatic stress such as less water, and change in weather patterns herbs in high altitude became vulnerable and found less and less.

Local people shared some experiences of climatic conditions, ecosystem function and process, and biological system, however most of the respondents were not aware about scientific facts and information regarding climate change, but they understood as rainfall and warming system. Moreover, respondents were unaware about changing climate and its impacts at local level but their knowledge in the local level changes cannot be overlooked.

Local peoples responded based on their past experience that warming days, erratic rainfall patterns, ecological variability, biological change and their adverse effects on human beings have increased. More than 50% respondents said that warming days have been increasing, rainfall pattern has become more unpredictable, seasons may have been changing, frequency of drought has increased, warmer wind flows these days, decreasing natural water sources, windstorm is getting stronger, changes in flowering and fruiting time (Rhododendron, Bauhania species), invasion of new plant species such as Banmara (Machania spp) Kalo banamara (Ageratina adenophora), Seto banamara (Lantana camera) and Gandhe (Ageratum spp) plant with bluish flower are found in abundance. These invasive species such as Kalo banamara (Ageratina adenophora), Seto banamara (Lantana camera) sifted in the higher altitudes also. The main reason for their adaptation may be increasing temperature in recent years. As a result of excessive spread of these invasive species, the local species which were in abundant numbers are decreasing in recent years and reduction of some indigenous tree (Dabergia spp, Bombax spp, Acacia spp), as well as Non Timber Forest Product species (Asparagus, Amala, Harro and Barro, Amrishio, Bamboo) in the Siwalik and Terai regions. Additionally, there were decreased fish availability in the stream and wild bee hives in the study areas (Table 3). Furthermore, local people reported that there is increasing the stream bed and expanding the sedimentation area in the Terai and Foothills sites. The impact on agriculture and natural resources will directly affect the livelihood of the local communities. Developing countries are the most vulnerable to natural disasters that have serious economic impacts (WWF Nepal, 2005).

Adaptation measures

In recent years, adaptation has become a key focus of the scientific and policy-making communities and is now a major area of discussion in the multilateral climate change process (NAPA\MOE, 2010). As we moved from Downstream to Upstream in all sites, we found various types of adaptation strategies followed by local people. Though, these strategies were for predictable influences they have been experiencing since time immortal, may not be effective in the response of climate change impacts. Some local coping and adaptation strategies adopted in response to observed risks and hazards related to climate and non-climatic factors. Ellis (2000) reported that rural people in developing areas accrue specific responses to cope with short-term shock events. However, these are often responsive rather than planned actions, with capacity to regenerate and initiate planned livelihoods adaptations limited by poverty and livelihood shocks. In fact, most of the coping activities followed by local peoples were in response of change they have experienced in daily life and according to their traditional beliefs and thus were not explored. These measures found to be event specific based on local knowledge and innovations, because most of the respondents were not aware about actual impacts of climate change and its variability. Much of the climate change adaptation literature provides similar dichotomies in temporal and spatial scales. Local-level adaptation actions, for example are often portrayed as reactive, while higher-level institutions are assumed to plan in an anticipatory manner for adaptation through policies, programs and, most recently through National Adaptation Plans of Action (Smit et al., 2001; Barrett et. al., 2001). Adaptation is associated with planned action, either anticipating a threat or averting its impacts and infers some measure of progress or consistency of response (FAO, 2007).

Different types of adaptation practices were found in Himalaya and Terai region. In high mountain regions adaptation measures were found very limited. Farmers were reported that degradation of the grass land and low grass production they have reduced the livestock numbers as well as practiced rotational grazing. Some respondent reported that hardship of the livestock and agriculture farming they were either changed the occupation such as Hotel business or migration from that place. Furthermore, in Mountain and Siwlik region, local people have been managing forest as a community forest, which may increase the resilience of community by fulfilling the demand of forest products and minimized shifting cultivation from indigenous communities (Chepang) in Siwalik region. They have adopted Sloping Agriculture Land Technology (SALT) as an agroforestry (Herto-Silviculture) practices in their steep land and minimized soil erosion. Majority of these local farmers were practicing vegetable farming instead of cereal crops as crop diversification, livelihood diversification to earn more income than cereal crops. Optimum utilization of marginal lands by planting fodder trees, fruit trees, and other grasses also observed. Additionally, upstream people are now started rain water harvesting, conservation pond and utilization of excess drinking water for vegetable production.

Similarly, in the Mid-mountain,Siwlik and Terai region, communities have managed the forest as a community forest, plantation tree in their communal and private land. They were adapted water pump, cannel irrigation for crop production, River training, and embankment construction to protect their agriculture land. They have also adopted use of high yielding varieties, multiple cropping and use of chemical fertilizer and pesticides for crop production. However, changes of local seed to improved seed of vegetables as well as cereal crops has resulted loss of local races. Similarly, there is trend of replacing local varieties of crops with hybrids, which in long run can threat to the agro-biodiversity, though may provide short term good outcomes compared to local races. Additionally, those affected from loss of land from flooding and river bank erosion in the last downpour rainfall events (1986, and 1993) were moved to encroach nearby forest land for agricultural cultivation and settlement in the foothills of the Siwlik region. The array of potential adaptive responses available to human societies is very large ranging from purely technological through behavioral to managerial and to policy (IPCC, 2007). For developing countries like Nepal, availability of resources and building adaptive capacity are particularly important.

It is reported that there were no any government or non government organization working to aware and minimize impact on climate change in the field level. Moreover, communities have formed many groups such as Mothers' group, Community Forest User groups, Bufferzone User Groups, Community Managed Cooperatives, Vegetable farmer's group for community level works such as, natural resource management, awareness raising, cleaning and fund collection. These local groups can become potential institutions to community as well as local level adaptation measures in the future. Owing to the presence of many institutions influencing each and every aspect of the community works as Agrawal and Perrin (2008) reported they are critically important in the design of adaptation projects.

Nepal's Response to Climate Change (Policy and practice)

Mitigation and adaptation policies for climate change are under process. Policies are directly and indirectly related with climate change through the program of sustainable forest management, biodiversity conservation, watershed management, water source protection, water harvesting, etc. These policies have envisioned program from its own perspectives. But, most of the policies do not include perspectives from climate change. Thus, these policies and strategies need further strengthening from context of climate change.

In response to Climate Change, Nepal has taken following initiatives (NAPA\MOE, 2009):

• Nepal signed the UNFCCC in Rio de Janeiro in June 1992 and ratified it on 2nd May in 19994. Since then, Nepal has been regularly participating in COPs and other subsidiary meetings.

• It also became party of Kyoto Protocol by submitting its instrument of Accession on September 16, 2005.

• To take advantage of the Clean Development Mechanism (CDM) as a source of new investment and technology, Nepal is trying to develop various CDM projects which promote clean energy and sustainable development in the country. Nepal has recently set up the National Designated Authority under the Ministry of Environment to approve CDM projects.

• National Climate Change policy and National Adaptation Program of Action are being formulated.

• The Alternative Energy Promotion Centre, together with several NGOs and private companies, is promoting clean energy efficiency technologies such as biogas, micro-hydro and solar through subsidies as well as technical assistance.

• Ministry of Environment has set up Climate Change Network comprising of representatives of relevant government bodies, NGOs, civil society and experts for information and knowledge management and policy input.

Furthermore, National level disaster relief fund has been working under the chairmanship of the Prime-minister and disaster relief committee has been working under the District administrative office to provide the immediate relief for climate induce disaster. Additionally, Government offices such as (Irrigation office, Soil conservation office, Water induce Disaster office) and some NGO such as Practical action, Red cross, are also involved at district level climate induce disaster relief activities.

Conclusion

Variations in temperature and precipitation patterns have impacts on various aspects of local life. People reported that these impacts are both negative and positive. Farmers' perceptions of climate variability were in line with climatic data records. Study found that Farmers' in the different regions were able to recognize that temperatures have increased, snow fall decreased and there has been a fluctuation in the rainfall pattern. Inadequate scientific monitoring makes it difficult to validate the observed changes. Natural resource degradation and poverty are already severe problems in Nepal, and there will be more severe problems in future if present scenario continues, particularly, as smallholder farmers do not have adequate resources to adapt to climate change.

Reviving traditional practices and improving knowledge on how to harvest rainwater, forest management, crop and livelihood diversification, provides one way of coping with different climatic variability. Appropriate technologies, suitable for the local context, are also helpful. Before planning any interventions, a proper assessment of the impact of climate change on water resources is essential. Adaptation measures such as crop diversification, crop and livestock insurance and risk transfer mechanisms should be developed to minimize the risk of climate change.

Empowering communities with information, technological skills, education and employment is the best way to address vulnerability. A location wise action-research is therefore necessary to identify and document climate change impacts and adaptation strateragy. The local observations described above provide a clear direction for future research and for development planning and adaptation management programs in different ecological regions. Policy and program should be formulating holistic approach to mitigate climate change and improve livelihood of the local communities.

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Table 1. Analysis of long term (1979-2008) temperature (0C) data analysis in different ecological regions

Region	Mean annual	Maximum	Minimum	Summer trend 0C\yr	Winter trend 0C\yr	Annual trend 0C\yr
Transhimalayan	6.8	14.3	-0.67	0.05	0.02	0.035
Midmountain	15.6	16.6	14.5	0.07	0.04	0.055
Siwalik	23.1	31.9	16.5	0.02	0.05	0.045
Terai	24.5	34.0	18.3	0.01	0.01	0.02

Table 2. Analysis of long term (1979-2008) rainfall (mm) data analysis

Region	Annual rainfall	Monsoom rainfall	Maximum	Minimum
Transhimalayan	179.4	79.0	297.1	8.5
Midmountain	5441.5	4615.4	6561.4	3445.6
Siwalik	2282.5	1900.7	3033.4	1680.5
Terai	1972.5	1659	2598.8	1529.2

Table 3. Local responses on various climate change related changes in different regions (n=400)

Major areas of impact	Responses	Yes (%)	No (%)	Don't know (%)
Climatic conditions	Snow fall decreasing	90	5	5
	Warming days has been increasing	85	10	5
	Rainfall pattern is unpredictable	80	10	10
	Seasons are changing	83	5	12
Ecosystem function and process	Incidents of drought is increasing	78	12	10
	Soil moisture depletion	84	5	11
	Wind pattern is getting warmer	75	10	15
	Wind storm is getting stronger	50	25	25
	Flood frequency	85	10	5
	Water source availability decreased	88	5	7
	Ground water table decreased	75	5	20
	Extinct plant species	83	10	7
	Frequencies of fire are increasing	75	15	10
Biological systems	Changes in flowering and fruiting time	70	15	15
	New diseases in Agriculture crops	82	10	8
	Invasive plant species seen (Forest & Agriculture land)	87	5	8
	Behavioural changes in livestock	50	10	40
	Decrease in grass production in pasture land	80	10	10
	Decrease in medicinal herb availability	70	10	20
	Decrease in Fish species in rivers	88	5	7

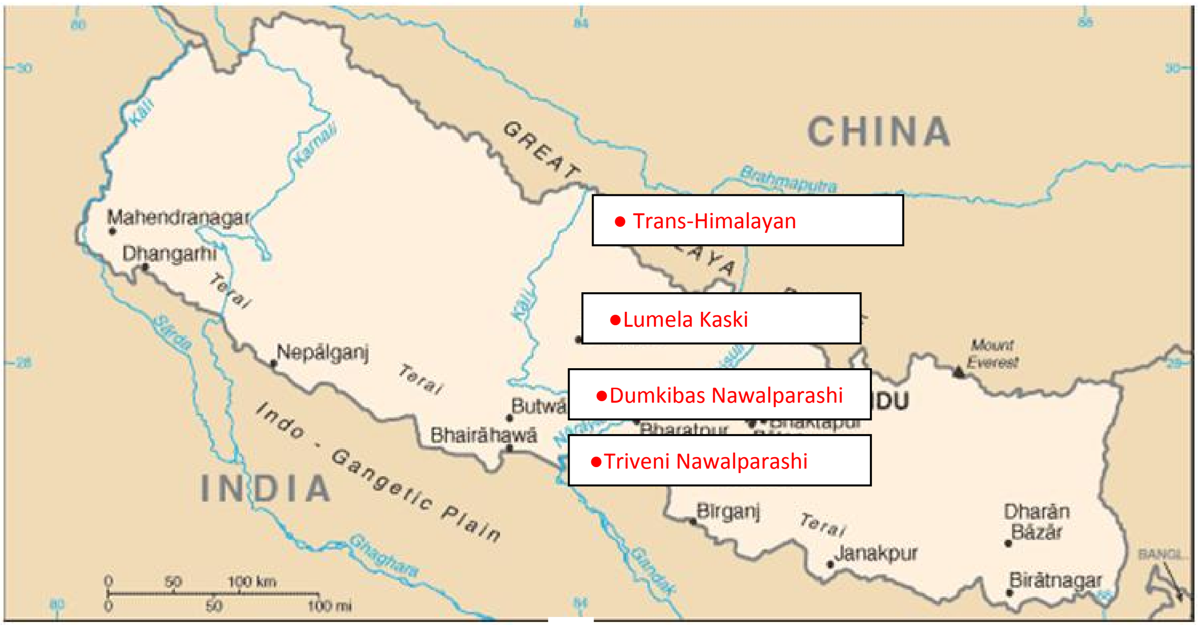

Figure 1. Study area

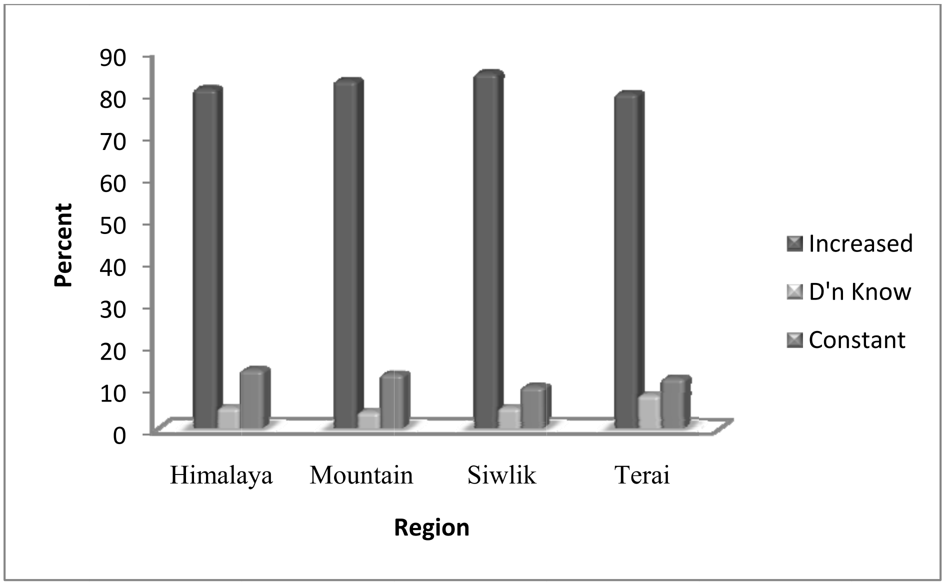

Figure 2. Farmers' response on temperature variability in different region (n=400)

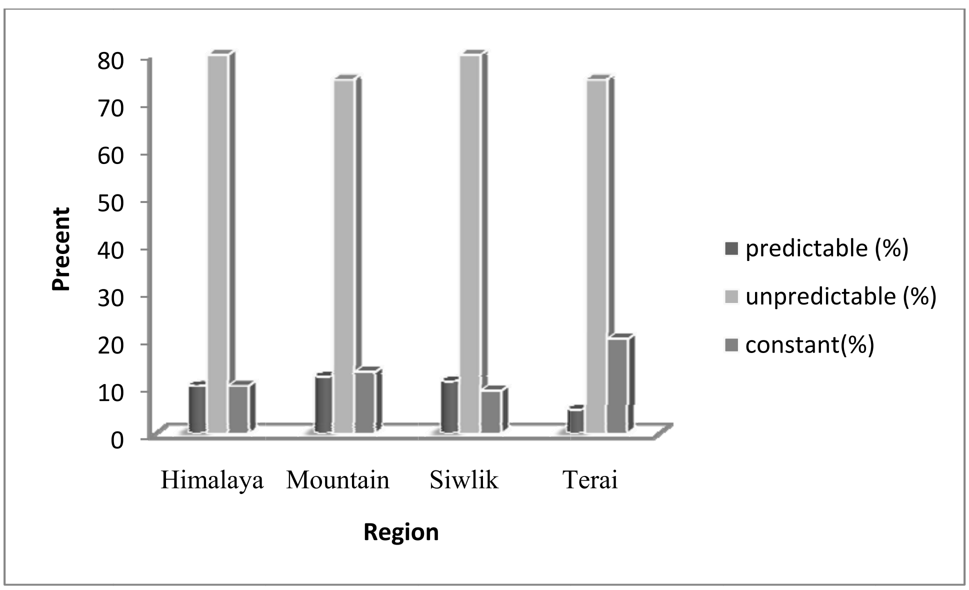

Figure 3. Farmers' response on rainfall variability in different region (n=400)