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Comparison of Adaptive Capacity and Adaptation Practices in Response to Climate Change and Extremes among the Chepang Households in Rural Mid-Hills of Nepal

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Abstract

Study of the community level adaptive capacity and adaptation practices is important to capture the ongoing processes, constraints and opportunities at the local level where adaptations ultimately occur. Even at the local level, emphasis must be placed on marginalized communities as they are the ones who are the most vulnerable. This study focuses on the Chepang community, one of the highly marginalized indigenous nationalities in Nepal. This paper presents micro-level analysis of the inherent adaptive capacity and the ongoing adaptation practices based on the information obtained through direct interaction with Chepangs at the household level. The adaptive capacity, taken as the function of asset possession by the households, and measured in terms of an aggregate index is compared across the four study sites. Ongoing adaptation practices are categorized according to fivefold classification based on risk pooling across space, time, assets, and households and measured in terms of adoption rate by the households. Finally adoption rate of adaptation practices is compared with adaptive capacity across the four study sites to analyze if the adoption rate is indeed determined by the inherent adaptive capacity. Results show that balanced possession of all asset categories is necessary to translate adaptive capacity into adaptation actions. There is thus a need for integrated development activities that aim to promote a balanced growth in terms of infrastructure, human capabilities, financial capital and social networks.

1. Introduction

Adaptation refers to the process, action or outcome in a system that helps to better cope with, manage or adjust to some changing condition, stress, or opportunity (Smit & Wandel, 2006). Adaptation to climate change is defined by Intergovernmental Panel on Climate Change (IPCC) as adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts (McCarthy et al., 2001). Human beings have always adapted to different stresses that may be economic, political, social, cultural, technological, and biophysical. Adaptation actions undertaken to address one type of stress may reduce or aggravate the risk to climatic stresses, and vice versa. The choice of high yielding hybrid varieties is a good example. These varieties are capable to address the problems of low productivity and food insecurity if managed properly; however these varieties are less resistant to drought, thus more vulnerable to untimely rains in rain-fed systems. The adaptation responses to two or more of these stresses may overlap, making it difficult to single out the adaptation practices formulated in response to climatic stresses only (Below et al., 2010). For example, a farming household may decide to shift from agriculture to livestock with a motive of profit maximization or in response to increasing drought spells hampering crops, or both. In addition, adaptation is often a dynamic process. A coping strategy like a switch in the crops or varieties grown by farmers in response to a short-term drought spell may over time be translated into permanent adaptation strategy suitable to long-term climate change. Adaptation actions suitable at the community level do not necessarily involve only local actors at the micro-scale; but may involve multiple scales and multiple actors. For instance, decisions to implement crop insurance schemes by the national level policy makers can be a suitable adaptation option for the subsistence farmers at the micro level. Rural communities have been adapting to climate related risks since time immemorial; however climate change may drive the frequency of such extreme events beyond their adaptive capacity and pose new challenges. For example, in a dry year a community may thrive on previous year's storage, wild foods, sale of livestock, and income from wage labor. However, if drought becomes recurrent for the second year, the community might cross the threshold of vulnerability due to the depletion of storage, lack of livestock to sell, and lesser regeneration of wild foods. With the unanimous agreement that climate change is an ongoing phenomenon, it is imperative that researches on community level adaptive capacity and adaptation practices be directed from the perspective of climate change and related extreme events.

Adaptation practices are the manifestations of adaptive capacity that is inherent in a system. IPCC defines adaptive capacity as the ability of a system to adjust to climate change including variability and extremes to moderate potential damages, to take advantages of opportunities, or to cope with the consequences (McCarthy et al., 2001). Assessment of current adaptive capacity of a system provides useful insights on the existing potential of the system to cope with climate disasters and also point out the shortcomings which need to be addressed to improve the adaptive capacity of the systems before such events occur. Many works has been done on the national level assessments of adaptive capacity to climate change (Brooks et al., 2005; Adger & Vincent, 2005; Vincent, 2004). While explorations of the adaptive capacity at the national level is important to make comparison across nations, such studies is lesser relevant at the sub-national and local level as it does not capture the processes and contextual factors that influence adaptive capacity at the level where adaptation ultimately takes place. Vincent (2007) demonstrates that the indicators of adaptive capacity cannot be generalized across scales. Indicators of adaptive capacity at the national level are unrepresentative at the sub-national or local scale. Thus, exploring the local context is important to gain insights into local constraints and opportunities. Similar to adaptive capacity, bottom-up approach has been emphasized to explore the ongoing and potential adaptation practices that can be promoted or implemented at the community level in response to the changing climate (Gbetibouo, 2009; Smit & Wandel, 2006). Even at the local level, the poorest rural communities relying dominantly on natural resources for their livelihoods are the ones who are the most vulnerable to the adverse impacts of climate risks. Geographical remoteness of the settlements of such communities, compounded by socio-economic and political marginalization further add to their vulnerabilities. In order to gain relevant policy insights so as to help such communities cope with various risks including climate change, it is important to capture the ground level realities of the livelihoods of these marginalized communities.

In this direction, Chepang community, one of the highly marginalized communities in Nepal, has been selected as the study population. Chepangs are one of the indigenous nationalities[1] of Nepal having a population of 52,237 constituting 0.23% of the total population. Majority of the Chepangs lives in the hilly villages of Chitwan, Makwanpur, Dhading and Gorkha districts. In Nepal, indigenous nationalities represent the marginalized section of the country. Their socio-economic and human development indicators lie far below the national average. Based on the Nepal Living Standards Survey 2003/04, hilly indigenous people (besides Newar and Thakali)[2] have higher poverty incidence of 43% compared to the Tarai indigenous people having poverty incidence of 33% (NIRS, 2006). The Chepang community has been categorized as one of the highly marginalized indigenous nationalities from the hills. Although their native area is surrounded by major highways of the country and is situated very near to the capital city Kathmandu, they are still marginalized from the mainstream of development of the country. Chepang thus qualify as an appropriate representative of the marginalized group of people in Nepal and is thus selected as the study population for this study. Chepangs are believed to be until the last 100-150 years ago a nomadic group ranging the forests of Nepal as described by Brian Hodgson in his 1848 article to be "living entirely upon wild fruit and the produce of the chase" (Hodgson, 1874, p. 45). Nearly a century later, a comprehensive study by Rai (1985) reported that though Chepangs still practiced a good deal of hunting and gathering, agriculture formed the mainstay of their livelihood, and they practiced *khoriya*. Under this system, a patch of land is cleared in the forest and cultivated for 2-3 years before the soil become exhausted. It is then left fallow allowing sufficient time for vegetation to regenerate; meanwhile they clear and cultivate other patches of land. However, introduction of new government policies put restrictions on hunting, gathering, and clearing of forest patches (Upreti & Adhikari, 2006), leading to the transition of their livelihood to sedentary agriculture (FORWARD, 2001). Chepangs predominantly rely on rain-fed subsistence agriculture. Due to rugged topography and stony nature of the land, only a small percentage of Chepang households are fully food self-sufficient (Piya et al., 2011a). Chepangs still depend upon wild and uncultivated edible plants (Maharjan et al., 2010). Chepangs also depend upon livestock, wage laboring, collection and sale of forest products, handicrafts, skilled non-farm jobs, salaried jobs, and remittance for cash income (Piya et al., 2011b). During the time of their food deficit, the Chepangs depend on informal sources for loan, which they pay back by selling their livestock, and agricultural or forest products.

This paper presents a micro-level analysis of inherent adaptive capacity and the ongoing adaptation practices based on the information obtained through direct interaction with the Chepang community at the household level. Adaptive capacity measured in terms of an aggregate index is compared across the four study sites. Also, the adoption rate of different adaptation practices is compared in terms of the percentage of households adopting each practice across the study sites. Inherent adaptive capacity is the minimum necessary condition for adaptations to take place, and adaptation practices are taken as the manifestations of adaptive capacity (Smit & Wandel, 2006). Some authors also opine that the capacity may not always be translated into action (Jakobsen, 2011; Vincent, 2007) or adaptive capacity is not always equivalent to capacity to respond (Gallopin, 2006). However these literatures do not make a quantitative comparison of adaptive capacity and adaptation practices. This paper compares the adaptive capacity and adoption rate of adaptation practices across the study sites and analyze if the adoption rate really correspond to the adaptive capacity. Such analysis is a step towards understanding the relationship between adaptive capacity and the process by which adaptation takes place; and has the possibility to guide future researches focusing on the analysis of underlying drivers of adaptation practices. The next section of the paper presents the theoretical framework for the analyses based on previous literatures. The third section deals with the methodology. Adaptive capacity and adaptation practices are dealt in the fourth and fifth sections respectively. The last part concludes the paper.

2. Theoretical framework for analysis

2.1 Framework for adaptive capacity

The substantial works on adaptive capacity is done after the publication of IPCC third assessment report in 2001, which identified adaptive capacity as a component of vulnerability. Many of the initial studies have focused on the adaptive capacity at the national level (Haddad, 2005; Adger & Vincent, 2005; Brooks et al., 2005; Adger et al., 2004; Yohe & Tol, 2002) and few of the latter studies have been focused at the subnational level (Jakobsen, 2011; Nelson, et al., 2010; Gbetibouo & Ringler, 2009). The earlier national level studies are aimed at comparative assessment of adaptive capacity at the national level to identify the countries with lowest adaptive capacity, thereby assisting in the adaptation related investment decisions under the United Nations Framework Convention on Climate Change (UNFCCC). The subnational studies are done with the objective of identifying the regional variations within the country, thereby facilitating specific target-group oriented resource allocations. All of these studies have contributed to form a conceptual basis for defining adaptive capacity by throwing an insight on the possible social and economic indicators of adaptive capacity. They conclude that many of these variables are not quantifiable and can only be qualitatively described. The earlier studies select the indicators of adaptive capacity based on subjective judgments while the latter ones promoted selection of indicators based on some theoretical underpinnings. Nelson et al. (2010) and Gbetibouo & Ringler (2009) utilize the sustainable livelihoods framework to analyze adaptive capacity and opine that the adaptive capacity of a household is the emergent property of the assets possessed. These studies confirm that possession of diversified set of assets enables the households to choose from various livelihoods options and switch from one strategy to another during the times of stress. Thus households with diversified assets and livelihood activities have higher adaptive capacity.

Adaptive capacity is multidimensional and is determined by a complex inter-relationship of multiple factors. As noted before, many variables representing adaptive capacity are not quantifiable. Nevertheless, devising an index to measure adaptive capacity is helpful to compare similar systems and provide insights into the underlying processes and determinants of adaptive capacity that is of relevance to policy makers. Indicators and indices are useful in representing a complex reality into simpler terms. However, the methodology adopted in the choice of indicators is very crucial, since choice of wrong indicators may lead to a construction of an invalid index. Choice of indicators to represent the index for adaptive capacity is constrained by the fact that adaptive capacity itself has no tangible element. The selection of suitable indicators can best be done based on some theories that provide insight into the nature and causes of vulnerability. However, even theory-based deductive approaches are constrained by data-limitations due to which subjectivity enters in the process of indicator selection. The best option is to verify the representativeness of the theory-based indicators with insights gained from focus group discussion conducted at the local level.

Following Jakobsen (2011) and Nelson et al. (2010), this paper uses the sustainable rural livelihoods framework given by

Ellis (2000) and DFID (1999) to analyze the adaptive capacity of the study community. The sustainable livelihoods approaches which views livelihood outcomes as a function of the ownership or access to livelihood assets is principally based on Nobel Laureate Amartya Sen's entitlements approach, where by households with sufficient range of entitlements, capabilities or assets have more choices of adopting strategies suitable to cope during the periods of adversities or minimize the associated risks (Jakobsen, 2011; Ludi & Slate, 2008). The lack of or limited access to livelihood assets increases the defenselessness or incapacity to avoid risks as well as increases the shocks and stresses to which an individual or household is exposed to (Shahbaz, 2008). On the other hand, households with diversified asset portfolio are more capable to reduce risks and to cope with or adapt to increased level of risks. Such households will have more options to substitute among alternative livelihood activities during the times of stress, thereby having more adaptive capacity. For instance, households with access to irrigation (physical assets) will face less risks of crop damage during droughts compared to those households depending entirely on rainfed agriculture. Similarly, households with higher savings (financial assets) or memberships in saving and credit institutions (social assets) have greater capability to minimize livelihood risks posed by crop failure during bad weather. Households having some non-farm sources in addition to farming will improve the adaptive capacity of the households against the climatic stresses through distribution of risks across various livelihoods sources.

2.2 Framework for adaptation practices

After the publication of IPCC third assessment report, there has been many documentations of ongoing adaptation practices around the world. Adger et al. (2007) in IPCC fourth assessment report provides examples of adaptation initiatives undertaken relative to climate risks that include measures taken in response to sea-level rise, salt-water intrusion, droughts, floods, extreme temperatures, permafrost melt, changes in ice cover, upward shift of natural snow-lines, and glacier melt. There are many studies that describe the adaptation practices adopted by rural farming communities in Africa and Asia (Below et al., 2010; Onyeneke & Madudwe, 2010; Gbetibouo, 2009; Bhandari & Gurung, 2008; Regmi, et al., 2008; Nhemachena & Hassan, 2007; Howden et al., 2005). The local coping strategy database managed by UNFCCC is an excellent collection of ongoing adaptation practices all over the world. Explorations of the ongoing adaptation practices among the rural communities reveal some very important features of adaptation to climate change. Firstly, these adaptation practices are not entirely new in the community; such practices have been ongoing in the community since a long time. Traditional soil conservation practices like mulching and terracing have always been there in the community. Secondly, adaptation practices that are suitable to address the adverse impacts of climate change may not be necessarily implemented only in response to climate change related risks. Investment in livestock, for example, may be a decision taken by a farmer to increase the household income rather than in response to increasing droughts or shifting seasons. Nevertheless, it serves to improve household income and to compensate for the crop losses caused by droughts or unfavorable shifts in the seasons. Thirdly, even planned adaptation activities are not always undertaken as a response to climate change alone, but embedded with other development projects like soil conservation, land-use planning, etc. Fourthly, adaptation activities may sometimes conflict with the development priorities. For instance, in the face of recurrent droughts or decreasing rainfall, farmers may switch back to the indigenous varieties of maize that are drought tolerant. This practice will possibly be in conflict with the development priorities of promoting hybrids to increase crop yields. However, farmer may perceive the risk of crop failure to be greater than the risk of food shortage, thereby favoring indigenous varieties to hybrids.

Agrawal (2010) proposes an analytical approach to classify adaptation practices based on distribution of risks across space, time, assets, and households. Based on these approaches of risk pooling, the adaptation strategies can be classified into five analytical categories of risk management techniques: 'mobility, storage, diversification, communal pooling and market exchange'. Mobility refers to the distribution of risks across space; storage helps to distribute risks across time; diversification is a strategy to distribute risks across assets; communal pooling is distributing risks across households within a community; and finally market exchange substitute for previous four categories through product exchange in the market. This paper adopts this five-fold classification of adaptation strategies as the analytical framework for analyzing the ongoing adaptation practices in the study community.

Mobility is a way of life for many rural household, which is not food self-sufficient and one or more members in the family adopt temporary labor-migration. Mobility as such is contested whether it is an adaptation mechanism or occurs when adaptation in a locality fails; there are diverse views on involuntary migration as an adaptation means given the social, cultural and economic pressures that is exerted on both migrating as well as receiving communities (Raleigh & Jordan, 2010). Nevertheless, for rural societies whose livelihood already involves mobility within definite time periods, constraints to mobility would be an indicator of failed adaptations. Storage is a means to reduce risks across time. There are various indigenous methods of storage of food to be used for dry periods in all the rural communities. With increasing uncertainties in the rainfall patterns, storage of water is also a relevant adaptation strategy. Storage helps to create buffer for the lean periods. Diversification is the most common adaptation method in the list of UNFCCC coping strategies database. Diversification may occur within assets, livelihood activities, and production technologies. Diversification helps to diversify risks across assets and capabilities by enabling the household to substitute among various sources when one source of livelihood fails in the event of stress. Communal pooling is characterized by joint action by the households within a community with a motive of increasing the coping range compared to what the households would cope with individually. Joint management of natural resources and labor pooling are very common examples. Communal pooling often requires mediation by a viable institution in the community. Market exchange helps to distribute risks through product exchange, provided that the households have fair access to the market. Rural households might need institutional support, at least initially, to help them with networking and bargaining for fair price of their products. A single adaptation practice can be a combination of two or more classes; for example diversification is usually combined with market exchange.

This classification system is different from previous literatures. IPCC assesses the current adaptation practices based on several criteria: spatial scale (local, regional, national); sector (water, transportation, etc.); type of action (physical, technological, etc.); actor (government, private sectors, communities, individuals); climatic zone (mountain, arctic, etc.); development level (least developed or developed country); time-scale (current coping vs. long term adaptation); and timing (anticipatory or proactive, reactive) (Adger et al., 2007). FAO (2007) further classifies adaptation practices into planned and autonomous (or spontaneous) depending on whether the practices are guided by external support or implemented by the communities on their own. These classifications are sometimes unclear. As Agrawal (2010) points out, with repeatedly occurring climate hazards, the distinction between short-term coping and long-term adaptation no longer holds. Similarly, climate extremes like droughts occurring frequently due to climate change may make it difficult to say whether the adaptation responses are proactive or reactive. Adger and Vincent (2005) opine that the distinction between planned and spontaneous adaptation is not entirely correct due to the fact that possibility of every individual or community action is controlled by the existing policies formulated by the government. These classifications do not shed light on the types of risks posed on the livelihoods by climate change and related extreme events. The analytical approach adopted in this paper, on the other hand, is more applicable to livelihoods studies as the classification is based on how the climate-risks affect the household assets and community capabilities across space and time.

3. Methodology

3.1 Data analysis

3.1.1 Choosing the indicators for adaptive capacity

Adaptive capacity index is constructed to empirically assess the adaptive capacity. As described in the theoretical framework, adaptive capacity of a household is taken to be an emergent property of the five types of livelihood assets viz. physical, human, natural, financial, and social. These indicators are not necessarily specific to climate shocks only but are also relevant in addressing other shocks like food shortages. Although only few of the selected indicators like house types and irrigation facilities have a direct role in minimization of risks from climate shocks, all of these indicators do assist households to combat climate shocks through risk pooling, risk distribution or as buffer during extreme climatic events. The relevance of each indicator in building household adaptive capacity in the face of climate related risks is discussed hereafter. Indicators for the physical assets are type of house, ownership of mobile phone, radio, access to solar panel/microhydro for electrification, agricultural tools, walking distance to the nearest road, and irrigated land. Out of these, only house quality and irrigation are directly related to climate risks. Possession of better quality house will improve the capacity to withstand the risks from extreme climate events. Type of house was indicated from a value of 1-3, 3 indicating the most durable type of house (see Table 1). Ownership of cellular phone and radio will increase the adaptive capacity through access to weather related information. Access to rural electrification sources will allow better functioning of the radios thereby improving the access to relevant information. Better access to information enables a household in planning proactive adaptation measures against climate risks. Walking distance to the nearest motor road, which in this case is also equivalent to the nearest marketplace, is assumed to be inversely related to adaptive capacity as household located far away from the markets will be in a disadvantageous position for lacking the opportunity of income generation from alternative sources like non-farm labor, which help in securing livelihoods during the periods of food shortage or crop failure. Farther distance from the roads also symbolizes poor access to inputs as the service centers are located at the road-heads. In addition, greater distance from the motor roads also means limited access to information as the marketplace acts as informal gathering centers where information exchange takes place, and also the formal institutions providing extension services are located there. Higher possession of agricultural implements means higher agricultural production and more irrigated land means lesser dependence on natural rain, which is becoming more unpredictable with climate change. Irrigation is directly related to climate shocks as it minimizes risks posed by droughts.

Table 1. Indicators for adaptive capacity

Component Indicators	Description of the Indicators	Unit	Hypothesized relation
Physical Assets	Type of house (1 = thatch roof, thatch/wooden wall; 2 = thatch roof, stone+mud wall; 3 = stone/tin/tile roof, stone/wood/brick+mud wall)	Ordinal value	+
	Have mobile phone (0 = No, 1 = Yes)	Ordinal value	+
	Have radio (0 = No, 1 = Yes)	Ordinal value	+
	Have access to solar panel/microhydro (0 = No, 1 = Yes)	Ordinal value	+
	Walking distance to nearest motor road	Hours	-
	Agricultural Tools	Value in NRs[3]	+
	Irrigated land	% of total	+
Human Assets	Highest qualification in the family	Years	+
	Trainings or vocational course attended by family members	Number	+
	Dependency Ratio	-	-
Natural Assets	Share of more productive land (*khet* + *bari*) possessed	% of total	+
	Share of less productive land (*khoriya*) possessed	% of total	-
	Have bullock (0 = No, 1 = Yes)	Ordinal value	+
Financial Assets	Gross annual income/ capita	NRs	+
	Livelihood Diversification Index	-	+
	Have remunerative income sources (salaried job/skilled non-farm job/ remittance) (0 = No, 1 = Yes)	Ordinal value	+
	Total household savings	NRs	+
	Ownership of goat, poultry, and pig	LSU[4]	+
Social Assets	Memberships in CBOs	Number	+
	Access to credit (1 = needed, but no access; 2 = credit used only for subsistence purposes; 3 = credit used for productive investment +/- subsistence; 4 = no need)	Ordinal Value	+

Human asset is represented by highest qualification in the family, trainings or vocational courses attended by the family members, and dependency ratio. These indicators are not directly related climate shocks; however they are still relevant because development of human capabilities through vocational trainings or formal education enable households to increase their income by undertaking skilled non-farm activities, which are less climate-sensitive compared to farming and gathering, thereby helping the households to avert climate risks. Furthermore, it also diversifies household livelihood sources which help to buffer the risks posed by climate on farm income. Households with higher dependency ratio will have more burdens on the earning members thereby reducing the adaptive capacity. The implication of dependency ratio is common to any types of shocks including climate.

The quality of land possessed by the households is taken as an indicator of natural assets. Chepangs possess three categories of land. Paddyland (*khet*) is the most productive category of land, usually having an irrigation source. *Bari* is terraced upland, which may or may not be irrigated, and is less productive than *khet*, but more productive than the third category, *khoriya*, which is unterraced sloppy land-plots. Natural assets, by their own nature, are more vulnerable to climate shocks than other types of assets. While terraced land types (*khet* and *bari*) are less prone to erosion, *khoriya* face greater risks of landslides and loss of top-soil due to run-off during rains. Households possessing higher share of *khet* and *bari* compared to *khoriya* will suffer less from climate disasters. Higher share of more productive land (*khet* and *bari*) also means higher food self-sufficiency, thus higher adaptive capacity. Higher share of *khoriya* indicates the opposite. Besides land, possession of bullock, which is the only means of ploughing fields in the hills, is another indicator of household natural assets.

Gross annual income/capita, livelihood diversification index, remunerative income sources, household savings, and ownership of small livestock are taken as the indicators of financial assets. These indicators of financial assets are not specific to climate shocks only. Gross annual income of the household is the sum total of the cash and non-cash income from 11 different sources (Appendix 1). Higher per capita income means greater availability of resources at disposal to maximize positive livelihood outcomes. Besides the amount of annual income, the sources from which the income is derived also need to be considered. If all of the income is derived from farming alone, then such income will be adversely affected during the years of bad weather. On the other hand, if the income is derived from more than one source, then risk will be distributed among the sources. In order to capture this aspect of income, Livelihood Diversification Index (LDI) is calculated; higher diversification indicating better ability of the household to switch among the activities when needed. Herfindahl index of diversification is used (Kimenju & Tschirley, 2009), which is calculated as

$$D_k = 1 - \sum_{i=1}^{N} (S_{i,k})^2$$

where, D_k is the diversification index, i is the specific livelihood activity, N is the total number of activities being considered, k is the particular household, and $S_{i,k}$ is the share of i^{th} activity to the total household income for k^{th} household.

LDI only gives a quantification of diversification of the livelihood sources, but does not shed light on the nature of diversification. For instance, households depending on agriculture, livestock, and forest will bear greater risk to climate vagaries compared to households depending on salaried jobs as one of the income sources. The nature of income sources is captured by taking remunerative income sources as one of the financial indicators. Among all the income sources salaried jobs, skilled non-farm jobs and remittances are considered to be remunerative income sources. Apart from earning comparatively higher incomes, these sources are less dependent on natural resources thus less affected by climate, thus minimizing the overall climate risks. However, only few Chepang households have income from these sources (Appendix 1). In addition to income at disposal, households which are able to make some savings out of their income will be able to make productive investments like family education or use the savings as buffer during the times of need. For Chepangs, small livestock (goat, pig and poultry) are also important sources of cash income; they keep these livestock as buffer to sell during the times of stress or to pay back the loan that they take from moneylenders (Piya et al., 2011b).

Finally, social asset is represented by the number of membership in formal community based organizations (CBOs) and access to credit. Membership in CBOs will improve the households' social networks and access to information through their constant contact with the outsiders during the meetings in CBOs. Also, management of resources like water collection tanks and forests is done jointly by the members of these CBOs. Such activities help in pooling risks across the households in a community. Access to credit is also taken as social assets because for the Chepangs, taking loans from social contacts is one of the most important strategies to cope with seasonal food shortages, which they repay by selling agricultural produce, livestock, or forest products. Thus, access to credits in this community is equivalent to the social safety nets against all types of shocks. Also, some semi-formal saving and credit organizations in the community have recently started providing interest-free loans for productive investment like vegetable farming, and rearing cattle. Thus, access to productive loans denotes the access of the households to existing credit providing organizations in the locality. Better the access to credit, higher will be the adaptive capacity of the households.

3.1.2 Calculation of the adaptive capacity index

Having chosen the suitable indicators, now these need to be normalized to bring the values of the indicators within the range of 0 to 1 so that they can be directly comparable (Nelson et al., 2010; Gbetibouo & Ringler, 2009; Vincent, 2004). Normalization is done by subtracting the mean from the observed value and dividing by the standard deviation for each indicator.

$$Normalized\ value = \frac{Observed\ Value - Mean}{Standard\ Deviation}$$

Next, weights should be assigned to these indicators. Some research follows equal weighting (Nelson et al., 2005; Vincent, 2004), however it may be too arbitrary and lead to overweighting of some less important indicators, while underweighting the important ones. Weighting can also be based on expert judgement (Vincent, 2007; Adger & Vincent, 2005), however this approach is often criticized for being too subjective, and is constrained by the availability of subject matter specialists or lack of consensus among the experts (Gbetibouo & Ringler, 2009). Assigning weight by Principal Component Analysis (PCA) following Filmer and Pritchett (2001) is thus preferred (Nelson et al., 2010; Gbetibouo & Ringler, 2009; Cutter et al., 2003). PCA is run for the selected indicators of adaptive capacity to assign the weights. The loadings from the first component of PCA (PC1) are used as the weights for the indicators. The loadings for each indicator varies between -1 and +1, sign of the indicators denoting the direction of relationship with other indicators used to construct the index. The magnitude of the loadings describes the contribution of each indicator to the value of the index. The first-step PCA was run for the indicators of each asset group separately to observe the relative importance of indicators within each asset category. From the weights obtained from first-step PCA, individual index values for each asset type was calculated. Second-step PCA was run using the index values for each of the five asset type to analyze which asset group contributes the most to the total adaptive capacity. Overall adaptive capacity index was calculated using the weights (loadings) obtained from the second step PCA run for the five asset categories. The normalized variables are multiplied with the assigned weights to construct the index using the following Index Formulae:

$$I_j = \sum_{i=1}^{k} b_i \left[\frac{a_{ji} - x_i}{s_i}\right]$$

where, 'I' is the Index Score, 'b' is the loading from first principal component i.e. PC1 (taken as weights for respective indicators), 'a' is the indicator value, 'x' is the mean indicator value, and 's' is the standard deviation of the indicators. Higher value of the index indicates higher adaptive capacity. However negative value of the index does not imply that the household has no adaptive capacity at all. This index does not give the absolute measurement of adaptive capacity; rather give a comparative ranking among the sampled households.

3.1.3 Analysis of on-going adaptation practices

Qualitative description of ongoing adaptation practices is done using the theoretical framework previously described. The discussion is based on information obtained from household survey and group discussions. The adoption rate (i.e. the percentage of households adopting the particular practice) is used for comparison among the four study sites. These adoption rates are further compared with adaptive capacity to analyse if the adoption of particular practice by a household is determined by the inherent adaptive capacity. As we shall see later in the discussion part, aggregate adaptive capacity index is not sufficient in explaining the relationship between adaptive capacity and adaptation practices. Analysis in terms of component sub-indices can give a better explanation, yet the analysis of adaptive capacity in terms of asset possession only is not enough to fully explain the rate of adoption by the households.

3.2 Study area and data source

This study covers all four districts that form the native area of the Chepangs, i.e. Chitwan, Makawanpur, Dhading and Gorkha districts. One Village Development Committee (VDC[5]) from each district is selected based on the dominance of Chepang population. Kaule VDC from Chitwan district, Kankada VDC from Makawanpur district, Mahadevsthan VDC from Dhading district, and Bhumlichowk VDC from Gorkha district form the four study VDCs (Figure 1). The settlements on hill tops are sparse, and connected by narrow foot-trails that run along the ridges. One Chepang settlement is separated from the other by a rivulet that flow in the grove between the ridges so that in order to go from one settlement to another, one has to climb down the grove, cross the rivulet, and again climb up the ridge. During monsoon, the rivulets are flooded, the ridges are very slippery, so that movements across the settlements become very difficult; the trails are covered by bushes with plenty of leeches, and falling stones with constant danger of landslides.

This study is based on the primary data collected by household survey conducted in two phases. The first phase of household survey was conducted in February-March 2010 and the second phase in May-June 2011. Sixty randomly selected households from each VDC form the sample for the household survey. Household survey was conducted using semi-structured interview schedule. The researchers visited the selected households and face-to-face interviews were conducted with the household members on the selected household's premises. All the households covered by the survey were untouched by roads and not connected to the central electricity grid. The first phase of the household survey was focused on collection of data related to demographics, livelihood assets, livelihood activities, income sources, and expenditures. Besides the household survey, group discussions were carried out to obtain a timeline of climate related disasters like flood/landslides, droughts, and hails in the locality; information on general perceptions of climate change; locally observed indicators; and the impacts on livelihoods. Follow-up field visit was again made in May-June 2011. This time the same households covered in 2010 were revisited for gathering supplementary data. Out of the total 240 households covered in 2010 field survey, 58 households in Kaule VDC, 56 households in Kankada VDC, 54 household in Mahadevsthan VDC, and 53 households in Bhumlichowk VDC could be revisited in 2011 survey; thus the final sample constitutes a total of 221 households. In the follow-up survey of 2011, questions were focused on the individual perceptions of climate change, adaptation strategies adopted, and the impacts of extreme climate events (flood/landslides, drought, hail) on crop production and livelihood assets.

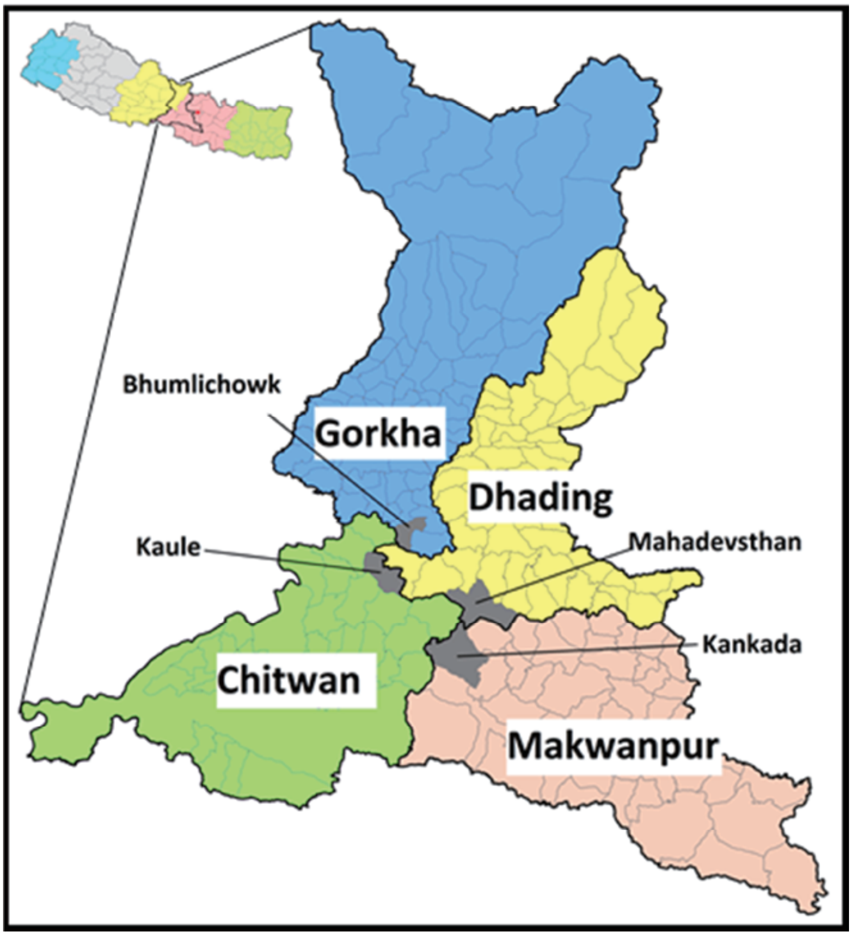

Figure 1. Maps of study districts showing study VDCs (shaded area)

4. Adaptive capacity of the Chepang households

In general, the mean value of the assets reveals that Bhumlichowk has comparatively higher asset possession while Kaule has the least asset possession among the study VDCs (Appendix 2). First step PCA was run separately for the five groups of indicators for each asset type, based on which separate index score for each-asset class was calculated. These index scores for the five types of assets was taken as the inputs for second step PCA, based on which aggregate adaptive capacity index score was computed. First step PCA shed light on the comparative contribution of individual indicators within each asset category. Second step PCA shows relative importance of the five types of assets that determine the total adaptive capacity. The weights obtained from PCA analyses are given in Figure 2. The index developed in this study makes use of both composite and aggregate index types. A single aggregate score of adaptive capacity index is computed while maintaining the transparency in the composite make-up of that score.

For physical assets, agricultural tools and mobile phone have the highest influence followed by house type and radio. Walking distance to the nearest road negatively impacts the adaptive capacity as hypothesized. For the human assets highest qualification and training received higher weights; dependency ratio decreases the adaptive capacity as shown by the negative sign of the weight. Under natural assets, ownership of good quality land i.e. *khet* and *bari* has higher impact in determining the adaptive capacity, while higher share of less productive land i.e. *khoriya* decreases the adaptive capacity as hypothesized. Among the financial assets, as expected remunerative income source that is not based on natural resources is the most important determinant of adaptive capacity followed by gross annual income/capita, savings, and livelihood diversification index. For the social assets, both the indicators have equal weights. The proportion of variation accounted for by the first principal components is 0.25 for physical assets, 0.42 for human assets, 0.66 for natural assets, 0.28 for financial assets, and 0.50 for social assets.

Second-step PCA shows that human assets and physical assets are the two most important determinants of overall adaptive capacity followed by social and financial assets. This shows that development of human assets in terms of education and skill development trainings is a must in order to be able to properly utilize the existing physical and financial assets. Furthermore, local institutions and social networks are equally crucial as demonstrated by the importance of social assets. Natural assets receives the least weightage, which is quite relevant given the fact that natural resources are more impacted upon by climate change and related disasters compared to the other asset types. Thus improving the adaptive capacity against climate extremities requires diversification to livelihoods that is less dependent on natural resources. The proportion of variation explained by the first principal component for second-step PCA is 0.40.

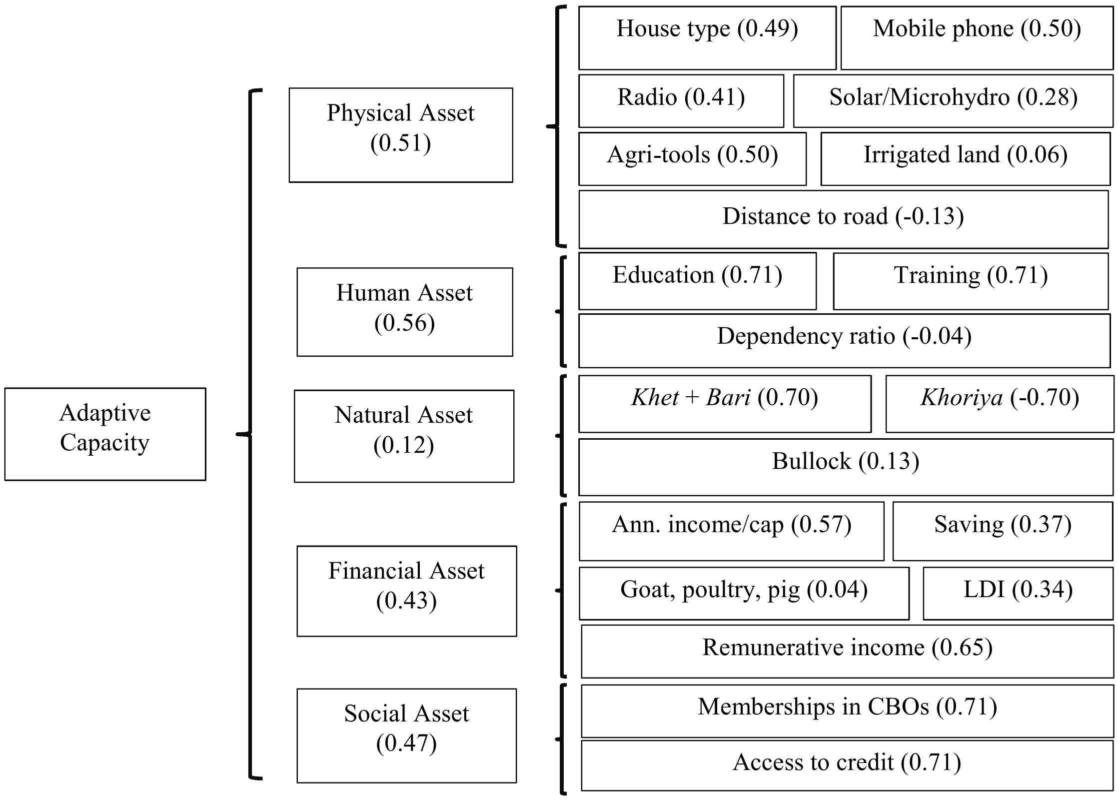

Figure 2. Structure of aggregate adaptive capacity index, composite sub-indices, and component indicators

Note: Figures in parenthesis are the loadings obtained from first principal component taken as weights for the respective indicators (b_i)

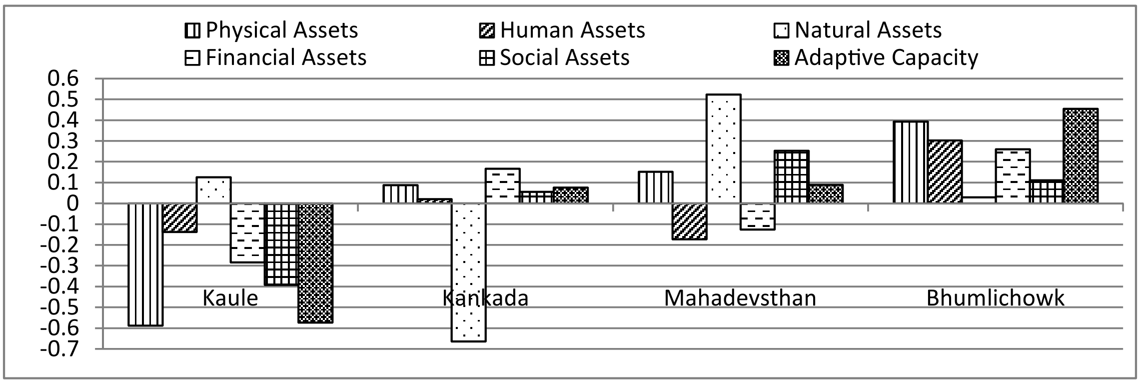

Figure 3. Index Scores (I_j) across the four study sites

Figure 3 shows the index values for adaptive capacity and its components across the four study sites. Bhumlichowk fares the best in three of the asset categories (physical, human and financial) and second-best in social assets, thereby scoring the highest in overall adaptive capacity. The mean values of individual indicators in Appendix 2 shows that Bhumlichowk ranks the first in terms of possession of physical assets (house type, radio, agri-tools), is nearest to the road, has comparatively higher percentage of irrigated land, highest education and training, highest annual income, highest saving and best access to credit. Kaule stands the last in terms of all the asset categories (except natural assets) and thus has the least adaptive capacity. Mahadevsthan ranks the second and Kankada third in terms of adaptive capacity index.

As shown by the weights obtained from PCA analysis, the first and foremost policy focus in the Chepang community should be to improve human assets and their access to physical assets. This does not imply that the remaining asset categories are not important at all. Financial assets and social networks are equally important as well. Highest qualification among the Chepang community is less than 5 years on average (Appendix 2), which is very low thus having several negative consequences in their livelihoods. Illiteracy, for example, hinders them from attaining the skills required to make more productive use of the available natural and physical resources. Policies should be geared towards improving the literacy rate of the community, and also towards providing trainings and vocational education for capacity building and skills development, so that they can diversify their livelihoods to more remunerative sources. Among physical assets, improving access to sources of information like mobile and radio along with better quality housing will help the community to lessen their vulnerability. Among the financial assets, non-natural resource based remunerative income source receives the highest weightage implying that promoting non-natural based remunerative income sources is very important to reduce their dependence on natural resources, subsequently reducing the vulnerability to climate change and extremes. Financial assets enable households to make investment in education and the savings can be used as capital for investments like buying good quality land or buying necessary inputs for cash crop cultivation.

5. Adaptation practices in the community

This paper describes the actual adjustments or practices at the community level that is of relevance in reducing the vulnerabilities or enhancing the resilience of the community to the observed and expected changes in climate and associated extreme events. These adaptation practices have been discussed in line with the classification already described under theoretical framework. Altogether 22 different adaptation practices were identified (Table 2). These practices can be categorized into six broad categories depending upon the nature of risk distribution. The adoption rate of each practice is compared across the four study sites. Further, these adoption rates are discussed in line with the asset holdings and adaptive capacity presented in the previous section.

5.1 Diversification

Diversification helps to pool risks across assets possessed by a household. Diversification includes changes in the choices of crops or varieties, improvement in production technologies and increasing the range of livelihood activities. Similar to the documentation in the UNFCCC coping strategies database, most of the adaptation practices in this study also fall within the diversification category. Similar findings have been reported by the studies related to rural adaptation practices by small-scale farmers around the world (Below et al., 2010; Gbetibouo, 2009; Howden et al., 2007; Wall & Smit, 2005).

5.1.1 Adjustments in varieties

There are two types of varietal adjustments made by the Chepang households: adoption of short-duration maize varieties and varietal mixing. Among the four study sites, most of the households adopting early varieties of maize are from Kankada (28.6%) followed by Bhumlichowk (22.6%); the least is from Kaule (5.2%). This variety is suitable in response to the late onset of post-winter rain that Chepangs wait to sow maize. Post-winter rain has been reported to shift by 1-1.5 months from early March to April. However, most of the households are still sowing the indigenous varieties because the short-duration variety cannot sustain drought especially during the tasseling stage. Since agriculture is basically rainfed, most households do not want to bear the risk of possible droughts. This might contradict the development goals of achieving higher yield; however studies have shown that households are often ready to sacrifice some level of their well-being rather than undertaking the risks. For example, Afar pastoralists in Ethiopia would be ready to live with some level of poverty in exchange for similar reductions in vulnerability (Agrawal, 2010).

As a risk management strategy, fewer households mix high yielding and indigenous varieties of maize seeds, either in the same plot or sow different varieties in different plots. In case of ample rain, hybrids will give higher yield; if in case rain fails to arrive timely, the indigenous varieties would still be surviving. For this strategy of mixing maize varieties, the rate of adoption is higher in Bhumlichowk (13.2%) and Kankada (10.7%) while the least is again from Kaule with only 1.7%.

The variation in adoption rates among the study VDCs is statistically significant for both the strategies under varietal adjustment. The adaptive capacity index score in Figure 3 shows that Bhumlichowk and Kaule stand at the first and last position respectively. As a general rule, it is expected that households with higher adaptive capacity has higher possibility of adopting most of the adaptation practices. The adoption rate of varietal selection corresponds with this expectation in that Kaule has minimum households adopting the practices while Bhumlichowk has either the highest or second highest adoption rates. Furthermore, adoption of hybrid varieties of maize is better explained by financial assets of the household as hybrid maize varieties need extra investment in terms of purchase of seeds and the fertilizer inputs required. Tallying the adoption rate with financial assets in Figure

Table 2. Existing adaptation practices across the four study sites

Adaptation practices	Number of households adopting the practice				P-value
	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	
1. Diversification					
Varietal selection					
● *Short-duration maize*	3 (5.2)	16 (28.6)	10 (18.5)	12 (22.6)	0.01***
● *Mixing different maize varieties*	1 (1.7)	6 (10.7)	3 (5.6)	7 (13.2)	0.1*
Collecting wild edibles	39 (67.2)	47 (83.9)	43 (79.6)	36 (67.9)	0.1*
Adjusting sowing time					
● *Late sowing*	35 (60.3)	28 (50.0)	25 (46.3)	29 (54.7)	0.48
● *Re-sowing*	2 (3.4)	0 (0.0)	0 (0.0)	1 (1.9)	0.32
● *Different dates in different plots*	0 (0.0)	0 (0.0)	0 (0.0)	7 (13.2)	0.00***
Soil conservation					
● *Terracing*	44 (75.9)	34 (60.7)	46 (85.2)	44 (83.0)	0.01***
● *Wall*	47 (81.0)	37 (66.1)	43 (79.6)	45 (84.9)	0.09**
● *Drainage canals*	32 (55.2)	13 (23.2)	34 (63.0)	33 (62.3)	0.00***
● *Legume*	48 (82.8)	50 (89.3)	47 (87.0)	51 (96.2)	0.15
● *Agro-forestry*	44 (75.9)	39 (69.6)	42 (77.8)	51 (96.2)	0.00***
● *Planting hedge-row*	4 (6.9)	6 (10.7)	0 (0.0)	15 (28.3)	0.00***
● *Cover crop*	5 (8.6)	10 (17.9)	0 (0.0)	4 (7.5)	0.01***
● *Mulching*	9 (15.5)	12 (21.4)	10 (18.5)	20 (37.7)	0.02**
● *Minimum tillage*	3 (5.2)	2 (3.6)	0 (0.0)	2 (3.8)	0.45
2. Communal pooling					
Use social networks					
● *Borrowing food*	51 (87.9)	44 (78.6)	42 (77.8)	42 (79.2)	0.47
● *Buy food on credit*	55 (94.8)	52 (92.9)	48 (88.9)	52 (98.1)	0.25
● *Cash loans*	52 (89.7)	46 (82.1)	46 (85.2)	45 (84.9)	0.72
3. Mobility + Diversification					
Temporary migration					
● *Wage labor*	51 (87.9)	47 (83.9)	43 (79.6)	40 (75.5)	0.35
● *Other non-farm jobs*	5 (8.6)	13 (23.2)	5 (9.3)	13 (24.5)	0.02**
4. Storage + Communal pooling					
Water collection pond	8 (13.8)	9 (16.1)	5 (9.3)	21 (39.6)	0.00***
5. Diversification + Market exchange					
Cash crop	27 (46.6)	39 (69.6)	11 (20.4)	49 (92.5)	0.00***
6. Storage + Diversification + Market exchange					
Livestock	39 (67.2)	44 (78.6)	36 (66.7)	35 (66.0)	0.42

Source: Field survey, 2010/2011
Note: Figures in parenthesis indicate percentage
***, **, * indicate significant at 1%, 5%, and 10% level of significance respectively
n denotes the number of households

3 shows that Bhumlichowk and Kankada VDCs having comparatively higher financial assets are also the VDCs with higher adoption rates for the varietal selections discussed above. Similarly, Mahadevsthan VDC ranking third in financial assets also ranks third in the adoption rates under varietal selection and Kaule VDC with least financial assets also ranks the last in the adoption rates.

5.1.2 Increased dependence on wild foods

The annual subsistence cycle of Chepangs is completed by the complementarity between farming and gathering, whereby they depend dominantly on wild foods during the dry months when the grain storage is depleted and new harvest is not yet available (Maharjan et al., 2010). Dependence on wild foods is not entirely a new phenomenon for this community; and the degree of dependence increases during the years when crops are damaged due to droughts, untimely rainfall, and landslides caused by torrential rains. Almost three-fourths of the households reported they increase their collection of wild foods in such years and the dependence is quite high across all the four study sites, the highest being in Kankada (83.9%) and the lowest in Kaule (67.2%).

This corresponds to the comparison of index score for natural assets in Figure 3. Kankada fares the lowest in natural assets (represented by landholding and bullocks), therefore higher dependence on forest edibles is very relevant. Similarly, Kaule has second highest natural assets index score, thus it's lesser dependence on wild food. Surprising here is again Mahadevsthan, where despite the highest value of natural assets index score, the percentage of households depending on forest for wild food is second highest among the four sites. The difference among the study sites is statistically significant.

5.1.3 Shifting the sowing dates

Shifting rainfall patterns have led to changes in sowing dates, most notably for maize. As discussed before, post-winter rains have been arriving lately, as a result of which maize sowing has also been delayed from early March to April. This adjustment, originally adopted as a short-term coping strategy might be possibly converted into a long-term practice, given the long-term changes in rainfall pattern. Some farmers adjust their sowing dates such that the tasseling stage of maize do not coincide with the possible short term dry-spells during late April and May. Nearly 53% of the households on average reported that they shift the sowing dates to match the rainfall pattern. Relatively fewer farmers reported re-sowing of maize after the previously sown maize failed to germinate due to lack of timely rain, or was damaged due to hailstorms that have been occurring for the past three years during April. For the above two practices of late sowing and re-sowing, the difference in adoption rate among the study sites is not statistically significant. The practices of late sowing or re-sowing are common practices as farmers under rainfed conditions quite naturally have to wait for the rains before they can sow their crops. Thus these practices are not necessarily determined by the level of adaptive capacity, and the adoption rates do not vary significantly across the four study sites.

Some innovative farmers also sow maize in different plots at an interval of one to two weeks for minimization of risks related to short-term droughts. This is a recent practice in response to the intense drought in April-May for the past two years that have severely damaged the maize crops. However this practice is adopted only in Bhumlichowk VDC, the VDC with best adaptive capacity. Since Bhumlichowk is the VDC with highest human assets development in terms of qualification as well as vocational trainings (Appendix 2), it can be expected that farmers in Bhumlichowk are significantly more innovative compared to the other VDCs.

5.1.4 Soil conservation practices

The mid-hills where the Chepangs live fall under the Mahabharata range, which have faced the highest incidents of torrential rains over the last 30 years in Nepal (Practical Action, 2009). These hills are thus very vulnerable to landslides. Soil conservation practices like terracing, building stone walls and dikes, digging drainage sluices during monsoon are quite common practices in hill agriculture and holds relevance in the face of climate change due to which events of short-duration high-intensity rainfall is increasing in Nepal (Baidya & Karmacharya, 2007). While terracing and making stone walls is practiced by most of the households in all the four VDCs, drainage is practiced by very few households in Kankada, where respondents have reported highest number of destructive landslides over the past ten years. Practices like legumes integration with cereals for improving the soil fertility, and agro-forestry are very common practices that are practiced by rural communities. Besides improving the soil fertility through addition of biomass, these practices also help to reduce soil erosion by preventing the loss of top-soil by wind and running water. The remaining four practices: planting hedge-row in unterraced slopes, cover crops to protect top soil, mulching and minimum tilling for soil water retention are practiced by fewer households. These simple yet potential soil conservation practices can be promoted among the Chepang households through effective extension services. Some non-governmental organizations working in Bhumlichowk are promoting hedge-row construction in unterraced *khoriyas*. Hedge-row construction at definite intervals across the slopes helps to catch biomass and soil carried along by run-off during monsoon, and the slope is gradually converted into terraces over the long-run.

Out of the nine practices identified for soil conservation, Bhumlichowk, the VDC with highest adaptive capacity, has the highest adoption rate for five practices and the second highest for three practices. The remaining three VDCs have either the lowest or second lowest adoption for five to six categories out of nine. The average number of soil conservation activities per household is also highest for Bhumlichowk (5 out of 9), followed by Mahadevsthan (4.11), Kaule (4.07) and Kankada (3.63) (not shown in the table). This is in accordance to the general expectations that VDC with highest adaptive capacity also has highest adoption rates.

5.2 Communal pooling: Utilizing the social networks

Most of the households (>78% in all four VDCs) depend upon social networks for borrowing food, buying foods on credit, and cash loans as coping strategies after a climate disaster. These practices, again, are not new in the Chepang community and are not only practiced in response to climate events. Borrowing grains from neighborhood and repaying either in grains or through agricultural labor contribution is a common practice among the Chepangs. But usually after a climate disaster like droughts, all the households in the neighborhood face food shortage together. During such times, Chepangs buy grains on credit from the shops at the nearest road-head market. As described under social assets, Chepangs depend upon informal sources of credit for fulfilling their cash needs. Many Chepang households have established a network with the road-head shopkeepers and money lenders for the purpose of credits and loans. The Chepangs repay by selling goat, poultry, commercial forest products, fruits, agri-products, honey, etc. Most literatures discredit this relationship between the Chepangs and shopkeepers/moneylenders due to the lower prices offered by the shop-keepers for the products and the high interest rates imposed on loans by the moneylenders. However, it should be remembered that such kinds of informal lending is indispensable for the Chepangs for whom sources of cash income is very few and seasonal, and there are no formal lending institutions at their disposal. Even if formal lending institutions exist, Chepangs lack necessary documents like citizenship certificates and land-registration certificates (Piya et al., 2011b), thereby restricting them from obtaining loans. Unless there are some measures implemented by the government or private institutions for lending money to the Chepangs, the existing informal networks continue to function as the social safety nets for the community. The adoption rate for the practices under communal pooling is not significantly different among the four study sites. The strategy of depending on social networks during the times of need is quite common in this community, and is an integrated component of their livelihoods. As a result, these practices are equally adopted in all the VDCs irrespective of the level of asset holdings.

5.3 Combination of mobility and diversification: Temporary labor migration

Temporary migration of male members during the dry season to nearby cities in search of non-farm jobs helps to pool risks across space and also diversify the livelihood activities in the household. The purpose for labor migration can be broadly classified into two categories: less-remunerative wage labor and other remunerative non-farm jobs. Wage labor includes jobs like portering, carrying stones for road construction, digging limestone mines, etc. These jobs are paid on daily or hourly basis. The adoption rate of wage laboring is quite high (>75%) in all the four sites and the difference is not statistically significant. Chepang households depend on seasonal wage labor during the dry periods every year when agricultural activities are not practiced due to lack of irrigation, and the households reported that their dependency on wage labor increases after a natural disaster. Wage laboring is also an integrated component of the Chepang livelihoods. Since majority of households adopt wage laboring as a source of cash income without significant differences across the study sites, this practice is not necessarily dependent upon the asset holdings of that particular household.

Other remunerative jobs include salaried jobs (clerks and guards in offices, teachers, assistants in petrol pumps, etc.); skilled non-farm jobs (carpenter, drivers, carpet weaving, etc.); and laboring in foreign countries especially Malaysia and India. Since these income sources are not based on natural resources, income flow is less affected by climate. Also annual income from these sources is comparatively higher (Appendix 1). Thus, assistance by the development agencies to diversify the households to non-farm remunerative jobs will help them reduce the risks posed by extreme climatic events. As can be seen from Table 2, very few households have been able to diversify to remunerative sources, the highest being 24.5% of households in Bhumlichowk and lowest in Kaule (only 8.6%). Bhumlichowk scores the highest in human assets (Figure 3) with the highest average qualification and vocational trainings (Appendix 2). The adoption rate of remunerative non-farm jobs corresponds to the index scores of human assets and financial assets for all the VDCs. Kaule and Mahadevsthan, the two VDCs scoring lower in human and financial assets also has very few households (around 9%) adopting remunerative non-farm jobs; meanwhile Bhumlichowk and Kankada VDCs having relatively higher index scores for human and financial assets also have relatively higher adoption rates (24.5% and 23.2% respectively). Higher education and vocational training is necessary to pursue salaried jobs or skilled non-farm jobs. Also financial resource is needed for investing in education, vocational trainings, and related expenditures to go abroad.

5.4 Combination of storage and communal pooling: Construction of water collection tanks/ponds

Irrigation is still a big constraint to agriculture in the Chepang settlements. Only 22% of the total land is irrigated (Appendix 2), due to which recurrently occurring droughts are major threats to Chepang livelihoods. Few small-sized cemented tanks or plastic ponds have been recently constructed for collecting water from natural sources in the Chepang area with support from government and non-governmental organizations. This practice helps in the distribution of risks over time by storing flowing water that was previously unused, and also across households as the use of water from these tanks is regulated by a group of households in the community. Water from these tanks is used for irrigation purposes; a single tank can serve 5-10 houses. During the dry seasons, water from these tanks is circulated among the household on a turn basis. The adoption is the highest, again for Bhumlichowk VDC (nearly 40%), the VDC having highest adaptive capacity, followed by Kankada (16.1%), Kaule (13.8%), and Mahadevsthan (9.3%). The difference across the study VDC is statistically significant. Once again Mahadevsthan VDC has the lowest adoption rate despite having higher adaptive capacity index score compared to Kaule and Kankada VDCs. Construction of water collection tanks or ponds in all the cases is supported financially and technically by some institutions, especially the non-governmental organizations (NGOs) working with the community. Thus, social assets in terms of households' memberships in community based groups formed by such institutions can explain the differences in the adoption rate of this adaptation practice. Though the mean number of memberships in CBOs is the highest in Mahadevsthan VDC, the household having access to water collection tanks is the least in this VDC. NGOs working in this VDC may not put emphasis on building collection tanks because Mahadevsthan VDC already has quite good source of irrigation as shown by the highest percentage of irrigated land among the four VDCs (Appendix 2). Otherwise, the adoption rate of rest of the three VDCs is in accordance with the household's possession of social assets in terms of mean number of memberships in CBOs (Appendix 2). Leaving Mahadevsthan VDC aside, both the adoption rate as well as membership in CBOs is higher in Bhumlichowk, followed by Kankada and Kaule.

5.5 Combination of diversification and market exchange: Growing cash crops

Diversification from subsistence agriculture to cash crops helps to increase the adaptive capacity of the households by increasing cash income. However cash crops like vegetables are more vulnerable to droughts, therefore this adaptation practice can only be realized when households have access to irrigation and market. The percentage of irrigated land is comparatively higher for Mahadevsthan (25%) and Bhumlichowk (20%) while it is very low for Kankada (3%) and Kaule (8%) (Appendix 2). In terms of households having access to some forms of irrigation, the rate is higher again for Mahadevsthan (59%) and Bhumlichowk (62%) while it is only 7% for Kankada and 22% for Kaule (not tabulated). In terms of walking distance to the motor road, Bhumlichowk is the nearest with average 0.72 hours, followed by Mahadevsthan (1.4 hours), while the distance is above 3 hours for Kaule and Kankada. Unsurprisingly, most of the households in Bhumlichowk (92.5%) grow cash crops (mainly tomato and few other vegetables) due to the availability of irrigation facilities and proximity to the road compared to other VDCs. Households in Bhumlichowk have stopped cultivating millet to allocate lands for vegetables because return from vegetables is much higher. However, in the absence of irrigation facilities, millet is a better option as it is more drought tolerant compared to vegetables. Surprisingly, after Bhumlichowk, Kankada has the second highest percentage of households (69.6%) diverting to cash crops, despite its distance away from the road and lack of irrigation facilities. However, different from Bhumlichowk, the cash crops grown in Kankada are blackgram and horsegram. These legumes are drought tolerant crops, thus do not require irrigation. Dried grains of these legumes are sold as pulses, thus perishability is not a problem and distance from the road matters less. Once again, Mahadevsthan VDC shows surprisingly the lowest adoption rate of cash crops despite a relatively higher percentage of irrigated land and proximity to the motor road.

5.6 Combination of storage, diversification, and market exchange: Raising livestock as buffer

As already discussed under adaptive capacity, small livestock, especially goats are a major source of financial income for the Chepang households. Goat is the most suitable livestock for the Chepangs because goats can easily walk across the difficult terrains. They are left to graze openly during the day and are brought back home in the evening. Nearly 70% of the sample households reported that due to recurrent droughts they have increased their focus on livestock and rear goats as a buffer to cope with natural disasters including droughts and landslides. The trend is very similar across the four study VDCs and the adoption rate does not differ significantly. The practice of growing small livestock as a source of cash income is also an integrated livelihood strategy for the Chepangs and is practiced by the households without any particular reference to climate shocks. This practice is followed by majority of the households without any significant differences in the adoption rates across the study sites. Thus, adoption of this practice is not determined by the level of household adaptive capacity or possession of any particular assets by the households.

Out of 22 different adaptation practices listed in Table 2, Bhumlichowk has the highest or second highest adoption rate for 18 practices and has the lowest adoption rate for only two of the practices. Bhumlichowk VDC has the highest adaptive capacity index score and also has a balanced possession of all the asset categories (Figure 3). It appears quite relevant for this VDC to have the highest adoption rates. In the same line, it will be expected that Mahadevsthan VDC, which ranks second in the adaptive capacity index score, must have the next highest adoption rates after Bhumlichowk. However, much to the contradiction, Mahadevsthan fares the lowest in terms of adoption rate, even lower than Kaule, the VDC with least adaptive capacity index score. Mahadevsthan has the highest or second highest adoption rate for only 5 out of 22 practices, while Kankada has 12 and Kaule 10. Similarly Mahadevsthan has the least adoption rate for 10 adaptation practices, while the figures are 7 each for Kankada and Kaule. This result has two important implications. Firstly, balanced possession of all asset categories is necessary to recognize the full adaptation potential. As already explained, Bhumlichowk VDC has the balanced possession of all types of assets, thus has the highest adoption rate. On the other hand, in case of Mahadevsthan VDC, despite having higher physical and natural assets, the adoption rate is not as expected mainly due to the imbalance in human and financial assets. No single asset is sufficient to adapt or cope with risks; rather balanced possession of all five types of assets is important. A minimum development of human capabilities and financial resources for capital investment are necessary to utilize the existing resources to the fullest. Secondly, assessment of adaptive capacity in terms of asset possession might not give the complete picture because it is not clear why Mahadevsthan VDC has surprisingly lowest adoption rates, even lower than Kaule VDC, despite the fact that Kaule has the lowest possession of all asset categories except natural assets. The institutions and policies also form an important backdrop against which households formulate the asset utilization strategies to maximize livelihood outcomes. The analysis in this paper is limited in the sense institutions and policies are not taken into considerations. Future researches that analyze the factors determining the implementation of adaptation actions including the institutions, policies and asset holding is recommendable to arrive at a better explanation of the process by which adaptive capacity is translated into adaptation practices.

6. Conclusion and recommendations

Analysis of adaptive capacity from the perspective of asset possession demonstrates that adaptive capacity is not only determined by the level of economic development, but also by the social and human factors. While higher income is undoubtedly important to help household formulate relevant adaptation strategies, development of human capacity and provision of financial capital is equally important in order to effectively mobilize the existing resources. Similarly, social safety nets hold high significance, especially in rural communities like Chepangs. The analysis of adaptive capacity shed some important insights of policy relevance. Efforts from government or non-government agencies in the Chepang community should be geared towards improving the human capacity through education and trainings that would in turn facilitate adoption of non-farm higher-income sources less vulnerable to climate vagaries. Agriculture is still the mainstay of the Chepang livelihood, thus infrastructure development like irrigation facilities and agricultural road would help facilitate higher production, possibility of growing cash-crops, and improved access to market for disposal of products.

Relating adaptive capacity to adaptation measures actually practiced made it clear that the inherent adaptive capacity is the minimum necessary condition for adaptation actions to take place. Further comparison of adaptive capacity with adoption rate shows that aggregate adaptive capacity is not the sufficient determinant of adaptation practices. Balance between the components of adaptive capacity, most notably human and financial capital is necessary to translate adaptive capacity into adaptation practices. Households in Bhumlichowk are consequently implementing most of the adoption practices as this VDC not only has the highest aggregate adaptive capacity, but also has a balanced possession of all the component asset categories. On the other hand, Mahadevsthan VDC has not been able to translate the existing adaptive capacity into practices, due to the imbalance in possession of human and financial assets. Similarly Kaule VDC also exhibits a low adoption rate as it ranks the lowest in most of the asset categories. The policy implications of these findings is that integrated development support should be provided to these communities focusing on education, vocational trainings, and development of infrastructure. Similarly provisions of easy credit for productive investment can enable the households utilize the skills developed from vocational trainings for income generation. Among the four VDCs, Kaule and Mahadevsthan need to be prioritized in providing development assistance. Ultimately, the utilization of livelihood asset is also determined by the existing institutions and policies. Future researches analyzing the role of institutions and policies to understand the process by which adaptive capacity is translated into adaptation action is recommendable.

Exploring the existing adaptation practices confirmed many important characteristics of adaptation practices highlighted by the previous studies. A single adaptation practice can serve more than one particular risks and it is indeed difficult to isolate the adaptation practices devised solely in response to climate risks. For instance, diversifying to non-farm income sources, cash crops, and livestock could be done either in response to climate risks or purely with economic motivation. Furthermore, livelihood activities like wage labor, collection of wild edibles, soil conservation practices, and borrowing from social networks are integrated components of Chepang livelihoods, and these activities are pursued even when the households are not faced with climatic disasters. Planned development activities like construction of water collection tanks are implemented primarily with the objective of agricultural development and climate change adaptation might be integrated within this activity as a secondary priority. Most of the adaptation practices listed in this paper is implemented spontaneously by the households without any assistance from the government or other development agencies. Assistance for climate change adaptation by the government is virtually non-existent in the study sites. Although the government has prepared a detail National Adaptation Programme of Action (NAPA), related projects are yet to be implemented. Conservation practices like mulching, minimum tillage, and cover crops are currently not widely adopted. These simple adaptation measures can be promoted through government extension services.

Endnotes

[1] According to National Foundation for Development of Indigenous Nationalities Act 2002, the term indigenous nationalities refer to tribes or communities having their own mother language and traditional rites and customs, distinct cultural identity, distinct social structure and written or unwritten history. Based on the same Act, Nepal Government has identified 59 Indigenous Nationalities who are classified into five groups comprising of endangered, highly marginalized, marginalized, disadvantaged, and advanced group based on a composite index comprising of variables like literacy rate, housing, land holdings, occupation, language, graduates, residence, and population size. The indigenous nationalities are further classified into Mountains, Hills and Tarai based on the geographical location where they form a majority (NIRS, 2006).

[2] Newars and Thakalis are the only two indigenous nationalities falling under the advanced category.

[3] NRs: Nepali Rupees; 70 NRs = 1 US$ at the time of field survey

[4] LSU: Livestock Standard Unit; LSU is aggregate of different types of livestock kept at household in standard unit calculated using the following equivalents; 1 adult buffalo = 1 LSU, 1 cow = 0.8 LSU; 1 calf = 0.4 LSU, 1 pig = 0.3 LSU, 1 sheep or goat = 0.2 LSU and 1 poultry = 0.1 LSU (Baral, 2005; CBS, 2003).

[5] VDCs are the lowest administrative tiers in Nepal, composed of 9 wards.

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Appendix 1. Gross annual income/household from various sources in the study sites

Source	Gross annual income/household (NRs)										P-value
	Aggregate		Kaule		Kankada		Mahadevsthan		Bhumlichowk		
	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	
Agriculture	221 (100)	36,224.5	58 (100)	15,577.1	56 (100)	33,824.4	54 (100)	30,947.3	53 (100)	66,732.3	0.00***
Livestock	178 (80.5)	12,710.7	46 (79.3)	14,151.6	46 (82.1)	10,888.6	41 (75.9)	10,005.0	45 (84.9)	15,565.8	0.30
Wage labor	158 (71.5)	28,384.0	44 (75.9)	29,804.5	35 (62.5)	28,488.6	39 (72.2)	24,794.1	40 (75.5)	30,230.0	0.65
Forest	201 (91.0)	4,980.9	43 (74.1)	3,451.4	56 (100)	7,018.3	50 (92.6)	4,219.5	52 (98.1)	4,783.8	0.08*
Salaried job	23 (10.4)	68,076.5	1 (1.7)	36,000.0	15 (26.8)	67,744.0	2 (3.7)	60,000.0	5 (9.4)	78,720.0	0.75
Skilled non-farm job	27 (12.2)	40,577.8	12 (20.7)	27,666.7	3 (5.4)	24,000.0	8 (14.8)	41,450.0	4 (7.5)	90,000.0	0.00***
Remittance abroad	7 (3.2)	81,142.9	1 (1.7)	50,000.0	-	-	2 (3.7)	145,000.0	4 (7.5)	57,000.0	0.68
Business	10 (4.5)	12,125.0	1 (1.7)	18,000.0	7 (12.5)	7,892.9	1 (1.9)	30,000.0	1 (1.9)	18,000.0	0.28
Old age allowance	26 (11.8)	6,715.4	8 (13.8)	7,500.0	10 (17.9)	6,660.0	6 (11.1)	6,000.0	2 (3.8)	6,000.0	0.52
Honey	58 (26.2)	1,145.6	13 (22.4)	2,052.2	20 (35.7)	1,139.9	11 (20.4)	719.5	14 (26.4)	646.6	0.22
Handicraft	33 (14.9)	2,923.6	7 (12.1)	1,751.4	8 (14.3)	618.8	15 (27.8)	4,900.0	3 (5.7)	1,923.3	0.05**
Total	**221 (100)**	**86,497.5**	**58 (100)**	**59,103.2**	**56 (100)**	**90,891.1**	**54 (100)**	**74,209.6**	**53 (100)**	**124,353.8**	**0.00****

Source: Field survey, 2010
Note: Figures in parenthesis indicate percentage
***, **, * denote significant at 1%, 5%, and 10% level of significance respectively, and n denotes number of households

Appendix 2. Mean values for indicators of adaptive capacity across the four study sites

Indicators	Aggregate (n=221)	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	P-value
House type	2.24 (0.48)	2.16 (0.45)	2.23 (0.47)	2.20 (0.49)	2.38 (0.49)	0.09*
Have mobile phone	0.19 (0.39)	0.07 (0.26)	0.29 (0.46)	0.15 (0.36)	0.25 (0.43)	0.01**
Have radio	0.66 (0.47)	0.47 (0.50)	0.70 (0.46)	0.74 (0.44)	0.75 (0.43)	0.02**
Have access to solar / microhydro	0.29 (0.45)	0.43 (0.50)	0.30 (0.46)	0.33 (0.48)	0.06 (0.23)	0.00***
Walking distance to nearest road	2.12 (2.62)	3.09 (0.82)	3.15 (0.69)	1.39 (4.76)	0.72 (0.33)	0.00***
Agricultural tools	3,222.3 (1,670.1)	2,520.7 (1,456.0)	3,233.0 (1,568.7)	3,480.7 (1,657.9)	3,715.5 (1,790.6)	0.00***
Irrigated land	13.06 (21.9)	7.72 (19.8)	2.94 (13.34)	22.45 (24.85)	20.03 (22.32)	0.00***
Highest qualification	4.62 (2.90)	4.36 (2.76)	4.88 (2.94)	3.74 (3.08)	5.51 (2.58)	0.01**
Trainings / vocational course	0.52 (0.78)	0.41 (0.62)	0.48 (0.74)	0.56 (0.88)	0.62 (0.86)	0.52
Dependency Ratio	1.21 (0.76)	0.93 (0.65)	1.42 (0.84)	1.11 (0.68)	1.40 (0.75)	0.00***
Share of productive land type	74.49 (25.46)	77.11 (20.97)	61.64 (33.34)	84.43 (23.24)	75.07 (15.66)	0.00***
Share of less productive land type	25.02 (25.03)	22.88 (20.98)	36.58 (32.65)	15.46 (23.27)	24.88 (15.64)	0.00***
Have bullock	0.66 (0.47)	0.64 (0.48)	0.71 (0.46)	0.59 (0.50)	0.70 (0.46)	0.51
Gross annual income / capita	17,122.0 (11,238.3)	12,927.7 (8,714.2)	18,219.5 (9,735.3)	16,037.5 (11,415.2)	21,657.6 (13,226.4)	0.00***
Livelihood Diversification Index	0.53 (0.14)	0.54 (0.17)	0.54 (0.14)	0.54 (0.13)	0.52 (0.13)	0.82
Have remunerative income source	0.26 (0.44)	0.24 (0.43)	0.32 (0.47)	0.22 (0.42)	0.25 (0.43)	0.64
Savings	2,136.9 (9,469.9)	1,119.9 (4,554.1)	1,822.3 (10,660.1)	1,481.7 (4,678.5)	4,249.6 (14,419.4)	0.3
Ownership of goat, poultry, and pig	1.93 (1.35)	1.61 (1.07)	2.22 (1.47)	1.87 (1.22)	2.03 (1.56)	0.09*
Membership in CBOs	1.11 (1.15)	0.88 (1.11)	1.05 (1.24)	1.41 (1.30)	1.11 (0.87)	0.1*
Access to credit	2.65 (0.95)	2.31 (0.86)	2.77 (1.06)	2.74 (0.85)	2.79 (0.95)	0.01**

Source: Field Survey, 2010/11

Note: Figures in parenthesis indicate standard deviation,
***, **, * indicate significant at 1%, 5%, and 10% level of significance respectively, and n denotes number of households