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Social vulnerability of alpine transhumance pastoralists of western Arunachal Pradesh to climate change

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Abstract
Climate induced adaptive capacity and vulnerability of 240 *Brokpa* pastoral nomads of West Kameng and Tawang districts of Arunachal Pradesh were assessed. An exclusively social vulnerability to climate change index was developed underlying the principle of IPCC by using 37 household level indicators. Results revealed that mean value of the vulnerability profile of the pastoralists of both districts were positive and indicated that vulnerability profile of the transhumance pastoralists of western Arunachal Pradesh is largely influenced by their adaptive capacity than exposure and sensitivity. Inter district comparison of vulnerability established that pastoralists of West Kamneg district were more vulnerable than the pastoralists of Tawang district. The findings of the study will be the key information for the policy makers to prepare an action plan to minimize negative impact of climate change among the transhumance pastoral nomads of the Himalaya.

Keywords: Climate change, Eastern Himalaya, Pastoral nomads, Social vulnerability, Transhumance

Introduction

There is now a growing recognition of the vulnerability and impacts of climate change on the key sectors of economic development like agriculture (Sarkar *et al*., 2014). The Intergovernmental Panel on Climate Change (IPCC) has clearly concluded that impact of human activities on climate is unequivocal (IPCC, 2007). It is assessed that impact of climate change will be more severe in mountain and coastal ecosystem specially in developing and least developed countries (IPCC, 2007). Changing climatic scenario is a major concern in the Himalayas because of its potential impacts on different aspects (Liu and Rasul, 2007; Aryal *et al*., 2014). People and communities, highly dependent on natural resources for livelihoods are more affected by climate change (Aryal *et al*., 2014). Indigenous inhabitants of mountainous regions in the developing and least developed countries are least responsible but most threatened by climatic change and are recognised as the most vulnerable groups (Devkota *et al*., 2013; McDowell *et al*., 2013; Gentle and Maraseni, 2012; Bardsley and Wiseman, 2012; Ghimire *et al*., 2010; Salick and Byg, 2007).

Transhumance is the seasonal movement of pastoralists with their livestock between fixed summer and winter pastures. In mountain regions, it implies movement between higher pastures in summer and lower valleys in winter. Transhumance pastoralism are based on the efficient use of seasonally abundant grazing resources in marginal environments without degradation (Nautiyal *et al*., 2003) and regulated by the customary rules and informal institutions like village councils (Aryal *et al*., 2014; Maiti *et al*., 2012; Dong *et al*., 2009; McVeigh, 2004; Rao *et al*., 2003).

The *Monpa* is the predominant tribe of both West Kameng and Tawang Districts of Western Arunachal Pradesh. Among the *Monpas,* livestock rearers are popularly known as *Brokpa*. The literal meaning of *'Brok'* is herdsmen and *'pa'* is community and thus the meaning of *Brokpa* is - community of the herdsmen residing in the high reaches of the eastern Himalaya of Arunachal Pradesh (Bora *et al.,* 2012). Transhumance pastoralism followed by them is continuing from the time immemorial. Yaks and its allied species are taken in herds to high altitude alpine pastures during summer and descended to mid altitude as winter approaches (Paul *et al*., 2010). They live in temporary huts or simply live in tents made of yakõs hair. In recent past, the *Brokpa* pastoral community is facing newer challenges due to the dwindling population of yak, degradation of high altitude pastures, and subsequently shortage of feed and fodder resources.

But these challenges would transform into threats as a synergistic effect of impending climatic change in this region. The level of vulnerability of different social groups to climate change is determined by both socio-economic and environmental factors (Deressa *et al*., 2008). In climate change research, two distinct notions of vulnerability have been recognised ï bio-physical and social (Nyong *et al.,* 2008). Bio-physical vulnerability is concerned with the ultimate impacts of a hazard event. Social vulnerability is viewed as a potential state of human societies that can affect the way they experience natural hazards (Prasad *et al*., 2014; Nyong *et al*., 2008; Vincent, 2004; Adger, 1999; Adger and Kelly, 1999). Therefore, a study was undertaken to assess the social vulnerability of transhumance pastoralists of alpine region of Western Arunachal Pradesh.

Materials and Methods

Study area, sampling plan and data collection: The transhumance pastoralists mainly concentrate in the Tawang and West Kameng districts of the Western Arunachal Pradesh. Therefore, the present study was carried out in these two districts of Arunachal Pradesh. Lumla, Tawang, Thingbu blocks of Tawang and Kalaktang, Dirang and Nafra-Buragaon blocks of West Kameng are in alpine region forming the study area. A block wise list of base villages with transhumance pastoralists was prepared in consultation with respective block level veterinary officers. Two villages from each block were randomly selected thus covering 12 villages in all.

A pastoralist who has more than 30 years of experience in transhumance pastoralism and having main income from livestock was considered as respondent for the present study. Household head was considered as respondent for the study. Twenty pastoralists (*Brokpas*) from each village were randomly selected. Thus total 240 *Brokpas* were interviewed at either their door steps or grazing ground during 2011 -12. Focused group discussions (FGD) were also conducted to triangulate the collected data from the household.

Construction of social vulnerability to climate change (SVCC) index: The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability to climate change as ï*the degree to which a system is susceptible, or unable to cope with adverse effect of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.*ò Exposure is the nature and degree to which a system is exposed to significant climatic variations. Sensitivity is the degree to which a system is affected, either adversely or beneficially by climate-related stimuli. Adaptive capacity is the ability of a system to adjust to climate change including climate variability and extremes, to moderate the potential damage from it, to take advantage of its opportunities, or to cope with its consequences (McCarthy *et al*., 2001).

Combination of both theory and data driven approaches was adopted while selecting the indicators used in this study.

i. Collection of the vulnerability indicators

a. Exposure

Historical changes in climatic variables like temperature and rainfall; occurrence and experience of extreme climate events were considered as indicators of exposure. In this study, it was assume that effect of climatic variable was equivalent across the district. Therefore, district level data of different indicators of exposure were also considered as household level data for that particular district. Climatic indicators were calculated from the high resolution daily gridded temperature and rainfall data for the Indian region during the period of 25 years (1975 - 1999) developed by the India Metrological Department, Pune, India. Different indicators were used to measure exposure at the household level (Box 1).

Box 1. Indicators to measure exposure at the household level

1. Numbers of years having excess number rainy days than normal
2. Numbers of years having excess rainfall
3. Variation in rainfall
4. Numbers of days having very heavy rainfall
5. Numbers of days having extremely heavy rainfall
6. Numbers of heat wave incidences
7. Numbers of cold wave incidences
8. Change in mean temperature
9. Change in mean maximum temperature
10. Change in mean minimum temperature
11. Number of extreme climatic events experienced

b. Sensitivity

Sensitivity could best be measured by a change in income or livelihood attributed only to climatic factors. However, it was not possible to find this type of data. Instead, we were obliged to make the simple assumption that those areas with higher frequencies of climate extremes were

subjected to higher sensitivity due to loss in yield and livelihood of rural masses. A total 4 variables (Box 2) were considered for calculating degree of sensitivity of the studied households.

Box 2. Indicators to measure sensitivity at the household level

1. Annual income from all sources
2. Proportion of income from livestock
3. Primary livestock product prepared
4. Subsistence ratio

c. Adaptive capacity

Adaptive capacity is conceptualized as the combined effect of five types of livelihood assets viz. physical, human, natural, financial and social. A total 22 variables/ indicators were collated from the different published literatures and consultation with the subject matter specialist for calculating adaptive capacity of a household (Box 3).

Box 3. Indicators to measure adaptive capacity at the household level

Human Asset
Age of the household head
Educational status of the household head
Family education status
Gender of the household head

Social Asset
Social participation
Community participation
Community cohesiveness
Extension contact
Social migration
Number of relative in the village or community
Assistance from family members residing outside the village or community
Assistance from external agency
Farmer to farmer extension

Physical and Natural Asset
Herd size
Modern farm equipment used
Sources of climatic information
Distance of the household from metal road
Distance to purchase critical inputs
Distance to sell farm output

Financial Asset
Proportion of household expenditure to livestock
Productive animal in the herd
Habit of savings

ii. Selection of the appropriate indicators and assignment of weights to the selected indicators

Normalization of indicators was done by subtracting the minimum value from the observed value and dividing by range. Next step is the testing of suitability of indicators. After, normalization, three factor analyses (one for each exposure, sensitivity and adaptive capacity) for each data set were performed using Principal Component Analysis for extraction and varimax method for rotation of the factors in SPSS 20. Two indicators namely ónumbers of extreme climatic events experiencedô and ósubsistence ratioôwere dropped as their commonality values were below the cut-off (0.50). Remaining indicators were used for further analysis *i.e.* assignment of weights to the indicators and method followed by Feroze and Chouhan (2010) adopted for this study to assign the weights to the indicators.

iii. Calculation of the vulnerability index

The normalized indicators are then multiplied with the assigned weights to construct the indices separately for each component of vulnerability *viz*., exposure, sensitivity and adaptive capacity separately. Finally, vulnerability index for each household is calculated as:

VI = AC ï (E + S)

Where, VI is the Vulnerability index, AC is the Adaptive Capacity index, E is the Exposure Index and S is the Sensitivity index

The overall vulnerability index facilitates inter-household comparison. Higher value of vulnerability index indicates lower vulnerability. Here, index value indicates the net effect of adaptive capacity, exposure and sensitivity. Negative value indicates combined effect of exposure and sensitivity suppressed adaptive capacity. This index does not give the absolute measurement of vulnerability; rather the index value highlighted a comparative judgement of among the studied households.

iv. Differential level of vulnerability among the sampled households

All the sampled households were categorised into three differential level of vulnerability *viz*., lower level of vulnerability, medium level of vulnerability and higher level of vulnerability on the basis of obtained score by the respective households. Cumulative square root frequency method was used to categorise households into three categories.

Results and Discussion

Vulnerability to climate change: The mean index value of components of adaptive capacity at household level in alpine region was variable (Table 1). Transhumance pastoralists of western Arunachal Pradesh had a mean value of 2.235 in human asset category with West Kameng district showing higher mean value (2.401) than Tawang district (2.070). Human asset of pastoralists of West Kameng district differed significantly (P<0.05) with that of Tawang district. Rural literacy rate (Anonymous, 2013) of West Kameng (65.85%) was higher than Tawang (57.56). This might be the reason of higher human asset possessed by the pastoralists of West Kameng district.

In social asset, pastoralists of Tawang district had the higher mean value (5.857) than West Kameng district (5.769 and mean value among all the pastoralists of Arunachal Pradesh was 5.813. In Tawang district, only one community *i.e. Brokpa,* pastoral nomads of The *Monpa* tribe is engaged in transhumance pastoralism, but in West Kameng, several communities e.g *Monpa*, *Mizi* etc are engaged in transhumance pastoralism. Hence, social asset possessed by the pastoralists of Tawang district were having higher index value than their counter parts of West Kameng district. But there was no significant difference in social asset among the pastoralists of Tawang district and West Kameng district with each other.

Pastoralists from West Kameng district had higher mean value in physical and natural asset category (4.470) as well as in financial asset category (1.755), whereas overall mean values (for alpine region) of these two asset categories were 4.043 and 1.607, respectively. Physical and natural assets possessed by the pastoralists of West Kameng district were significantly (P<0.05) higher than their counter parts of Tawang district. It was also found that pastoralists of West Kameng district differed significantly (P<0.01) from the pastoralists of Tawang district in terms of their financial asset.

Mean values of vulnerability and its components of pastoralists of Western Arunachal Pradesh were also variable (Table 2). Pastoralists from West Kameng district possessed higher adaptive capacity with mean value of 14.395 than their counter parts of Tawang district (13.002). There was a significant difference in the adaptive capacity of the pastoralists of West Kameng and Twang districts. Pastoralists of West Kameng districts (6.000) also had higher exposure than their counter parts of Tawang district (4.000). Like exposure, pastoralists of West Kameng districts (1.479) had higher sensitivity than their counter parts of Tawang district (1.322). Degree of exposure and sensitivity of the pastoralists of West Kameng district was significantly different from the pastoralists of Tawang district.

Mean values of pastoralists of each district as well state were positive with overall mean value 7.298 (Table 2). District with lower vulnerability value indicated that pastoralists of that district were more vulnerable. Hence, pastoralists of West Kamneg district were more vulnerable than of Tawang district. Pastoralists of West Kameng district had the higher adaptive capacity and in the same time they possessed higher exposure as well as sensitivity. This could be the reason of higher vulnerability of pastoralists of West Kameng district. But interestingly, vulnerability of the pastoralists of the two studied districts of alpine region were not significantly

Table 1. Average value (Mean ± S.E) and comparative evaluation of different components of adaptive capacity

Study area	Human asset	Social asset	Physical and natural asset	Economical asset
West Kameng (n=120)	2.401±0.085 (4.898)	5.769±0.158 (9.406)	4.470±0.252 (10.227)	1.755±0.074 (4.159)
Tawang (n=120)	2.070±0.085 (4.892)	5.857±0.171 (9.687)	3.617±0.163 (8.055)	1.459±0.068 (3.172)
Man Whitney U Statistics (West Kameng Vs Tawang)	5559** (P<0.002)	6873.500 (P>0.544)	5870* (P<0.013)	5634.500** (P<0.004)
Arunachal Pradesh overall (n=240)	2.235±0.610 (5.036)	5.813±0.116 (9.686)	4.043±0.152 (10.227)	1.607±0.051 (4.159)

*Indicates significant at 5% percent level of significance, in a two tail test

**Indicates significant at 1% percent level of significance, in a two tail test

Values in parenthesis indicate range

Table 2. Average value (Mean ± S.E) and comparative evaluation of vulnerability and its different components

Study area	Adaptive capacity	Exposure	Sensitivity	Vulnerability
West Kameng (n=120)	14.395±0.340 (17.293)	6.000	1.479±0.032 (1.755)	6.916 ± 0.336 (17.984)
Tawang (n=120)	13.002±0.317 (17.984)	4.000	1.322±0.0371 (1.793)	7.679 ± 0.313 (17.773)
Man Whitney U Statistics (West Kameng Vs Tawang)	5610** (P<0.003)	7260** (P<0.001)	5510** (P<0.002)	6423 (P>0.149)
Arunachal Pradesh overall (n=240)	13.699±0.236 (18.612)	4.999 ± 0.065 (2.000)	1.401±0.025 (1.865)	7.298 ± 0.231 (18.997)

*Indicates significant at 1 % percent level of significance, in a two tail test
Values in parenthesis indicate range

Table 3. Distribution of households of western Arunachal Pradesh according to differential level of vulnerability

Study area	Medium (7.286 to 11.147)#	Low (11.148 to 18.558)#	High (-0.439 to 7.285)#
West Kameng (n=120)	12 (10.000)	50 (41.667)	58 (48.333)
Tawang (n=120)	18 (15.000)	42 (35.000)	60 (50.000)
Arunachal Pradesh overall (n=240)	30 (12.500)	92 (38.333)	118 (49.167)

#Indicate score of categorisation
(Remaining) Values in parenthesis indicate percentage

different when all its components *i.e*. adaptive capacity, exposure and sensitivity differed significantly with each other. Aryal *et al*. (2014) studied the vulnerability of the transhumant communities of three village development committee namely Khumjung, Majhigaun, Kalinchok of Nepal and found that there was variation in the level of exposure, sensitivity and adaptive capacity. Piya *et al*. (2012) also studied the vulnerability of Chepang community of Nepal and reported that adaptive capacity was the main driver of higher vulnerability. Tambe *et al*. (2011) stated that village communities of Sikkim had the highest exposure to climate change coupled with high sensitivity and low adaptive capacity resulting in higher vulnerability.

Differential level of vulnerability of the respondents

Half of the pastoralists from West Kameng (48.333%), Tawang (50.000%) and Arunachal Pradesh overall (49.167%) were in higher vulnerability category followed by medium and low level of vulnerability (Table 3). Agro-climatic region has significant contribution in climate induced vulnerability and present study was confined only in a single agro-climatic region *i.e*. alpine region of western Arunachal Pradesh. This might be the reason of almost equal distribution of pastoralists in different categories of vulnerability. The present study also got confirmation from Williams and Hardison (2013) and Xu *et al*. (2009) who concluded that indigenous inhabitants of mountainous regions of developing and least develop countries are most vulnerable to climate change.

Conclusion

The present vulnerability assessment correlated five types of livelihood assets *viz*., physical, human, natural, financial and social with the exposure and sensitivity of the transhumance pastoral community of the eastern Himalaya. The positive vulnerability value also proved that vulnerability profile of the transhumance pastoralists of Western Arunachal Pradesh was largely influenced by these five livelihood asset. Therefore, to mitigate the risk of climate change, adaptive capacity of the household must be enhanced. Improvement in each and every aspect of livelihood assets will help to augment adaptive capacity which will lead to reduce vulnerability of that particular household at first then to the region. Hence, it may be concluded that emphasis must be given at household level in parallel with the regional level.

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