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Adapting to climate change: Traditional coping mechanism followed by the *Brokpa* pastoral nomads of Arunachal Pradesh, India

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Transhumance system of livelihood of the *Brokpa* pastoral nomads inhabiting in the yak tracts of Arunachal Pradesh with special emphasis on climate change adaptation was assessed in the present study. A representative sample of the 240 *Brokpa* pastoral nomads from all the yak rearing tracts of Arunachal Pradesh was selected randomly. The *Brokpa* pastoral nomads mainly depend upon livestock, like yak, yak-cattle hybrid etc, rearing for their livelihood. They perceived that season cycle has been changed in lower and mid altitude. They also perceived that onset of summer is getting started 1-2 month(s) earlier than before and also extended by 2-3 months. Therefore, *Brokpa* pastoral nomads of Arunachal Pradesh have expanded their migration duration by 2-3 months in searching of congenial environment for their livestock specially yak and yak-cattle hybrid. They adopted 10 coping mechanisms to cope up with negative impact of climate change. Among the coping mechanisms, 'duration of migration has expanded by 2-3 months' and 'change in pasture utilization practice' were found to be mostly adopted.

Keywords: Adaptation, Coping mechanism, Climate Change, Pastoral nomads

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Climate change is now recognized as a phenomenon that will be seen and experienced by people all over the world. It is a global phenomenon, but impacts are local and so do the adaptation capacities, preferences and strategies. The Northeastern states of India are expected to be greatly affected by climate change because of their geoecological fragility, strategic location vis-à-vis the Eastern Himalayan landscape and international borders, their trans-boundary river basins and the inherent socioeconomic instabilities[1].

More recently, adaptation to climate change and variability has also come to be considered an important response option worthy of research and assessment, not simply in order to guide the selection of the best mitigation policies, but rather to reduce the vulnerability of groups of people to the impacts of climate change, and hence minimize the costs associated with the inevitable[2,3,4]. According to the latest assessment report of Intergovernmental Panel on Climate Change (IPCC) refers climate change to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and /or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any changes in climate over time, whether due to natural variability or as a result of human activity. Whereas adaptation refers to adjustment in ecological, social or economic systems in response to actual or expected climate stimuli and effects or impacts.

The *Monpa* is a primitive tribe inhabiting parts of West Kameng and Tawang district of Arunachal Pradesh. They constitute more than 80 % of the population of the two districts. The *Monpa* who are inhibiting in the highland of these two districts are mainly depended on livestock for their livelihood and it is also reported that 62 % of their livelihood requirements is provided by yak (*Poephagus grunniens* L.)[5]. The pastoral nomad of the *Monpa* tribe is popularly known as B*rokap* (tenant herdsmen) and transhumance system of livestock rearing is their main source of livelihood. The future of transhumant pastoralists depends on the way they will manage their stay and livestock in over stocking winter

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grazing land[6]. But 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. But, now-a-days, these challenges transform in to threat as a synergistic effect of impending climatic change in the one of most vulnerable and fragile ecosystem of mountainous region of Western Arunachal Pradesh. In this backdrop, a systematic study was carried out on the adaptation strategies followed by a specific pastoral nomads inhibiting in this fragile environment with special focus on traditional mechanisms to cope up with changing climatic scenario.

Research methodology

The *Brokpa* pastoral nomads entails seasonal migration with entire household, yak, cattle & other animal and mainly concentrate in the highlands of the western Arunachal Pradesh, *i.e.* Tawang (longitude 90° 15' E and 27° 45' N and) and West Kameng District ($91^0$30'E to $92^0$40' E longitude and $26^0$54' to $28^0$01' N Latitude). Therefore, the present study was confined mainly in the different yak tracts of Arunachal Pradesh. Nyukmadung, Lubrang, Senge, Mandla-Phudung, Dirnang Basti and Chhander village were selected purposively from West Kameng District; and Jangda, Shyro, Rho, Mirba, Mukto and Sherjong villages were selected from Tawang district (Fig. 1). The *Brokpa* who has more than 30 years of experience in livestock rearing of at least one species among cattle, yak, mithun, goat, sheep and pig; and having main income from livestock was considered as respondents for the present study. Village wise lists of livestock depended households were prepared with the help of livestock enumerator of that respective villages. Household head was considered as respondents for the present study. Subsequently, from each selected villages, 20 respondents were selected randomly. Thus, total 240 *Brokpas* were interviewed during 2011 -12 with the help of local leader like *Gaon Burha* (village headsman) with the help of an open ended survey schedule to record the information on different aspects of climate change and adaptation strategies to cope up with climate change as well as socio-economic scenario. Before selection of questions for interview schedule, relevant previous studies on the *Brokpa* community[7], *Monpa* tribe[8] and impact of climate change on biodiversity of Arunachal Pradesh[1,9] were consulted. For the confirmation of the selected questions for interview schedule and to get an insight regarding perception of *Brokpa* community on climate change & its impact; and their coping mechanism, a pilot study was conducted in the non-sample villages. Focused group discussion (FGD) and simple observation method was also employed to carry out this work (Fig. 2). Secondary information necessitated for this study was collected from District Commissioner's office of the both district. The explanatory research design with complementation of descriptive statistics was adopted to explain the recorded data and draw the meaning full conclusion from the study. Prior informed consent obtained from the *Gaon Burha* (village head man) for sharing and publishing their traditional coping mechanism as adaptation strategies to acknowledge them formally. While seeking informed consent, the researchers have explained the purpose of the research, its sponsors, potential benefits and possible problems associated for people and the environment, research methodology and participation of residents of the community. They were given an opportunity to read the summarized facts of research through their *Gaon Burha*. Traditional coping mechanisms for climate change among the pastoralists of Ethiopia were described in narrative form[10]. Therefore, data were subjected to represent in narrative form in the present study.

Climate change is operationalized, for the present study, as any changes in climate over time, whether due to natural variability or as a result of human activity. Awareness is the state or ability to perceive, to feel, or to be conscious of events, objects or sensory patterns. Awareness regarding climate change was operationalized as the conscious feeling of the *Brokpa* pastoral nomads regarding the changing climatic scenario. At first, the respondents was directly asked whether they feel any change in climate over the past 30 yrs on the binary response 'YES' or 'NO'.

Adaptation refers to adjustment in ecological, social or economic systems in response to actual or expected climate stimuli and effects or impacts. Adaptation strategies was operationalized as the measures adapted and/or followed by the *Brokpa* pastoral nomads to cope up with the adverse impact of climate change on livestock rearing and/or their livelihood for sustainable livestock productivity and/or sustainable livelihood security.

The *Brokpa* pastoral nomads who recognised changing climatic scenario were directly asked

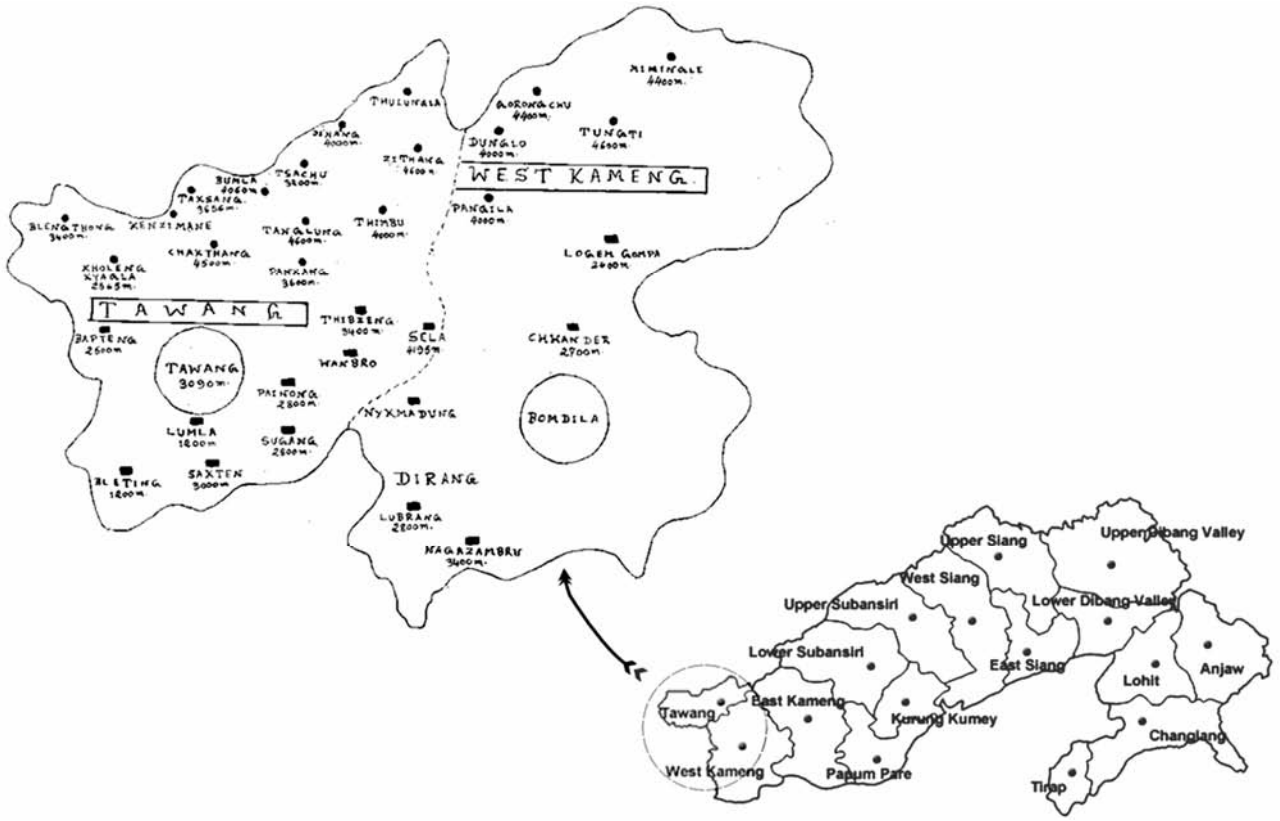

Fig. 1—Yak tracks of Arunachal Pradesh

whether they adopt any measure to cope up with the negative impact of climate change on the binary response 'YES' or 'NO'. Those who responded 'YES', again they were requested to put their response on a three point continuum viz. continued the adoption, discontinued the adoption and never followed/adopted with the score of 2,1, and 0 on a prelisted adaptation strategies for both the region. A list of adaptation strategies were prelisted during a pilot survey in the study area using the snowball technique. Therefore, in order to quantify the adaptation strategies, an exclusive '**Climate change adaptation index (CCAI)**' was developed by using the following formula:

$$\text{Climate Change Adaptation Index CCAI} = \frac{\text{Obtained Score}}{\text{Maximum Obtainable Score}}$$

Adaptation strategies with higher index value indicate that these adaptation strategies has comparatively more cope up capacity than the adaptation strategies with lower index value. Ranking of these adaptation strategies were done according to their higher index value.

Fig. 2—Focused Group Discussion with *Brokpa* Community members is going on

Results and discussion

Climate change adaptation among the Brokpa pastoral nomads *of Arunachal Pradesh who recognized the changing climatic scenario*

The results presented in Table 1 depicts that 78.3 %, 85 % and 81.6 % of the *Brokpa* pastoral nomads of West Kameng district, Tawang district and

Arunachal Pradesh overall, respectively, were aware regarding the changing climatic scenario. Those who aware were subsequently asked if they had responded through adaptation to reduce negative impacts of climate change and 80.9 %, 70.6 % and 75.5 % of them stated that they have adopted at least one adaptation strategies to cope up with climate change. Remaining 19.1 %, 29.4 % and 24.5 % of *Brokpa* pastoral nomads of West Kameng district, Tawang district and Arunachal Pradesh overall, respectively, did not do any thing to cope up with climate change. Native people of Arunachal Pradesh perceived changing climatic scenario in great extent[1].

Adaptation strategies followed by the Brokpa pastoral nomads in Arunachal Pradesh

Proliferation of yak-cattle hybridization

Hybridization between yak and cattle is recorded from time immoral. Species hybridization between male hill cattle and female yaks is common in Arunachal Pradesh. Yak herders practice inter-species breeding for better production as *Dzomo* is known for its better production and adaptation at lower altitude. Now-a-days, yak herders are forced to migrate to higher altitude in search of congenial environment for yak to maintain its productivity. But, these high altitude pastures are devoid of basic amenities like transport, electric, healthcare, market, etc. Whereas, mid altitude pastures are full of these basic amenities but underutilized, because, it is too high for cattle and too low for yak. Therefore, due to their easy adaptability at mid altitude, species hybridization between yak and hill cattle is getting more importance among the yak herders. F_1 males are known as *Dzo* and females as *Dzomo* in most parts of yak-breeding tract of the state. Yak herders also perceived that hybrids (F_1) are superior to yaks in milk production. However, subsequent generations are less productive and uneconomical. Interestingly, yak herders reported that male offspring (*Dzo*) of inter species crossing are always sterile and they use only for draught purpose. Yak herders also revealed that hybridization between yak and cattle is practiced since time immemorial and is a common practice among the yak herders of Arunachal Pradesh. Herders also perceived that during last one or two decades, this practice gets momentum and changing climatic scenario is the main responsible for this. Previous studies established that local breed of yak is decreasing and hybridization is the main responsible for this[7,11].

Table 1—Climate change adaptation among the *Brokpa* pastoral nomads of Arunachal Pradesh who recognized the changing climatic scenario (percentage)

Study Area	Recognized changing climatic scenario	Adaptation among those who recognized	
		Adapted	Not adapted
West Kameng (n = 120)	78.3	80.9	19.1
Tawang (n = 120)	85	70.6	29.4
Arunachal Pradesh overall (n = 240)	81.6	75.5	24.5

Migrate to higher altitude

The comfortable zone of temperature for yak ranges from 5°C to 13°C[12] with an average of 10°C[13]. The desirable relative humidity for yak ranges from 50 - 65 % with an average of 60 %[12]. Thermal Humid Index (THI) of around 52 is the comfortable upper limit for yaks[14]. But, in cattle the comfortable limit of THI is 72[15,16]. It is also recorded that air temperature of Nykmadung area of West Kameng district (at 2750 MSL) was more than 10^0C during May – October, THI of that area crossed the comfort zone, *i.e.* 52 during May – September and relative humidity is over the 65 % through out the year[14]. Therefore, the *Brokpa* pastoral nomads are forced to migrate to the higher altitude in the search of congenial environment for their yak and yak-cattle hybrid (Fig. 3).

Duration of migration has expanded by 2-3 months

A close relationship between the seasonal migration and round the year activities of yak herder

Fig. 3—Naga Grazing Ground (14000 ft MSL) – An important summer grazing ground of West Kameng District, Arunachal Pradesh

was observed. Availability of green forage grasses and climatic conditions were determining factors of migration. Yak herdsmen used to divide a year into four parts, viz. spring, summer, autumn and winter. During the summer (May to September) they stayed at alpine pasture at an altitude of 3,000 - 4000 m above mean sea level (MSL) and it is the productive season of yak husbandry as the availability of flash green grasses is adequate. Maximum of calving takes place in this season and they start making milk products. In the second half of this season, breeding of yaks starts due to the good health condition. During the autumn season (middle of September to November) yak herdsmen started down migration and utilize the green grasses of the mid altitude. Yaks are still productive and they continue preparation of milk products. Finally, they reach to lower altitude of 2000 - 2500 m above mean sea level and start winter grazing. During the winter season (December - February) they stop milking and leave the animals to the nearby forest. Once in a week during the entire season, they used to offer common salt to their animal. Sometimes, they collected leaf of tree fodder (*Quercus wallichiana*, Acer campellii, *Salix humboldtiana*, *Buddleja asiatica*, *Symplocos racemosa*, *Castanopsis sp., Ligustrum myrsinitis*, *Acer hookeri*, *Spirala sp*, *Embelia robusta*, Domreb and *Berberis sp*) and fed to milch *Dzomo.* In the month of March-April (spring season) when summer set in the lower altitude they start for up migration for cold weather. It is the start of calving period and milking of animals. Body condition also improves due to availability of grass on the transit route.

Brokpas revealed that 10-15 yrs back, they used to start upward migration in the month of May – June. They also revealed that during last 10-15 yrs, winter period had shortened and temperature during the mid of March is not at all congenial for yak. Therefore, they were forced to start upward migration during the last week of February to mid of March. Previous studies established that herders move with their herds in search of water and pasture to different locations during different times of the year[10].

Change in timing of migration

All the yak herders, using grazing grounds of particular village, meet at a pre-fixed place during the festival (New Year celebration of the *Monpa* community) or second week of February and discuss about the distribution of grazing routes for that particular year. They also fixed the date of movement to the respective grazing routes. Date of movement mainly depended on the temperature. Yak herders believed that yak feel warm from the mid of February or first week of March as winter is gradually shortening. Therefore they forced for early migration. They also reported that cycle of migration used to complete during the month of December, but, 10-15 yrs back, it was in the month of November. Present study got support from previous studies like pastoral nomads of Tibet[17], Ladakh[18], eastern Sudan[19] and Syria[20] changed their timing of migration due changing climatic scenario.

Herd diversification

Yak is the predominant animal reared by the *Brokpa* pastoral nomads. Domestication of yak in particular has led to progress, prosperity and economic advancement for the *Brokpas* because of the value of the yak as a pack animal and its products from milk, hair, hides and meat. *Dzomo*, the yak-hill cattle hybrid, is also popular among the *Brokpa* pastoral nomads and prized for its quality milk, ghee and *churpi* (a traditionally wet cheese made of fermented yak milk). *Brokpas* of mid altitude prefer this animal but most of the lower altitude *Brokpas* prefers *Galang* (local hill cattle). Sheep flock is also very common in lower to mid altitude of this region. Due to the availability basic amenities in mid altitude pastures, most of the *Brokpa* pastoral nomads are mostly interested in mid altitude pasture and used to keep all types animal to attain maximum profitability.

Our study finds support from other parts of world also. The shifts in composition of herds sometimes occur in response to changes in environmental circumstances[21]. After the 2006 flood of Dassanech and Nyangatom of South Omo zone, Ethiopia, pastoralists started keeping camels with in their herd[10]. Herd diversification helps to prevent a total herd loss by keeping animals with a range of tolerance levels to climatic stresses[22,23].

Change in pasture utilization practice

Traditional yak husbandry system involves migration in search of better pasture. Yak herders practices two-pasture utilization strategies. During summer, yaks are taken to high altitude alpine pasture (4,500 m MSL and above). In winter, they return to pockets nearer to their villages located at mid altitude sub-temperate alpine pastures (3000 m MSL). They also utilized the grazing routes as pastures during their upward and downward migration. Pasture

utilization strategy is also depends on the climatic scenario. It is already discussed that *Brokpa* pastoral nomads are forced to migrate higher altitude. Therefore, previously used transit pastures are presently using as winter halt. Pastures of near to 2500 m above MSL are presently using as transit. *Brokpa* pastoral nomads opined that these pastures were using as the summer halt before 10-15 yrs.

Rejuvenation of degraded high altitude pastures

Synergistic effect of 'changing climatic scenario', 'over livestock population pressure per unit area of pasture', 'infestation of wild weed spp. (*Rumex* spp.)', and 'indiscriminate use of pastures' are the major cause of degradation of high altitude pastures as perceived by the *Brokpa* pastoral nomads. They also perceived that rejuvenation of degraded pastures is an urgent need for their sustainable livelihood security. Therefore, yak herders in collaboration with National Research Centre on Yak has started rejuvenation of degraded high altitude pastures by introducing new species of grasses like *Dactylus glomerata* L*, Lolium perenne* L, *Setaria sphacelata, Festuca arundinacea* and legumes like *Trifloium repens* L. and *Trifolium pratense.*

Feed supplementation

The *Brokpa* pastoral nomads are now a days offering feed supplementation to their animal for better productivity. Locally available feed resources like maize crushed are being used as supplementation. They are providing feed supplementation mainly in winter season when adequate grass is not available. Few *Brokpa* pastoral nomads also adopted the complete feed blocks (CFB) prepared by the National Research Centre on Yak during winter season to maintain the body weight and productivity of their animal.

Adopting livestock healthcare practices

Arunachal Pradesh is full of different medicinal herbs. These herbs are being used by the highlanders for the treatment of their own as well as their Livestocks. But, now a days, *Brokpa* pastoral nomads used to prefer mid altitude pastures, where yaks are mixed with local cattle and as a result yaks and cattle suffer from various infectious diseases like foot-and-mouth disease (FMD), brucellosis, haemorrhagic septicemia (HS), chlamydiosis, salmonellosis and infectus bovine rhinotrachitis (IBR). Their own traditional knowledge is not so much successful to control these diseases. Therefore, they adopt modern health care practices like vaccination, etc. to protect their herd from fatal diseases and to maintain proper production and productivity.

Searching of alternate sources of income

The *Brokpa* pastoral nomads adopted several subsidiary income generating activities like collection of star fruit from the forest, labourer of apple & kiwi orchard and in Border Road Organisation. They adapt these subsidiary income generating activities mainly in winter season for marinating their livelihoods. Transhumance system of livestock rearing is considered as difficult, tough and devoid of modern amenities. Therefore, the younger generations of yak herdsmen are now not willing to continue with the age-old yak rearing as their profession.

During extreme climatic events like severe draught pastoralists cope up by engaging in non pastoral activities and increasing their off-farm income[10,24,25]. Different researchers reported several such activities like charcoal making[22], collection of wild fruits[26,27], engaging in petty business and sale of assets.[22]

State of adoption of adaptation strategies followed by the Brokpa* pastoral nomads *of Arunachal Pradesh

Table 2 revealed the state of adoption of the 10 coping strategies followed by the studied *Brokpa* pastoral nomads. Majority (63.2%) of the *Brokpa* pastoral nomads from West Kameng district did not followed the first adaptation strategies, *i.e.* proliferation of yak-cattle hybridization and remaining 36.8 % of them adopt this practice. Most of the *Brokpa* pastoral nomads of the West Kameng district did not keeping neither yak nor yak-cattle hybrid in their herd. This may be the reason of non-adoption of this practice. But, there was an opposite scenario in Tawang district. Majority (70.8 %) of the *Brokpa* pastoral nomads of Tawang district adopted this practice. Out of 14231 yak and yak-cattle hybrid of Arunachal Pradesh, 10022 were in Tawang district (Livestock Census of Arunachal Pradesh, 2007). This may be reason of higher adaptation of this practice. Nearly half of the respondent (51.4 %) continued this strategy and only 19.4 % of them discontinued this adaptation. From F_2 onwards, yak-cattle hybrid is less productive and male offsprings were sterile. This may be the reason of the discontinuance of this practice among the *Brokpa* pastoral nomads of Tawang district.

Table 2—Adaptation strategies followed by the *Monpa* pastoral nomads of Arunachal Pradesh (percentage)

Adaptation strategies	West Kameng district (n=76)				Tawang district (n = 72)			
	F	C	D	NF	F	C	D	NF
Proliferation of yak-cattle hybridization	36.8	31.6	5.3	63.2	70.8	51.4	19.4	29.2
Migrate to higher altitude	52.6	52.6	0.0	47.3	77.7	56.9	20.8	22.2
Duration of migration has expanded by 2-3 months	100	84.2	15.8	0.0	100	81.9	18.1	0.0
Change in timing of migration	52.4	52.6	0.0	47.3	69.4	69.4	0.0	30.6
Herd diversification (Yak + Cattle + Hybrid + Sheep + Pony)	50.0	23.6	26.3	50.0	54.2	26.4	27.8	45.8
Change in pasture utilization practice	100	75.0	25.0	0.0	100	72.2	27.8	0.0
Rejuvenation of degraded high altitude pastures	52.6	52.6	0.0	47.3	69.4	44.4	25.0	30.6
Feed supplementation	84.2	57.8	26.3	15.7	97.2	77.8	19.4	2.8
Healthcare practices	60.5	34.2	26.3	39.4	61.1	61.1	0.0	38.9
Searching of alternate sources income	52.6	52.6	0.0	47.3	76.4	76.4	0.0	23.6

ADS: Adaptation Strategies; F – Followed; C – Continued; D – Discontinued; NF – Never Followed

The same table depicts that 52.6 % of the *Brokpa* pastoral nomads of West Kameng district used to migrate higher altitude in search of congenial environment for their animal. All those who adopted this strategy are continuing this practice. But, 20.8 % of *Brokpa* pastoral nomads of Tawang district discontinued. Tawang it self situated in high altitude than West Kameng, therefore, it was not necessary for all the *Brokpa* pastoral nomads of Tawang district to migrate to higher altitude all the time.

All the *Brokpa* pastoral nomads of West Kameng and Tawang district were happy to migrate 2-3 more months than before. But, only 15.8 and 18.1 % of them of the both districts, respectively, reported that they discontinued this practice. These *Brokpa* pastoral nomads are more interested in yak-cattle hybrid now-a-days instead of pure yak. Therefore, they discontinued this practice.

As far as change in migration is concerned, it was found that 52.4 and 69.4 % of *Brokpa* pastoral nomads of West Kameng and Tawang district, respectively, reported that they have changed their timing of migration due to the changing climatic scenario. It was also interesting that all those who adopted this practice are continuing and there is no evidence of discontinuance.

Half of the *Brokpa* pastoral nomads of west Kameng district diversified their herd with yak, cattle, yak-cattle hybrid, sheep, pony, etc. and remaining half of the *Brokpa* pastoral nomads never diversified their herd. In Tawang district, these figures were 54.2 and 45.8, respectively. They believed that diversification was cause of several problems like more diseases in the herd, difficult in migration, etc. Due to these reasons; 26.3 and 27.8 % of the *Brokpa* pastoral nomads of West Kameng and Tawang district, respectively, discontinued and maintaining the herd with a single type of animal.

All the *Brokpa* pastoral nomads of West Kameng district and Tawang district changed pasture utilization strategy according to the changing climatic scenario. But; 25 and 27.8 % of the *Brokpa* pastoral nomads of Kameng district and Tawang district, respectively, discontinued this practice.

The *Brokpa* pastoral nomads of Arunachal Pradesh perceived that high altitude pastures were degrading day by day due to several factors like changing climatic scenario, over livestock population per unit of area, infestation of wild weed, etc. More than half (52.6%) and 69.4 % of the *Brokpa* pastoral nomads of West kamneg district and Tawang district, respectively, adopted this adaptation strategy. All those who adopted this strategy were continuing in West Kamneg district. But, 25 % of the *Brokpa* pastoral nomads of Tawang district discontinued this practice. Condition of the high altitude pastures of West Kamneg district are in worst condition than Tawang district. This adaptation strategy started under the guidance of National Research Centre on Yak situated in West Kameng district. Therefore, scientists of the institute are regularly following this practice. This may be the cause of continuous adoption of this practice in West Kamneg district.

Livestock rearing of Arunachal Pradesh is a classic example of 'zero-input' based livestock rearing. But, to maintain the productivity and body weight of animal during winter season, the *Brokpa* pastoral nomads of the region has started offering locally available concentrates and complete feed blocks prepared by NRC on Yak. Table 2 depicts that 84.2 % and 97.2 % of the *Brokpa* pastoral nomads of West Kameng district and Tawang district were feeding supplementation to their livestock.

Livestock rearer of Arunachal Pradesh is mainly depended on ethno-veterinary practices. But, at present, they adopted modern health practices like vaccination, etc. It is revealed from the same table that 60.5 % and 61.1 % of the *Brokpa* pastoral nomads from West Kameng district and Tawang district, respectively, adopted this adaptation strategy. The *Brokpa* pastoral nomads of Tawang districts perceived the benefits of modern healthcare practices. Therefore, those who adopted this practice are continuing in Tawang district. But, it was also found that a sizeable numbers of the *Brokpa* pastoral nomads of West Kameng district (26.3 %) discontinued this practice. Livestock healthcare facility of West Kameng district is not covering all the grazing grounds. Therefore, due to the non-availability of health care facility, the *Brokpa* pastoral nomads of West Kameng discontinued this practice.

Table 2 also depicts that 52.6 % and 76.4 % of the *Brokpa* pastoral nomads of West Kameng district and Tawang district, respectively, were searching alternate source of income during lean season for their livelihood. It was also found from the same table that all those who adopted this practice were continuing.

Ranking of adaptation strategies followed by the Brokpa pastoral nomads of Arunachal Pradesh

From the Table 3, it can be easily remarked that the adaptation strategy 'duration of migration has expanded by 2-3 months' was the most preferred adaptation strategy in both the studied district of Arunachal Pradesh, i.e. West Kameng district, Tawang district. People of Arunachal Pradesh perceived that season cycle has been changed in lower and mid altitude. They also perceived that onset of summer is getting started 1-2 month(s) earlier than before and also extended by 2-3 months. Therefore, *Brokpa* pastoral nomads of Arunachal Pradesh have expanded their migration duration by 2-3 months in searching of congenial environment for their livestock specially yak and yak-cattle hybrid.

'Change in pasture utilization practices' was the second most preferred adaptation strategy in West Kamneg district, but, it ranked third in Tawang district. 'Feed supplementation' got the third rank in West Kamneg district, but, it was second most important adaptation strategies in Tawng district. Four adaptation strategies, *i.e.* 'migrate to higher altitude', 'change in timing of migration', 'rejuvenation of degraded high altitude pastures' and 'searching of alternate sources of income' got the equal importance and ranked forth by the *Brokpa* pastoral nomads of West Kameng district. Adaptation strategies like 'proliferation of yak-cattle hybridization', 'herd diversification' and 'healthcare practices' were the least preferred among the *Brokpa* pastoral nomads of West Kameng district. 'Proliferation of yak-cattle hybridization' was one of the significant adaptation strategies. Most of the yaks of West Kameng district are found in Dirang block and few in Kalaktang block. Respondents from Dirang adopted

Table 3—Index score and ranking of adaptation strategies followed by the *Brokpa* pastoral nomads of Arunachal Pradesh

Practices	West Kameng (76)		Tawang (72)	
	Index Score	Rank	Index Score	Rank
Proliferation of yak-cattle hybridization	0.34	VII	0.61	VII
Migrate to higher altitude	0.53	IV	0.67	VI
Duration of migration has expanded by 2-3 months	0.92	I	0.91	I
Change in timing of migration	0.53	IV	0.69	V
Herd diversification (Yak + Cattle + Hybrid + Sheep + Pony)	0.37	VI	0.40	IX
Change in pasture utilization practice	0.88	II	0.86	III
Rejuvenation of degraded high altitude pastures	0.53	IV	0.57	VIII
Feed supplementation	0.71	III	0.88	II
Healthcare practices	0.47	V	0.61	VII
Searching of alternate sources of income	0.53	IV	0.76	IV

this practice only. Therefore this practice got least preference among the *Brokpa* pastoral nomads the West Kameng district.

'Herd diversification', 'rejuvenation of degraded high altitude pastures', 'proliferation of yak-cattle hybridization', 'migrate to higher altitude' and 'change in timing of migration' were least preferred adaptation strategies among the *Brokpa* pastoral nomads of Tawang district.

Conclusion and policy implications

The *Brokpa* pastoral nomads of Arunachal Pradesh perceived changing climatic scenario and to cope up with negative impact of climate change, several coping mechanism were adopted. Among the coping mechanisms, 'duration of migration has expanded by 2-3 months' and 'change in pasture utilization practice' were found to be most among them. It was also found that the *Brokpa,* who adapted these practices, were continuing by considering its importance. Though the coping mechanisms are the traditional one, but, it may be concluded that all the 10 identified coping mechanisms have a scientific basis.

In this study, it is proved that local and/or native people held good knowledge base regarding changing climatic scenario and adapt suitable strategies to cope up with negative impacts of climate change. It was also found that these adaptation strategies were in the line of recommendations made by the climate researchers. Therefore, it is suggested that during implementation of the developed action plan on climate change, a representative from livestock rearers must be in the core group of programme implementation and livestock rearers' feedback must be incorporated during refinement of action plan.

Though the coping mechanisms are the traditional one but little attention has been paid to the consequences of adaptation policies and practices for sustainability. In the present study it was found that proliferation of yak-cattle hybridization gets momentum in the present changing climatic scenario. Though it is profitable but should not be encouraged. Yak presently a threatened species. If hybridization is encouraged, then, in coming future yak will be endangered species and may be disappear from meadows of the Himalaya. Central and Arunachal Pradesh state government are providing incentives to maintain pure yak herd. But, people are more interested in yak cattle hybridization. Therefore, policy makers must keep vigil on the beneficiary of the programme.

Pastoralists are themselves started rejuvenation of degraded high altitude pastures. Therefore, public bodies must help pastoralist by providing modern means for participatory rejuvenation of pastures through proper training on scientific and site specific management of high latitude pastures.

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