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# Vulnerability of Pastoralism: A Case Study from the High Mountains of Nepal

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**Abstract:** Pastoralism in the Himalayan region of Nepal has undergone significant socio-economic and ecological changes. While there are numerous contributing factors behind these changes, the effect of a changing climate has not been thoroughly studied. This paper adds a significant contribution to the knowledge base through analysis from a survey of 186 herder households, interviews with 38 key participants, and four focus group discussions with individuals from three National Parks and Conservation areas in the high-mountain region of Nepal. Additionally, a review of the existing policies and programs on pastoralism was carried out. Results demonstrate several reasons behind the decline of transhumance pastoralism: Policy focus on the establishment of conservation areas, increasing vulnerability to extreme events (avalanches, snowfall, storms, and disappearing water sources), and ineffective government policies and programs. Hardships involved in herding combined with changing social values and the degradation of pasture quality were identified as contributing factors to the growing challenges facing mountain pastoralism. Similarly, the declining interest among herders to continue their profession can be traced to vulnerability associated with escalating climate change impacts. Considerable knowledge gaps regarding threats to high-altitude pastoralism remain, and continued research on pastureland conservation, capacity development, facilitation for climate change adaptation, and coping strategies for herders in the high mountains is urgently needed. Our analysis suggests that non-climatic variables such as policy and globalization were more influential in eroding pastoralism as compared to climate change.

**Keywords:** range land; livestock farming; transhumance system; livelihood

## 1. Introduction

Vulnerability is a pervasive facet of livelihoods in the Hindu Kush Himalaya (HKH) region and has always been a harsh reality of the high-mountain environment [1]. Jodha [2] elucidated that mountains in the HKH regions have specific characteristics, such as fragility, marginality, inaccessibility, and poverty. These characteristics are expressed in the vulnerability of the mountain people. In recent decades, human activities, changes in land-use, and climate change have accelerated this vulnerability across all ecosystems in the Himalaya region [3]. Indeed, to a considerable degree, poverty and vulnerability overlap: Both being multidimensional in nature with common causes that lead to similar risks and outcomes [1]. This is further exacerbated by climate change and environmental degradation due to the local inhabitant's dependence on ecosystem services for their livelihoods.

The high-mountain region is home to nearly seven percent of Nepal's population of nearly 2 million people [4]. Aside from tourism, pastoralism is the mainstay of the mountain people and an age-old practice. The mountain areas are inhabited by several ethnic groups; namely, Sherpa, Rai, Limbu, Tamang, Jirel, Gurung, Thakali, and Magar who speak a variety of local dialects. The primary livelihoods of these ethnic groups involve animal husbandry, such as the rearing of Chauri (Yak), goats, and sheep in particular. The herding of Yak/Nak/Chauri/sheep in a transhumance form of pastoralism has been practiced for generations in the region with a total livestock population of 48,865 as of 2017 [5].

The pastoralism system in the high mountains of Nepal involves free grazing of livestock on the lower rangeland (three to five months), moving to higher altitude pastures in the summer, and then returning to lower altitudes during the winter where homesteads and farmlands are located. The pastoral systems in the mountainous areas of Nepal have been recognized as noteworthy indigenous pasture management systems [6,7]. As described by Dong and others [8], Kreutzmann [9] suggested that pastoralism requires maintaining an ecological balance between pastures, livestock, and people. It is accomplished through the vertical movement of livestock as an adaptive grazing strategy due to a harsh climate. This adaptive approach helps to mitigate the seasonal severity of winter conditions while enabling the optimum utilization of natural resources in the alpine region during the summer period [9–11].

Innovative forms of pastoralism have served as key livelihood strategies of people living in the high mountains [12]. These adaptations allow biophysically marginalized ecosystem resources to be economically productive in the region [13]. Thus, high-mountain pastoralism deserves attention due to its considerable geographical coverage, support for local livelihoods and national economy, and culturally notable indigenous practices of animal husbandry [14,15]. However, this unique practice is on the verge of extinction due to various socio-political and ecological factors.

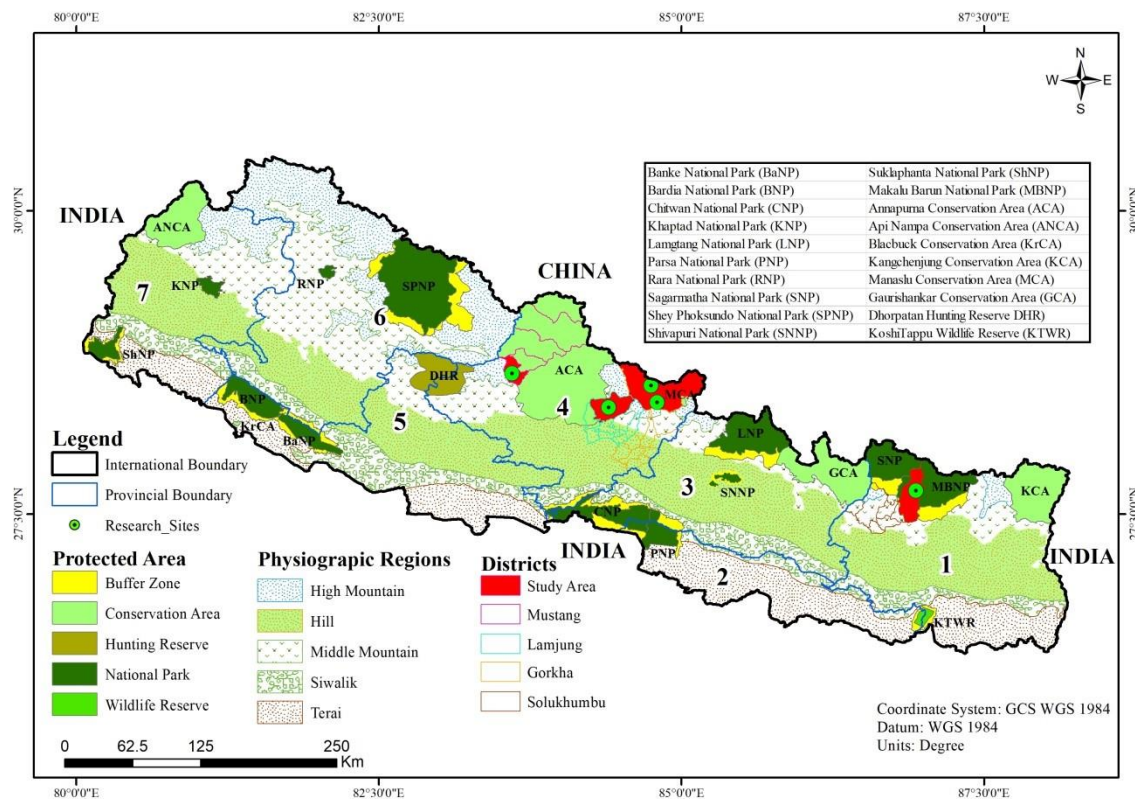
Factors contributing to this decline include globalization, human migration, modernization, trans-border conflict, agricultural intensification, tourism, rangeland nationalization, conservation area creation, changes in property rights, formulation of new policies and institutions, and a changing climate [8,9,15–20]. Other important factors include the gradual shrinkage of productive grazing land, decreasing motivation among younger generations of herders [21] changing lifestyles, uncertainties due to climate change, and shifting growth patterns of vegetation [22]. Moreover, the blanket policy approach of the Nepali government has overlooked the socio-cultural, economic, and ecological aspects of the unique and intricate relations between the mountain ecology and livelihoods of local communities [23]

These stressors have resulted in the loss of traditional norms, customary practices, communal ownership and harmony, indigenous knowledge, and institutions in subsistence pastoral systems. This has led to a decrease in the adaptive capacity of these mountain ecosystems [8,9,24]. According to Salzman [25] 'modernity' can be used as a weapon in cultural struggles, since it implies hierarchy, whether synchronic ("one society being superior to the other") or diachronic ("the recent 'modern' period being superior to the past 'traditional' period"). Hence, pastoralism in the mountain region is under increased pressure due to globalization and marginalization [10]. In this context, this paper aims to explore the critical factors leading to the decline of pastoral systems while adding to the knowledge of adaptation practices in a changing sociopolitical and environmental context with the goal of sustaining local livelihoods in the high-mountain region of Nepal.

## 2. Materials and Methods

### 2.1. Study Area

The study was conducted in three protected areas situated in the high-mountain region representing eastern and western regions of Nepal. These included the Makalu Barun Conservation Area in the Sankhuwasbha district, the Manaslu Conservation Area (MCA) in the Gorkha district, and the Annapurna Conservation Area (ACA) in Lamjung and Mustang districts (Figure 1).



**Figure 1.** Locations of study areas and high-mountain National Parks and Conservation Areas of Nepal.

The high-mountain region covers parts of 25 districts and constitutes 44.3% of the total land area of Nepal out of which 23.9% belongs to the High Himal region [26]. It encompasses the northernmost part of Nepal on the border with Tibet and lies to the north of the Mid-Hills region with an altitudinal range beginning at 2000 m of elevation up to alpine pastureland at approximately 4500 m [27]. Transhumance agro-pastoralism practices are prevalent at different altitudes in different seasons and various ethnic groups utilizing mixed farming systems and livestock species are found throughout the region (Table 1).

## 2.2. Data Collection and Analysis

This study employed both qualitative and quantitative research approaches to collect primary and secondary data at the field level. Data collection was carried out from January to March in 2018. Three key instruments were used for data collection: Key informant interviews, focus group discussions, herder's surveys, and a household survey questionnaire. Similarly, review and analysis of policy documents relevant to the vulnerability of the pastoral management practices were completed. The surveys primarily focused on the issues around grazing management, rangeland improvement activities, and rules and regulations for grazing (*dejure* and *defacto* practices). Review and analysis were focused on farming practices of transhumance pastoral systems, as well as legal and institutional frameworks for livelihood support programs in the area. Equally, there was a focus on the vulnerability, context, and influence in pastoral communities, such as: Household income from various farm and off-farm activities, farm labor availability, migration, marketing, resource availability, perceptions of climate change, and adaptation measures in the changing context within each of the survey instruments. The survey tools were initially tested and further refined before effective data collection began. Prior consent from herders and key informants were obtained before we began the survey through verbal agreements between the researchers and the interviewee/participants. In addition, the objectives of the research and its application and outcomes were explained to the respondents.

**Table 1.** Description of study sites, populations, livelihoods, livestock, and agricultural systems.

General Information	Makalu Barun NP	Manaslu Conservation Area (MCA)	Annapurna Conservation Area (ACA)
District	Shankhuwasawa	Gorkha	Lamjung and Mustang
Municipality	Mahakulung RM	Tsumhbri RM (Loo and Sirdibas)	Marsyangadi (Ghermu) & Thasang RM
Altitudes for grazing (msl)	1500–4500	1700–4500	1500–5166
No. of households ( )		839	
No. of Goths/ herds	48 headers	40	97—Lamjung case
Avg. livestock numbers (LU)/households	10	15	20
Livestock types	Yak, Chauri, Cow/ox, Sheep and Goat, Buffalo (only low altitude),	Yak, Chauri, Cow/ox, Buffalo Sheep and Goat	Cow/ox, Buffalo, Sheep and Goat, Yak/Chauri- (Mustang only)
Livestock numbers trend	decreasing	decreasing	decreasing
Trend Transhumance system practices at HH (%) decreasing	35%	40%	50%
Transhumance system	Yes	Yes	Yes
Major crops	Millet/ Rice/Maize	Millet/ Barley /Maize/Potato	Millet/ Maize/ Potato/ Barley
Major income from livestock (%)	46	64(livestock and crops)	67 (livestock and crops)
Major ethnic groups (> 60%)	Rai/Limbu	Gurung	Gurung-Lamjung Thakali-Mustang
Food security from local production—months	3–4	4–7	4–6

The data collection process was initiated through focus group discussions, which were conducted within four key groups, each representing one study site. These groups were comprised of 10 to 15 participants each, with each discussion lasting for approximately 2 h. There was a total of 38 key informant in-depth interviews conducted to discuss certain issues, which might not have been openly discussed within the group setting. A total of 186 surveys were conducted among herders at the household level (Table 2).

Secondary data consisted of long-term meteorological data from nearby weather stations (temperature and precipitation) collected by the Department of Hydrology and Meteorology (DHM), Government of Nepal. Likewise, information on livelihood improvement activities provided to the local communities was obtained from the National Park and Conservation Area office records.

The data were reviewed, coded, and entered into Microsoft Excel and the Statistical Package for Social Sciences (SPSS). The data were processed and reviewed to verify for accuracy before being analyzed using basic descriptive statistics. The results are presented in the form of graphs, table and figures with narrative descriptions, and discussion of the findings presented as case studies and individuals stories.

**Table 2.** Description on data collection.

Study Sites District	Rural Municipalities (RM) and Village	No. of Herders/Household Interviews	No. of Focus Group Discussions	No. of Key Informant Interviews
Makalu-Barun, NP-Sankhuwasabha	Mahakulung RM	48	1	13
Manasolu Conservation Area—Gorkha	Tsumhbri RM (Loo and Sirdibas)	63	1	10
Annapurna Conservation Area—Lamjung	Marsyangadi RM Ghermu	33	1	8
Annapurna Conservation Area—Mustang	Thasang RM	42	1	7

### 3. Results and Discussion

#### 3.1. Changing Livelihood of the Pastoral Communities

We found the farming of livestock to be one of the main occupations and income sources of the mountain pastoral communities followed by regular jobs and wage labor. Most of the households practiced a mixed farming system, i.e., transhumance pastoral system with crop production on their homestead farmlands. As noted by other authors, animal husbandry is a mainstay of the subsistence economy in the mountainous region of Nepal [28,29]. Livestock farming contributes between 46% and 67% of the household incomes, annually (Table 3). Moreover, livestock production, along with crop production and pastureland, are interlinked with the sustainability of mountain farming systems. This unique combination has helped enhance the mountain farming, since livestock also produce manure to maintain the soil fertility as well as providing the draught power needed to plow the farmland. Similarly, in-situ manuring through livestock herding on pasture land helps to maintain soil fertility.

**Table 3.** Income sources of the households in the study areas expressed as a percentage.

Income Source	Makalu Barun NP	MCA	ACA—Lamjung	ACA—Mustang
Livestock	46.27	29.5	50.5	50.5
Agriculture	9.4	35	5	10
Tourism	2.44	1	5	24
Remittance	5.0	5	15	6
Job/Labor	33.3	20	10	5
Non-timber Forest Products	2.0	8	5	5

However, we observed a decreasing trend of livestock farming in the study areas along with a labor shortage for transporting farmyard manure, thereby resulting in increased use of chemical fertilizers for crop production. The increasing trend of migration to cities and abroad for education, jobs, and business has resulted in a shortage of labor nationwide. Studies suggest that increased income opportunities are driving this migration pattern [30] with populations usually migrating from areas of low economic opportunities to areas with better opportunities. Thus, ultimately, the changing livelihoods among pastoral communities from traditional mixed farming systems to more market-driven opportunities are leaving farming systems in the mountain region in an unsustainable situation.

However, a mixed strategy may offer a diversified livelihood, thereby reducing risk by spreading it across various enterprises [31]. This could be a positive approach towards countering contemporary threats such as climate change. Such strategies also play an important role for reducing the impact of

food and nutrition insecurities [31,32]. Transhumance pastoral systems offer considerable value for sustainability through their ecological knowledge, indigenous practices, beliefs, and culture, which enhances the capacity and resilience of traditional agro-pastoral systems [33–35]. The integration of such knowledge, when combined with scientific approaches and technologies, may also result in the effective management of livestock and rangeland resources [36,37]. The pastoral communities of the Himalayas utilize sensitive resources, such as high-mountain pastures, through three modalities; namely, characteristic mobility patterns, socio-economic organization, and property rights. Thus, there is a need for urgent action through policy and program instruments to conserve the unique livelihoods developed over centuries by the Himalayan mountain community.

Furthermore, Acharya and Baral [24], as well as Banjade and Paudel [23], stress that the livelihoods of the transhumance pastoralists are threatened due to a number of socio-cultural, economic, and ecological stressors. Similarly, a concurrent degradation of high-elevation forests and a subsequent loss of biodiversity further exacerbate the livelihood security of these pastoral communities. This is supported in a study by Bhusal and others [15], that reported on excessive deforestation and forest degradation at high elevations. On top of this, newly emerging markets, increased awareness and demand for education, and increasing opportunities for employment in urban centers threaten the way of life of the traditional pastoralists [23].

### 3.2. Vulnerability and Adaptation of the Pastoral Communities to Climate Change

The context of vulnerability in this study is explained in terms of exposure and sensitivity to the climatic and non-climatic factors affecting the pastoral communities and their adaptation of livelihood strategies. Both data collected in the field and a review of existing literature were considered in the analysis of the vulnerability. Our results support the hypothesis that pastoral communities in the Himalayas have been impacted by multiple stressors, such as extreme climate events (snowstorms, avalanches, and landslides) that are unpredictable and catastrophic in nature. Similarly, the changing socio-economic context and lack of focus on effective policies and programs for high-altitude pastoralism have contributed to the decline of the transhumance pastoral system. Therefore, the authors have focused the analysis of the vulnerability of pastoral communities and adaptation strategies on the following three aspects:

- National policy and institutional frameworks,
- Modernization and changing social values,
- Climate change impacts.

#### 3.2.1. National Policy and Institutional Frameworks

We found that the policies and institutional frameworks including the Forest Act of 1993 [38], the Local Self Governance Act of 1999 and the Pastureland Nationalization Act of 1974 have led to increased bureaucracy and complexity by creating multiple authority structures with overlapping jurisdictions. Over several generations, villagers who had adopted transhumance systems as their primary livelihood strategy were forced to modify their practices due to changing policies and priorities of the government. These acts and regulations effectively ended the traditional management system, and local users' rights and interest in pastoral management systems were gradually eroded.

The National Park and Conservation Area Act and Regulations have also had the effect of restricting grazing in rangeland areas lying within Protected Areas. Similarly, the Forest Act of 1993, which includes a provision to hand over the forest management rights to local communities (Community Forests), has the unintended consequence of excluding the rights of the transhumance pastoral community to freely graze their livestock in the community forest in Mountain areas [15,24,34,39]. For example, paraphrasing one of the survey respondents (a 70 year old herder): *“Before, we used to graze our livestock freely in these forests without any restrictions. However, after the implementation of*

*protection oriented policies, several institutions are here with restrictive rules that have made herding difficult. Nowadays it is hard to graze freely and even the quality of pasture is poor”.*

It is estimated that around 27% of the area in rangeland in Nepal lies within National Park and Conservation Area boundaries, and of this, 80% exists in the High Mountains Region [40]. It follows that the majority of high-mountain and alpine zones have now been converted into National Parks and Conservation Areas across Nepal. This situation has created conflicts between the authorities charged with protection and the local herding communities who are struggling to access resources in high-mountain areas (14). Furthermore, livestock predation by wild carnivores is also increasing, particularly by leopards, which only adds to a greater vulnerability of the pastoral communities. For instance, within the study areas, a total of 152 livestock were killed over the last two years (2017 and 2018, Table 4). In the past, herders used to employ dogs to watch over their flocks of sheep and herds of goats as an early warning system. However, presently, park authorities do not allow the use of dogs within or near park boundaries. These policies and provisions have added to the vulnerabilities felt by the pastoral communities. As a result, the number of herders continues to decline as they seek alternative livelihood options such as tourism, trek guiding, and hospitality management; while those left behind struggle to survive with decreased mobility. This has a direct impact of the decline of transhumance grazing practices (14).

Adding to the complexity of policy formulation and implementation, Nepal has recently adopted a Federal structure with three tiers of government (i.e., Central Government, Provincial Government, and Local Government at the Municipality level). The present constitution (2015) gives the responsibility of natural resource management and livestock development to the Provincial and Local Governments. However, we observed that rangeland management is being neglected by these local institutions in both planning and programs. This has created confusion and further degradation of the limited natural resources. For illustration, herders have long complained that the intensive collection of medicinal plants, such as *Cordyceps* sp., results in mass movement of workers, camping in sensitive areas, littering, and the excavation of sensitive grassland, resulting in further degradation of the rangeland.

On the other hand, we found some positive aspects of policy implementation that has helped to reduce pastoral vulnerability in some manner. For instance, there is a provision to allocate from 30% to 50% of Park revenue to be utilized in the buffer zone area surrounding the Parks for resource conservation, development, and livelihood improvement of the local communities. This is achieved through the formation of Buffer Zone User Groups (BZUGs) and Councils as per buffer zone management regulations of 1996 and guidelines from 1999 [41].

The study found that income-generating activities, livestock development programs (such as veterinary services, fodder, and forage production both within the buffer zone area and on private land), improved vegetable farming, ecotourism promotion, etc., were practiced in the high-mountain region buffer zone areas. Similarly, several capacity enhancement training courses were provided by Park staff to the user groups. Stakeholders were served primarily in impoverished communities with a focus on the poor, marginalized people, and women, in an effort to enhance their livelihoods and promote sustainable resource management in the buffer zone area. These initiatives have played a role in reducing the pressures on resources surrounding the Parks while simultaneously enhancing local community participation in the management of resources in the National Parks and Conservation Areas and Buffer Zone Areas. Additionally, provision of compensation mechanisms [42] for livestock predation from wild carnivores has also had positive impacts on these pastoral communities (Table 4). There is evidence that these activities have helped to improve the livelihoods of some of the pastoral communities in the study area, in addition to improving rangeland management to some extent. Other studies in Nepal have also reported enhanced livelihoods of buffer zone communities due to: Income diversification, capacity enhancement, resource conservation, ecotourism promotion, increased farm production, and reduced conflict between Park authorities and communities through revenue distribution schemes [43–45].

**Table 4.** Livestock predation from the wild carnivores and loss compensation in the study area over a two-year period from 2017 to 2018.

Study Sites	Species (Number)				Total Killed (Number)	Total Compensation (NRs *)
	Sheep/Goat	Cow	Ox/Calf	Chauri/Yak		
Malaku Barun National Park	18	1	1	1	21	30,000
Manasulu Conservation Area	72	1	8		81	918,100
Annupurna Conservation Area	42	4	4		50	177,350

\* (\$1 US=NRs.114); Source: [43–45].

### 3.2.2. Modernization and Changing Social Values

Despite their remoteness, mountainous regions do not exist in isolation. In fact, these regions are increasingly connected with the global community through the expansion of roads, airports, tourism, migration, and communication networks. Thus, globalization has resulted in pastoral societies now dealing with the realities of increased exposure to opportunities and challenges of markets, off-farm activities, jobs abroad, tourism and hospitality, and remittance payments. This has altered social values and therefore made traditional herding occupations less attractive than in the past [15]. We found that in general, younger generations were less motivated or interested in continuing this traditional occupation as compared to their parents and grandparents and would rather opt for regular employment in urban centers, migrating abroad for employment, or pursuing higher education opportunities in nearby cities.

One of the local elders surveyed shared: *“the young generation has found this occupation to be less attractive from both the social and economic points of view. They have to tolerate the hardship of high altitude life throughout the year which they are simply not prepared to endure”*.

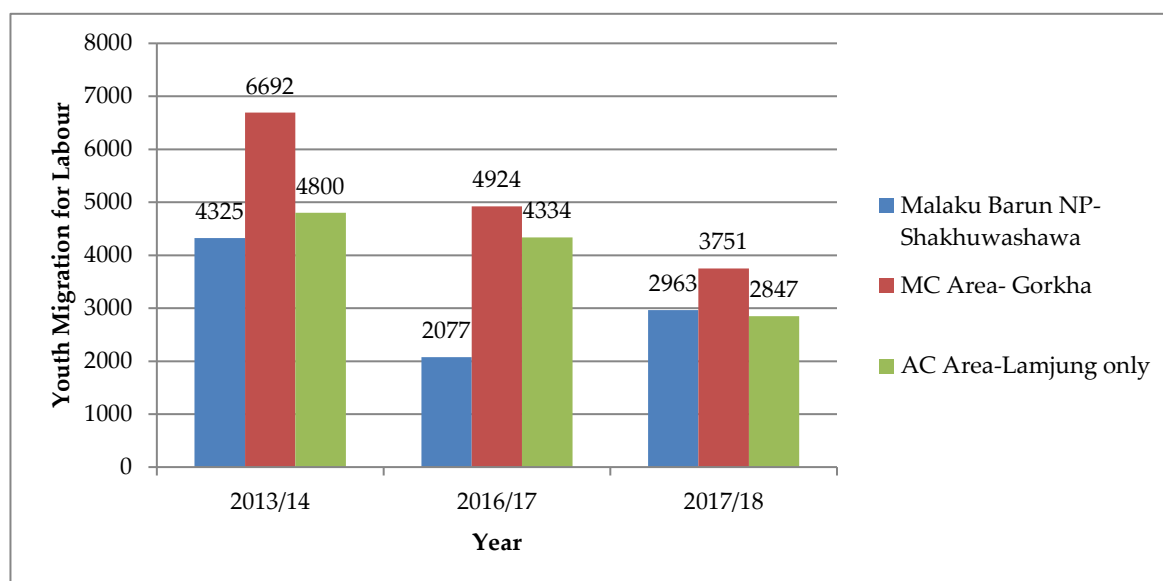
This has been a serious concern among the herders, and they are gradually abandoning this way of life. With the phenomenon of globalization, markets are emerging, advanced education is increasing, and multiple options for employment outside the community has led to a reduced interest in pursuing traditional pastoral practices [23]. We observed that in all of the study areas, over 60% of the youth have moved either to the city or abroad in search of employment opportunities (Figure 2). Eco-tourism opportunities are also gaining momentum as an attractive business within the study areas, particularly in Lamjung and Mustang districts of the Annapurna Conservation Area (Table 5).

Similarly, it has been reported that in recent years, particularly in the high-mountain region, that pastoral communities are receiving more benefits from the sale and use of non-timber forest products, particularly from the Himalayan fungus-caterpillar, known as Yarshagumba (*Ophiocordyceps sinensis*) which occurs in alpine rangeland regions. A study from the far western rangeland of the Alpine zone reported that average household cash income from *O. sinensis* was \$2174USD per annum [46], which is greater than the total regular annual income of 90% of households in the region.

The above activities have brought about changes in the socioeconomic conditions of the mountain communities through awareness, increased education, and exposure to globalization, which has discouraged livestock farming in the mountain region. Adding to this was 10 years of Maoist armed conflict (from 1996 to 2006) in the country, which hit rural areas particularly hard. This resulted in youth migration to the cities or abroad in search of security and employment rather than staying in villages and farming. Hence, the effect of globalization in the mountain region has resulted in declining traditional pastoral systems due to changing societal values, disappearing customs, traditional values, weak social networks and institutions, and neglected common property management (i.e., rangeland). Several studies illustrate similar observations; changes in socioeconomic conditions have led to migration



causing the decline of traditional pastoral systems and indigenous institutional arrangements in the Hindu Kush Himalaya [47–49].



**Figure 2.** Numbers of youth migrating from the study areas over a five-year period (2013–2018).

**Table 5.** Number of tourist visits over a five-year period within the study area (2013–2018).

Study Sites	Year				
	2013	2014	2015	2016	2017/2018
Malaku Barun National Park (MBNP)	1083	1270	833	1537	2358
Manasulu Conservation Area (MCA)	5331	5658	2287	5747	7203
Annapurna Conservation Area (ACA)	124,998	1,144,481	83,419	144,409	

Source: Nepal Tourism Board, 2018.

However, some positive consequences of globalization were observed in the mountain region. The study found that socioeconomic conditions of the households queried have improved due to diversification of household income from off-farm business (e.g., tourism, hotel business, and remittance from abroad). Herders also reported an increase in market demand for sales of livestock, sheep, and goats, in urban centers, particularly during the Hindu festivals of Deshai and Tihar. There is also an increase in availability of feedstock grains and farm inputs for farmers due to improvements in rural road connectivity near remote villages. However, overall, there appears to be a decline in the sustainability of mountain farming systems that comes with this increased dependency on the market for purchasing inputs for agriculture, such as an increase in chemical fertilizer use rather than farmyard manure for crop production. Adding to this are local farm labor shortages and increased food insecurity [50]. Rangeland in the alpine region is also degrading due to unmanaged harvesting of non-timber forest products, particularly *O. sinensis* where large numbers of collectors litter rampantly.

### 3.2.3. Climate Change Impacts

Our field level consultation with herders and local communities reflects an increase in average temperatures over the past 8–10 years (Table 6). In some locations, however, local people reported unprecedented cold events including the month of May. The findings lead to the conclusion that the temperature in the Himalayan landscape has been steadily increasing, but the rate of increase varies across the regions. This correlates with the findings of The International Centre for Integrated Mountain Development (ICIMOD), which reports that as early as from 1901 to 2014, the annual mean

surface air temperature has significantly increased in the HKH, at a rate of about 0.10 °C per decade ( $p > 0.05$ ). Similarly, extremely cold days and nights have declined (0.85 and 2.40 days per decade, respectively), while occurrences of extreme warm days and nights have increased (1.26 and 2.54 days per decade, respectively). Warm nights have increased and days with frost decreased significantly throughout the region [1].

**Table 6.** Herders perceptions of climate change impacts in their communities.

Climate Change Perceptions	Makalu Barun National Park	Manasulu Conservation Area (MCA)	Annupurna Conservation Area (ACA)
Increase temperature	65.5	77	79
Increased snow melting	70.3	80	85
Total rainfall decreasing	60.4	60	90
Amount of snowfall decreased	60.2	65	91
Decrease in water sources	60.1	70.4	71
Pasture resources	70	75.5	65.2
Invasive species	75	65	68
Livestock disease increased	20	33	30

The Himalayan region and people are already vulnerable to natural disasters and economic shocks due to fragility, marginality, inaccessibility, and poverty [2]. Over the past decade, scholars have argued that global warming is a major concern in this region due to its impact on ecosystems and nature-based livelihood dependency of mountain and downstream communities [1,34,48,50]. It is reported that the warming trend is more pronounced at higher elevations with a steady annual warming trend ranging from 0.04 to 0.06 °C reported across Nepal [3,51]. The transhumance system is one of the traditional adaptation strategies to cope with climate variability in vulnerable communities. It is practiced as an adaptive approach to rangeland resource management, especially for livestock grazing in the high-mountain region. The local people's perceptions and scientific studies correlate with a warming climate in the mountain regions (Table 6).

Along with higher temperatures, herders indicated that more than 80 percent of the communities have experienced an increase in water stress due to decreased rainfall and a delay in the arrival of the monsoon rains by 15 to 20 days. Erratic rainfall, high-intensity storms, less or unpredictable snowfall, and frequent avalanches were other common observations of local people (Table 7).

**Table 7.** Loss of livestock from extreme climatic events in the high-mountain regions of Nepal from 2018 to 2019.

Main Disaster	Main Livestock Species	Numbers of Animals Lost	Estimated Loss (NRs)	General Location
Avalanche	Sheep and yak	250		Manang district (ACA)
Snowstorm	Sheep and Yak	1634	53,085,000	Manang/ACA
Snow and Avalanches	Sheep and Goat	3921		Mustang (ACA)
Snow and Avalanches	Yak	522		Mustang (ACA)
Landslide	Goat, Buffalo	709	134,219,000	Different part of mountain region

Source: GoN Livestock Statistics of Nepal, Government of Nepal, Ministry of Livestock Development, Kathmandu, Nepal; Government of Nepal, Ministry of Livestock Development, Kathmandu, Nepal. 2017.

One of the Nomads from Upper Mustang explained, "It is very difficult for us to predict climate events. Over the last winter (2018), we were pounded with snow for two months and there was no grass to graze

*livestock and the Yaks began to starve, with nearly 30 yaks dying due to starvation in one of our families. We have not experienced it before”.*

This shows that there is increasing variability in precipitation patterns across the landscape, which coincides with findings from past studies; for example, there has been significant internal variability on annual and decadal time scales with climatic models predicting an increase in monsoon precipitation due to greenhouse-gas-induced warming [1,48,51,52].

Multiple stresses of rangeland resources from anthropogenic and climate change impacts, such as rising temperatures, reduced snowfall, and precipitation, has resulted in decreased biomass production and degradation of rangeland in the study areas. Furthermore, local herders also reported that increases in the unpredictability of heavy snowfall and avalanches have occasionally led to heavy losses of their livestock (Table 7). Bhatta and others [48] and Wester and others [1] also warn that warming in the Himalayan region could result in more rapid melting of snow cover and glaciers along with increasingly erratic rainfall and more frequent droughts leading to a decrease in regional ecosystem services. Aryal and others [34] make a case that climate variables could seriously affect marginalized transhumance communities due to their high dependency on rangeland resources, limited access to modern facilities, markets, and alternative incomes. Likewise, Dong and others [8] also noted that climate change/variability has propelled fragile pastoral agro-ecosystems into more a vulnerable state in the Himalayan region.

The above discussion and analysis reveal that over the past few decades, unprecedented changes have occurred in the patterns of resource use, developmental activities, and socioeconomic dynamics in the mountain regions of Nepal. These changes are generally influenced by geopolitical and policy changes, globalization and modernization, and associated socio-economic transformations within the society. This, coupled with a rapidly changing climate in the Himalayas, has large impacts the transhumance system in the region. Nonetheless, our analysis of the three major areas of the vulnerability of the pastoral systems of the mountain regions of Nepal suggest that non-climatic variables such as policy and globalization were more influential in eroding pastoralism as compared to climate change.

### 3.3. Adaptation Strategies

A variety of adaptation strategies have been adopted by pastoral communities in the mountain region of Nepal to protect their livelihoods. Various policies and programs from the government have also been provided to minimize the vulnerability of these pastoral communities. Hence, to overcome vulnerability and avert the risks arising from socioeconomic transformation, globalization, and climate change, households have adopted different strategies in the study area (Table 8).

**Table 8.** Adaptation strategies adopted by pastoral communities in study area expressed as a percentage of those surveyed.

Adaptation Strategy	Makalu Barun NP	MCA	ACA
Seasonal vertical movement of animals	100	100	100
Migration from village for work elsewhere	70	70	65
Rangeland improvement activities (water source protection, seeding and improved grass cultivation)	50	30	30
Decrease in livestock numbers	30–35	20–30	30–40

Furthermore, adaptation strategies can be grouped into categories that encompass mobility, land management, diversification, intensification, and storage in the changing contexts for securing livelihoods of the mountain dwellers. In this context, adaptation strategies have been implemented

through policy/institutions both at the community and household levels in order to minimize risk and vulnerability of the pastoral communities as described in Table 9.

**Table 9.** Adaptation strategies at three levels: Government, community, and household.

Adaptation Strategy	Government Institutional Level	Community Level	Household Level
Mobility (Vertical movement)	Grazing permit, local government tax, Rotational grazing provision	Traditional Institutions as well as Park authorities grazing use decisions	Change in livestock numbers, species
Range land management	Policy, guidelines formulation, Water source protection, removal of invasive species, rotational grazing, improved grass Seeding (outside National Park), water supply	Plantation of the fodder and grasses in communal land Resource conservation and monitoring	Household participate for trail improvement, water sources protection, fencing the grass land, seeding grasses during fallow periods in the rangeland
Diversification (off farm income, communal pooling, conflict management, herding livestock)	Promotion of the off-farm activities, Institutions (Buffer Zone committees, Conservation Area Management Committees) formation, Improve physical facility, support livestock development program	Buffer Zone provide different livelihood options, Livestock insurance, Tourisms promotions, off farm activities, Loan through cooperatives, Income generation activities	Income diversification (Labor/off farm income/tourism, remittance),
Market assess-increased the adaptation	Road connections, infrastructure development for marketing promotion	Cooperatives, commodities, User groups cooperation, Facilitation of marketing strategies	Access to domestic livestock markets in cities, new process value added products (wool clothes, cheese, butter, ghee, non-timber forest products etc.
Intensifications	Facility for Input availability, Service provide for farm intensification: e.g., Improve Vet service, seed, fertility	Common land management, irrigation management, dairy products collections, feed resources availability	Improved livestock species, decreased numbers, plantation fodder and forage in private land, vegetable, fruits farming
Storage	Inputs support		Crop residue, grain or grasses for winter feeding, grazing in fallow land
Promotion of traditional system		Traditional livestock farming promotion through festival of Yak/Churias tourism promotion (Taplanjung) Fresh Blood as medicinal use (Mustang) Horse riding competition (Kahaptad)	

#### 4. Conclusions

Our analysis revealed that despite the strong socio-economic and ecological significance of traditional pastoralism in the mountain region, it is in a transitional phase due to increasingly diverse challenges involving the herding system. The socio-economic changes, policy focus on establishing more conservation areas, and recentralization of local rights, combined with increasing impacts of climate change and risks of extreme weather events such as avalanches, heavy snowfall, intense storms, and drying water sources are contributing factors. These stressors are exacerbated by uncoordinated governmental policies and programs that have collectively contributed to the decline of the transhumance system in the high mountains of Nepal. It is not surprising that the hardships of herding, changing social values, pasture quality deterioration, and unclear policy and regulatory frameworks have all contributed to the growing decline in mountain pastoralism. It is our belief that the government programs and policy interventions for high-altitude pastoralism development have been inadequate to properly address the distinct socio-economic and ecological features of these

mountain regions. In addition, increasing climate change impacts are causing increased uncertainty, thereby contributing to a declining interest and motivation among the new generation of herders to continue this occupation.

Several strategies will be needed if these trends are to be slowed or reversed. We recommend capacity enhancement and continuous facilitation for adaptation measures and coping strategies be provided to the herders as a priority action. It is hoped that these efforts will encourage and attract younger generations towards this occupation. Additionally, specific incentives considering the socio-economic drivers should be developed to sustain the local mountain economy. The traditional rights of mountain communities in the current forest and rangeland management policies have not been recognized and these must be addressed through appropriate policy reformulation. The effects of globalization on social and economic activities and changing lifestyles of the local communities are a particular threat to the wellbeing of youth in these communities. Thus, we recommend that local institutions should promote profit-oriented sustainable farming activities along with links to markets and associated value-added product development in order to minimize production risks for these mountain communities. Further research is needed in order to close the knowledge gaps related to location-specific issues in order to provide knowledge useful in future design and implementation of more effective policies and programs, which will lead to development of future healthy and resilient mountain economies.

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## References

1. Wester, P.; Mishra, A.; Mukherji, A.; Shrestha, A.B. (Eds.) *The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People*; Springer: Berlin/Heidelberg, Germany, 2019.
2. Jodha, N.S. Mountain perspective and sustainability: A framework for development strategies. In *Sustainable Mountain Agriculture Volume 1: Perspectives and Issues*; Practical Action Publishing: Rugby, UK, 1992; pp. 41–82.
3. Shrestha, A.B.; Wake, C.P.; Mayewski, P.A.; Dibb, J.E. Maximum temperature trends in the Himalaya and its vicinity: An analysis based on temperature records from Nepal for the period 1971–1994. *J. Clim.* **1999**, *12*, 2775–2786. [[CrossRef](#)]
4. Ministry of Population and Environment. *MoPE National Population Report*; Ministry of Population and Environment: Kathmandu, Nepal, 2017.
5. Government of Nepal, Ministry of Livestock Development. *GoN Livestock Statistics of Nepal, Government of Nepal, Ministry of Livestock Development, Kathmandu, Nepal*; Government of Nepal, Ministry of Livestock Development: Kathmandu, Nepal, 2017.
6. Karki, J.; Mcveigh, C. *Status of Grassland in Mountain Protected Areas: Management Issue and Gaps, Langtang National Park (LNP)*; ICIMOD: Kathmandu, Nepal, 1999.
7. Sharma, B. The role of pasture and fodder development programme for landless farmer in degraded forest land of mid and high Hills of Nepal. In *Agriculture and Environment. Agri-Environment and Biodiversity Section*; Ministry of Agriculture and Cooperatives, Singh Durbar: Kathmandu, Nepal, 2006; pp. 89–99.
8. Dong, S.; Kassam, K.-A.S.; Tourrand, J.F.; Boone, R.B. *Building Resilience of Human-Natural Systems of Pastoralism in the Developing World*; Dong, S., Kassam, K.-A.S., Tourrand, J.F., Boone, R.B., Eds.; Springer: Basel, Switzerland, 2016.

9. Kreuzmann, H. *Pastoral Practices in High Asia: Agency of 'Development' Effected by Modernisation, Resettlement and Transformation*; Springer: Berlin/Heidelberg, Germany, 2012.
10. Montero, R.G.; Mathieu, J.; Singh, C. Mountain pastoralism 1500–2000: An introduction. *Nomadic Peoples* **2009**, *13*, 1–16. [[CrossRef](#)]
11. Aryal, S.; Cockfield, G.; Maraseni, T.N. Globalisation and traditional social-ecological systems: Understanding impacts of tourism and labour migration to the transhumance systems in the Himalayas. *Environ. Dev.* **2018**, *25*, 73–84. [[CrossRef](#)]
12. Pandey, M.R.; Chetri, M. Nomads and pastoralism: Linkage with biodiversity conservation in Upper Mustang, Nepal. *Our Nat.* **2005**, *3*, 42–49. [[CrossRef](#)]
13. McVeigh, C. Himalayan herding is alive and well: The economics of pastoralism in the Langtang valley. *Nomadic Peoples* **2004**, *8*, 107–124. [[CrossRef](#)]
14. Ghimire, S.K.; Parajuli, D.B. Indigenous knowledge and practice on pasture resource management: Among the Pugmo people of the Shey Phoksundo National Park, Dolpa. *Wildl. Mag.* **2001**, *3*, 7–14.
15. Bhusal, P.; Banjade, M.R.; Paudel, N.S. Pastoralism in Crisis: Mounting Challenges in Herding System in High Altitude Region of Nepal. *J. For. Livelihood* **2018**, *16*, 56–70. [[CrossRef](#)]
16. Axelby, R. 'It takes two hands to clap': How Gaddi shepherds in the Indian Himalayas negotiate access to grazing. *J. Agrar. Chang.* **2007**, *7*, 35–75. [[CrossRef](#)]
17. Shaoliang, Y.; Ning, W.; Peng, L.; Qian, W.; Fusun, S.; Geng, S.; Jianzhong, M. Changes in livestock migration patterns in a Tibetan-style agropastoral system. *Mt. Res. Dev.* **2007**, *27*, 138–146. [[CrossRef](#)]
18. Bassett, T.J. Mobile pastoralism on the brink of land privatization in Northern Côte d'Ivoire. *Geoforum* **2009**, *40*, 756–766. [[CrossRef](#)]
19. Banerjee, S. Shift from transhumance and subtle livelihood patterns of the bhotia community and its impact on Tibetan sheep population in Sikkim (India). *World Appl. Sci. J.* **2009**, *7*, 1540–1546.
20. López-i-Gelats, F.; Fraser, E.D.; Morton, J.F.; Rivera-Ferre, M.G. What drives the vulnerability of pastoralists to global environmental change? A qualitative meta-analysis. *Glob. Environ. Chang.* **2016**, *39*, 258–274. [[CrossRef](#)]
21. Shrestha, B.S.; Joshi, B.R.; Joshi, H.D. Migratory Small Ruminants: Their Potential and Economic Contribution in the High Hills and Mountains of Nepal. In *Proceedings of the 6th National Workshop on Livestock and Fisheries*; Nepal Agricultural Research Council: Lalitpur, Nepal, 2006.
22. Parajuli, D.P.; Paudel, L.N.; Gyawali, R.R. Changes in pastoral production systems in high-altitude village-rangeland interfaces in Nepal. *High-Alt. Rangel. Their Interfaces Hindu Kush Himalayas* **2013**, *48*, 48–54.
23. Banjade, M.R.; Paudel, N.S. Mobile pastoralism in crisis: Challenges, conflicts and status of pasture tenure in Nepal mountains. *J. For. Livelihood* **2008**, *7*, 49–57.
24. Acharya, D.; Baral, N.R. Neglected High Altitude Rangelands of Nepal: Need for Reform. *J. For. Livelihood* **2017**, *15*, 103–119. [[CrossRef](#)]
25. Salzman, P.C. *Pastoralists: Equality, Hierarchy, and the State*; Routledge: Abingdon, UK, 2004.
26. Department of Forest Research and Survey (DFRS). *DFRS State of Nepal's Forest*; Department of Forest Research and Survey (DFRS): Kathmandu, Nepal, 2015.
27. Acharya, D. *Natural Resource Management in High Altitude Areas in Nepal: A Review and Synthesis of Information*; Livelihoods & Forestry Programme: Kathmandu, Nepal, 2003.
28. Pawson, I.G.; Jest, C. The high-altitude areas of the world and their cultures. *Biol. High-Alt. Peoples* **1978**, *14*, 17–45.
29. Bauer, K.M. *High Frontiers: Dolpo and the Changing World of Himalayan Pastoralists*; Columbia University Press: New York, NY, USA, 2004.
30. Mallick, B.; Vogt, J. Cyclone, Coastal Society and Migration: Empirical Evidence from Bangladesh. *International Development Planning Review* 2012. Available online: <https://doi.org/10.3828/idpr.2012.16> (accessed on 12 February 2018).
31. Wright, I.A.; Tarawali, S.; Blümmel, M.; Gerard, B.; Teufel, N.; Herrero, M. Integrating crops and livestock in subtropical agricultural systems. *J. Sci. Food Agric.* **2012**, *92*, 1010–1015. [[CrossRef](#)]
32. Herrero, M.; Thornton, P.K.; Notenbaert, A.M.; Wood, S.; Msangi, S.; Freeman, H.A.; Bossio, D.; Dixon, J.; Peters, M.; van de Steeg, J. Smart investments in sustainable food production: Revisiting mixed crop-livestock systems. *Science* **2010**, *327*, 822–825. [[CrossRef](#)]

33. Gómez-Baggethun, E.; Corbera, E.; Reyes-García, V. Traditional ecological knowledge and global environmental change: Research findings and policy implications. *Ecol. Soc. A J. Integr. Sci. Resil. Sustain.* **2013**, *18*, 72. [[CrossRef](#)]
34. Aryal, S.; Cockfield, G.; Maraseni, T.N. Vulnerability of Himalayan transhumant communities to climate change. *Clim. Chang.* **2014**, *125*, 193–208. [[CrossRef](#)]
35. Fraser, J.A.; Frausin, V.; Jarvis, A. An intergenerational transmission of sustainability? Ancestral habitus and food production in a traditional agro-ecosystem of the Upper Guinea Forest, West Africa. *Glob. Environ. Chang.* **2015**, *31*, 226–238. [[CrossRef](#)]
36. Blyth, S.; Groombridge, B.; Lysenko, I.; Miles, L.; Newton, A. *Mountain Watch*; UNEP World Conservation Monitoring Centre: Cambridge, UK, 2002; p. 80.
37. Knapp, C.N.; Fernandez-Gimenez, M.E. Knowledge in practice: Documenting rancher local knowledge in northwest Colorado. *Rangel. Ecol. Manag.* **2009**, *62*, 500–509. [[CrossRef](#)]
38. Ministry of Forests and Environment, Department of Forests and Environment. *GoN Forest Act*; Government of Nepal (GoN); Ministry of Forests and Environment, Department of Forests and Environment, Singh Durbar: Kathmandu, Nepal, 1993.
39. Gentle, P.; Thwaites, R. Transhumant pastoralism in the context of socioeconomic and climate change in the mountains of Nepal. *Mt. Res. Dev.* **2016**, *36*, 173–183. [[CrossRef](#)]
40. Government of Nepal (GoN), Ministry of Forests and Environment. *GoN Nepal Biodiversity Strategy*; Government of Nepal (GoN), Ministry of Forests and Environment: Kathmandu, Nepal, 2002.
41. Government of Nepal (GoN), Ministry of Forests and Environment. *GoN Buffer Zone Management Guideline*; Government of Nepal (GoN), Ministry of Forests and Environment: Kathmandu, Nepal, 1999.
42. Government of Nepal (GoN). *Wildlife Damage Relief Guideline*, 2nd ed.; Government of Nepal (GoN): Kathmandu, Nepal, 2017; Volume 2013.
43. Budhathoki, P. Linking communities with conservation in developing countries: Buffer zone management initiatives in Nepal. *Oryx* **2004**, *38*, 334–341. [[CrossRef](#)]
44. Silwal, T.; Shrestha, B.P.; Bhatta, B.P.; Devkota, B.P. Revenue distribution pattern and park-people conflict in Chitwan National Park, Nepal. *Banko Janakari* **2013**, *23*, 35–41. [[CrossRef](#)]
45. Lamichhane, B.R.; Persoon, G.A.; Leirs, H.; Poudel, S.; Subedi, N.; Pokheral, C.P.; Bhattarai, S.; Gotame, P.; Mishra, R.; DeLongh, H.H. Contribution of buffer zone programs to reduce human-wildlife impacts: The case of the Chitwan National Park, Nepal. *Hum. Ecol.* **2019**, *47*, 95–110. [[CrossRef](#)]
46. Pouliot, M.; Pyakurel, D.; Smith-Hall, C. High altitude organic gold: The production network for *Ophiocordyceps sinensis* from far-western Nepal. *J. Ethnopharmacol.* **2018**, *218*, 59–68. [[CrossRef](#)]
47. Namgay, K.; Millar, J.E.; Black, R.S.; Samdup, T. Changes in transhumant agro-pastoralism in Bhutan: A disappearing livelihood? *Hum. Ecol.* **2014**, *42*, 779–792. [[CrossRef](#)]
48. Bhatta, L.D.; Shrestha, A.; Neupane, N.; Jodha, N.S.; Wu, N. Shifting dynamics of nature, society and agriculture in the Hindu Kush Himalayas: Perspectives for future mountain development. *J. Mt. Sci.* **2019**, *16*, 1133–1149. [[CrossRef](#)]
49. Ning, W.; Rawat, G.S.; Joshi, S.; Ismail, M.; Sharma, E. *High-altitude Rangelands and Their Interfaces in the Hindu Kush Himalayas*; International Centre for Integrated Mountain Development (ICIMOD): Lalitpur, Nepal, 2013.
50. Tiwari, K.R.; Rayamajhi, S.; Pokharel, R.K.; Balla, M.K. Determinants of the climate change adaptation in rural farming in Nepal Himalaya. *Int. J. Multidiscip. Curr. Res.* **2014**, *2*, 234–240.
51. Government of Nepal (GoN), Ministry of Environment, Science and Technology. *GoN National Adaptation Program of Action (NAPA)*; Government of Nepal (GoN), Ministry of Environment, Science and Technology: Kathmandu, Nepal, 2010.
52. Shrestha, A.B.; Wake, C.P.; Dibb, J.E.; Mayewski, P.A. Precipitation fluctuations in the Nepal Himalaya and its vicinity and relationship with some large scale climatological parameters. *Int. J. Climatol. A J. R. Meteorol. Soc.* **2000**, *20*, 317–327. [[CrossRef](#)]

