STRENGTHENING THE RESILIENCE OF TRANSHUMANT YAK PRODUCTION SYSTEM IN BHUTAN: A REVIEW

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ABSTRACT: Transhumant system of yak (*Bos grunniens*) farming plays a vital role in the livelihood of highland communities in Bhutan. Presence of yak-based transhumant systems in high altitude areas utilizes available natural resources in the area. Besides, the yak farming communities have a unique culture. However, an increasing number of households are said to leave yak farming. Therefore, this review was carried out to explore reasons for the decline and possible options for strengthening its resilience. The yak farming is under pressure from external factors such as socio-economic developments, policies and climatic conditions affecting forage and labour availability for herding yaks. Forage shortage for yaks is caused mainly due to overgrazing and grazing competition with other livestock species and wild ruminants. The other reasons for forage shortage are due to restriction on burning of shrubs around rangelands resulting to grazing land invasion by non-forage plant species. Labour shortages are caused due to increased access to alternative economic activities and modern education. Household members are increasingly involved in *Cordyceps* harvesting, tourism and other economic activities. Forage shortage and conservation policies had seemingly resulted in increased yak mortality due to accidents and wild predators. Therefore, to strengthen the resilience capacities of the system in regard to forage and labour availability, several options are possible. The options range from education and governmental policies for land management and development of infrastructures to better grazing management, including the reduction of yak herd size.

Keywords: Forage shortage; labour; transhumant system; yak herding

1. INTRODUCTION

Himalayan rangelands are the traditional homeland for millions of pastoralists who earn their livelihood through herding livestock (Wu et al. 2014). Climatic conditions in the Himalayas are mostly alpine, although altitudes vary ranging from snow-capped mountains to tropical and sub-tropical climates at lower valleys (Bolch et al. 2019). The highlanders in Himalayas rely largely on available natural resources despite the high altitude areas having one of the harshest climatic conditions in the world (Dorji et al. 2020a; Wangchuk et al. 2013).

Bhutan is a Himalayan country situated in Southeast Asia between China in the north and India in the south, east and west. Bhutan has yak-based transhumant communities. These

transhumant communities migrate their yak herds between temperate and alpine rangelands at altitudes ranging from 2500 to 6000 metres above sea level (masl) (Derville and Bonnemaire 2010; Ura 2002). The reason for migration of yak herds to lower altitudes during part of the year (winter months) are to avoid harsh winter climatic conditions and forage shortage (Dong et al. 2016). The highland farming communities in Bhutan own very small areas of land to grow agricultural crops. In addition, rangelands are not agriculturally friendly (climatic conditions favorable to grow crops are comparatively shorter in the high altitude areas), and therefore, have limited options besides yak farming (Dorji et al. 2020a). Thus, yaks play an integral livelihood role for the communities of highland pastoralists (Gyamtsho 2000). Yaks provide food, fuel, fibre, draught power and products to sell (Figure 1) (Verma and Khadka 2016; Wangdi 2016) However, an increasing number of households are said to leave yak farming (Phuntsho and Dorji 2016).

The yaks are found in ten northern districts of Bhutan (Figure 2). Yak is suitably adapted to survive in a cold and harsh mountainous environments (Dorji et al. 2020a). Yaks survive well in high altitude areas due to few functional sweat glands, wool with thick long outer coat and fine and dense undercoat, and also due to accumulation of subcutaneous fat prior to winter (Wiener et al. 2003). Besides food and economic importance, the yak farming communities are important for Bhutan due to their unique culture and tradition (Dorji et al. 2020a).

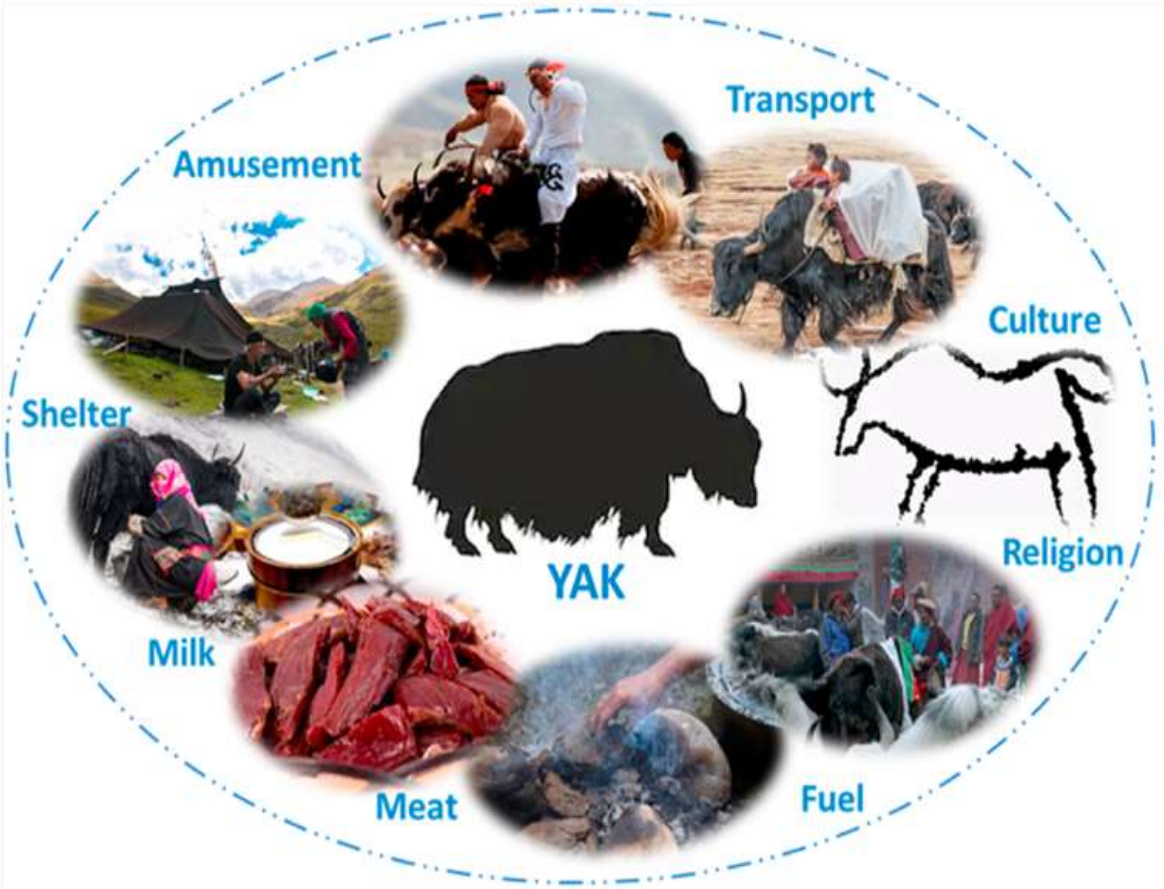

Figure 1. The yak is crucial for livelihoods, social life, socio-economic positions and ethnic traditions for pastoralists (Source: Jing et al. 2022).

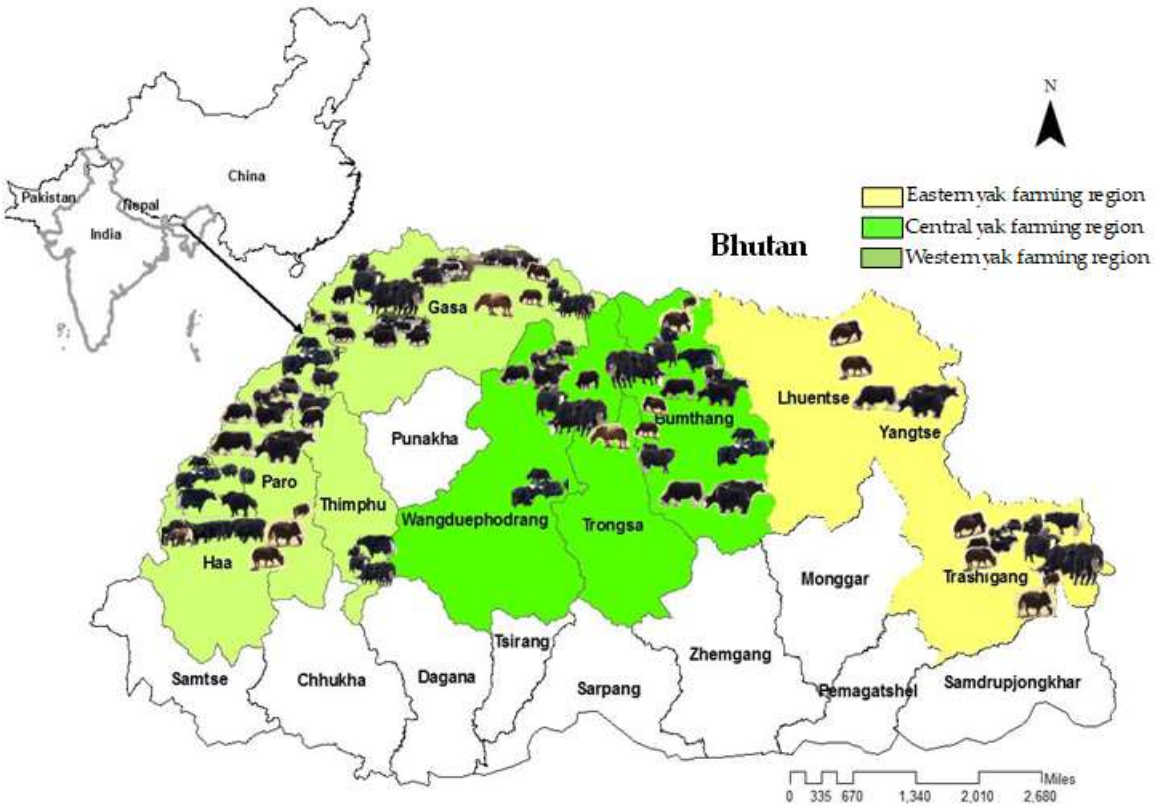

Figure 2. Map of Bhutan with its yak farming districts with shaded colors (Source: Dorji 2020)

This is true even in the other regions of yak rearing countries because the yak has been closely related with the culture, religion and social life of the herders and their families (Wiener 2013). Majority of the yak herding communities in Bhutan have their own unique culture, dress habit and native language (Gyamtsho 2000). The preservation and promotion of culture and tradition is one of the four pillars of the Bhutanese development philosophy called Gross National Happiness (GNH) (RoGB 2002). The unique culture together with mountainous landscapes in yak rearing areas attracts tourists from across the world (Dorji et al. 2020a). As per the Siok and pek-Dorji (2022), tourism is reported as the second largest contributor for Bhutan's Gross Domestic Product (GDP), after hydropower.

Furthermore, due to their presence for pastoral activities along the northern border, they play an important role in protecting and securing the areas or resources from any external encroachment (MoAF 2017; Wangdi 2016). Their presence basically supplements the Royal Government of Bhutan (RGoB) in safeguarding the border security. Without the yak herders in the region, RGoB probably needed to allocate a vast amount of resources for border security (Wangdi and Norbu 2018). Besides, the yak farming has positive impact on mountain ecosystem services (Dong et al. 2015).

Researchers have reported several aspects that the yak farming communities have to deal with. External factors like socio-economic development, national policies, and climate change were the most important aspects of yak farming in Bhutan (Dorji et al. 2020a). There are policies that prohibit traditional methods of rangeland management that subsequently have negative impact on forage availability (Wangchuk et al. 2013). Pressure on forage availability is reportedly strong in yak rearing

areas. This calls for a need to explore ways for the yak herding communities in Bhutan to increase forage availability for their yaks (Derville and Bonnemaire 2010). Likewise, socioeconomic developments, for instance, an access to modern education, legalization of *Cordyceps sinensis* (Caterpillar fungus) collection and tourism continue to put pressure on labour availability for yak herding (Dorji et al. 2020a). Therefore, relying on published scientific papers, this review intends to assess ways to strengthen the resilience of the Transhumant Yak Production System (TYPS) in Bhutan. The focus will be on socio-economic development affecting labour availability for yak farming, and the national policies affecting forage availability. In addition, this review includes potential impacts of climate change on forage availability.

2. MATERIAL AND METHODS

A literature search was performed in Google scholar (Google 2020) and BOKU:LITsearch (UB 2021) between October 1, 2020 and January 29, 2021, and subsequently added and managed in Mendeley Desktop v1.19.8. The search phrases used in the Google scholar were "yak production system in Bhutan", "pastoral system in Himalayas", "livelihoods of highland communities in Himalayas", "mountain ecosystem services", "rangeland management", "challenges of yak farming" and the search term used in BOKU:LITsearch was (Yak* OR transhumant* OR pastoral* OR resilience* OR adaptability*). In total, 66 papers (including reports) from the Google scholar and 10 papers from BOKU:LITsearch were downloaded. Three duplicate papers were removed. In March 2023, another two studies published in 2022 were referred. Further, the Land Act of Bhutan 2007, the Forest and Nature Conservation Act of Bhutan 1995 and the Bhutan Forest Act 1969 were also reviewed to gain a deeper understanding of those Acts. The review paper finally included 48 international papers, three national reports, one international report, and one local news report.

3. RESULTS & DISCUSSIONS

3.1 Key challenges of TYPS in Bhutan

According to Gyamtsho (2000), understanding the environmental and socio-economic conditions of an area is a prerequisite to know what and why people are doing what they do. Yak farming communities in Bhutan are under pressure due to environmental and socioeconomic factors.

3.1.1 Challenges linked to environmental factors

3.1.1.1 Conservation policies and forage availability

The Constitution of Bhutan states that at least 60% of the country should remain under forest cover for all times. Thus, general conservation policies such as The Bhutan Forest Act 1969, Forest and Nature Conservation Act of Bhutan 1995 and The Land Act of Bhutan 2007 are to be implemented. There are potential impacts by those regulations on TYPS. The Forest and Nature Conservation Act of Bhutan 1995 is an amendment of The Bhutan Forest Act 1969, and the Act prohibits both, setting of fires (including burning of rangelands) and hunting of any wild animals. These Acts are strongly related with other government regulations and policies on the protected area network (Lham et al. 2019). Indeed, majority of the yak herding areas in Bhutan are located within the protected areas such as National Parks and Reserves (Phuntsho and Dorji 2016) and livestock predation along protected areas were noticeably on rise (Lham et al. 2019). Yaks travelling longer distance to obtain forage are found to often encounter with wild predators (Dorji et al. 2020a). To create harmonic co-existence between the yak herders and wild

predators, the majority of yak herders suggested compensation of the livestock lost to predators, and livelihood alternative measures (Dorji and Powrel 2022). However, compensation for wildlife predation seemingly varied across the country. Livestock insurance scheme to compensate yak herders of the livestock lost to wild predators may be strongly encouraged.

Prior to implementation of those Acts, herders used to burn rangelands to control scrub to encourage palatable plant growths (Gyamtsho 2007). Thereafter, many sites have been invaded by scrub impeding the growth of herbs resulting to significant reduction in forage production (Gyamtsho 2007; Tenzing et al. 2017), posing a serious threat to the herders' livelihood (Wangchuk et al. 2013). This statement was confirmed both by the herders and the livestock professionals in a study conducted by Dorji et al. (2020a). Both yak herders and livestock professionals perceived the abolishment of the traditional rangeland management practice to rejuvenate forage growth as the main cause for forage shortage (Dorji et al. 2020b).

Rangelands in Bhutan are owned either communally, privately or by monastic bodies across the country (Tenzing et al. 2017; Tshering et al. 2016). Yak farmers obtained access to pastures belonging to other entities through arrangements (Dorji et al. 2020b). Upon nationalization of the rangelands as per the Land Act of Bhutan 2007, the system of rangeland arrangements between herders and monastic bodies or with other herder communities are to be dissolved (Dorji et al. 2020b). Thus, the herders can no longer access pastures belonging to other entities through arrangements when the Land Act of Bhutan 2007 is fully implemented. The rangelands are to be leased back to yak herders irrespective of owning yaks thereby highlanders who do not own yaks can rent out their share of grazing land (Tshering et al. 2016). The main idea of nationalization of rangelands through the Act is to ensure equal access to rangeland resources by relevant users, which seems a pertinent approach and would encourage highlanders to stay back and resume yak farming. However, according to Wangdi and Norbu (2018), the Act is still under transitional phase, which was put under 10-year grace period since its enactment in 2007, and therefore unrealistic to speculate about the long-term consequence of the Act. Since most of the rangelands are not owned directly by the yak farmers, it seemingly complicates the establishment of proper pasture management in the rangelands. Although the Act allows herders to improve pastures in the rangelands which was prohibited in Forest and Nature Conservation Act 1995 (Tenzing et al. 2017), implementation of the Act may not lead to proper pasture management either, because in the Act, livestock farmers are given only user rights and not the management rights for rangelands (Dorji et al. 2020a).

3.1.1.2 Other factors affecting forage availability in the rangelands

Yak herders from up to 85% to 100% (depending on the region) are facing forage shortage (Dorji et al. 2020a). The forage scarcity is mostly during the winter season (Dorji et al. 2016). During winter, no new biomass is produced because the plant growth is stopped due to cold temperatures. The winter forage shortage translates into severe losses of live weight of yaks (Wangchuk and Dorji 2008). Forage shortage for yak is also caused due to grazing competition from other livestock species, especially horses (Dorji et al. 2020a). Horses are used for transporting necessary items for tourists and Cordyceps collectors. Presence of horses alongside yaks in the rangelands contribute to overgrazing (Wangdi 2016). Besides, there is also grazing competition from wild ruminants (Dorji et al.

2020a). TYPS mainly depends on summer pastures and forests but summer pastures are less productive due to overgrazing (Wangchuk and Dorji 2008; Moktan et al. 2008). Cordyceps collection further contribute to forage shortage for yaks, which can be explained in several ways. Firstly, the Cordyceps harvesting period coincides with budding time of rangeland grasses and trampling of young grasses resulted in degraded pastures quality (Wangchuk et al. 2012). Secondly, herders migrate yaks to summer rangelands (Cordyceps habitats) earlier than they did previously, aimed at collecting the fungus and allowing yaks to trample and graze over young grasses. Another reason for forage shortage is perceived to be due to an increase in family yak herd size. The increase in family yak herd size resulted from some households giving up yak farming and sale of their yaks to the remaining herders (Tshering et al. 2016). Besides, some families reportedly own unproductive cattle allowing grazing competition on the available rangeland which might be replaced with few productive animals.

One of the reasons for quitting yak farming uncovered by Tshering et al. (2016) was due to inadequate government supports and better income opportunities. Due to geographical isolation, benefits of modern development are limited for herders (Derville and Bonnemaire 2010). Thus, one of the strategies to encourage yak farming is to focus on providing basic amenities like health and communication services to yak herders to motivate and reduce rural urban migration (Dorji et al. 2020b). The government having placed importance of highlanders role, a "Flagship program" was developed (MoAF 2017) as a multisectoral program; however, in the 12 five year plan it was implemented as the Highland Development Program (HDP) under the Department of Livestock, Ministry of Agriculture and Forests. The programs were aimed at improving socio-economic and livelihood of highland communities through provision of facilities to improve yak genetic resources, rangeland development, product development and diversification (wool and milk), establishment of institutions such as yak cooperatives and federation. Besides, the Royal Highland Festival was initiated in 2016 to boost the economy and promote the highland culture (Palden 2016). Genetic improvement program for yaks earmarked under the highland development program would ultimately help increase resilience. It would improve yak productivity through selective breeding and allow maintaining a smaller number of high yielding yaks thereby reducing pressure on the rangelands.

3.1.2 Impact of climate change on forage availability

In the Southeast Asia, Ahrens and Dobler (2015) predicts a median warming of 2.5°C by end of 21st century. In Eastern Himalayas including Bhutan, the annual average temperature from 1977 to 2000 has increased by 0.01°C in the foothills, 0.02°C in middle Himalayas and 0.04°C in the higher Himalayas (Verma and Khadka 2016). Global warming can be a major issue for nature-based livelihoods of highland dwellers due to its impact on ecosystems (Bolch et al. 2019). Warming of high-altitude areas reduce rangeland quality due to decreased net aboveground productivity at the meadow habitats (with reduced palatability) and less digestible shrubs at the shrub-land habitats (Klein et al. 2007). Changing climatic factors such as temperature, humidity, precipitation and light intensity might affect metabolism and modify nutritive value of plants though grown on the same soil (Getabalew and Alemneh 2019). Likewise, the findings of Bernard et al. (2019) conclude that drought and early snow melt down from warming could reduce nitrogen availability in sub-

alpine rangelands due to reduced litter biomass and decomposition. According to Dorji et al. (2020a), 32% of herders interviewed believed that reduced snow cover as one of the reasons for reduced forage availability because grasses and forbs require melt water from the snow to grow. On the contrary, another 32% of respondents believed more snow coverage on rangeland to be the cause of forage shortage.

The grasses on the rangelands are more sensitive to higher temperature resulting in reduced grass diversity affecting forage availability (Klein et al. 2007). Apart from policies, appearance of new plant species resulting in a decline of forage quality and availability were reportedly perceived as an impact of climate change by pastoralists in northern Bhutan (Wangchuk and Wangdi 2018). Wu et al. (2016) also found pastoralists experiencing changes like decreasing water sources through dying up of spring wells and waterfalls, appearance of unknown grass species, glacier retreat with unusual snowfall and degrading Himalayas due to climate change. Increased ice melt and weather extremes due to warming have increased likelihood of glacial lake outburst flood (GLOF) events in Himalayan mountains (Riaz et al. 2015). Lugge GLOF in October 1994 (Watanbe and Rothacher 2016) and Lemthang GLOF in June 2015 (Gurung et al. 2017) both in Bhutan had damaged grazing and agricultural lands down streams.

3.2 Challenges linked to socioeconomic factors

3.2.1. Social factors affecting labour availability for yak herding

The highlanders in Bhutan are geographically and socially isolated, and their livelihood has been dependent on transhumant yak farming (Gyamtsho 2000). However, the highlanders now have more access to other economic and livelihood opportunities, which seemingly led the younger generations to lose their interest in the yak farming (Wangdi 2016). With the introduction of the modern education system, most children of highlanders are being sent to school for their education (Dorji et al. 2020a). After attending schools, those literate youth and young adults distance themselves from yak herding as they prefer to stay back in urban areas (Wangdi 2016). Access to modern education and road connectivity were improved for sustainable and equitable socioeconomic development of highland communities in Bhutan. While the life of yak herders has improved with these developments, the changes had also resulted in decrease in successors for yak herding (Dorji et al. 2020a). Migration of literate youth from highland communities to urban areas in search of better livelihood has become a growing concern for both yak farming communities and government. The modern education system is focused towards producing professionals other than educated yak herders, and there is limited content in the education system to encourage the younger generations to become educated yak herders.

Although the yak farming is a household business for highlanders of Bhutan, male members of family are involved in other part time economic activities such as tourism, Cordyceps collection and other income activities (Dorji et al. 2020a). In their absence, female members of family are tasked with yak herding activities. The women are mainly involved in collection of water, fuelwood and fodder for yaks (Iffat 2006). The climate change impact on rangelands has resulted in less water availability, fuelwood and fodder for yaks. Hence, on one hand, the role of women in highland communities has further increased over the years (Verma and Khadka 2016). On the other hand, the increased involvement of women in yak farming can be considered as promotion to gender equity because women now have access to and

control over resources (Wangdi 2016; Wangchuk and Wangdi 2015). However, with increased involvement of women in yak herding, managing yak herds in harsh climate and rugged landscape would become more difficult for women (Dorji et al. 2020a). The aged yak herders are giving up yak herding task because they are no longer able to travel long distances with their yaks (Dorji et al. 2020b).

3.2.2. Economic factors affecting labour availability for yak farming

The access of highlanders to alternative economic activities such as Cordyceps collection (especially in the western and central regions) and tourism were seen as one of the important factors affecting labour availability for yak herding. Collection and sale of *Cordyceps sinensis* was legalized in 2004 by the RGoB to motivate highland residents. It became an attractive alternative economic activity for highlanders, especially younger generations due to generating much higher income compared to yak farming (Wangdi 2016), and became a factor of change for yak farming (Derville and Bonnemaire 2010). Cordyceps is an invaluable fungus harvested every year in the period from May to July and is sold at gold price (Wangchuk et al. 2012). The proportion of men heading the family and herding yaks has declined following the legalization of Cordyceps collection (Wangchuk and Wangdi 2015). A similar trend was found by Joshi et al. (2013) in the Hindu Kush Himalayan (HKH) region.

With the cash income earned from collection and sale of Cordyceps, they are able to send their children to school, procure livestock, including yaks (Dorji et al. 2020b), and power chainsaw (Wangchuk et al. 2012). The investment of cash income in procurement of yaks by certain yak herders is a desirable approach for sustainable yak farming. However, some yak herders are found to invest the income to buy agricultural land and houses in lower valleys (Derville and Bonnemaire 2010; Wangchuk and Wangdi 2015) suggesting that they want to permanently settle in lower valleys and quit yak herding. Families who traditionally own agricultural land in lower valleys are found to leave yak farming, and the main reasons are due to easier access to social services and economic opportunities while residing in lower valleys.

Involvement of one or more members of yak herding family in Cordyceps collection activity would affect labour availability for herding yaks. Nevertheless, according to Dorji et al. (2020a), yak herders argued that Cordyceps collection is not the cause of labour shortage reasoning they spend just about two months in a year for Cordyceps collection. Based on our understanding from different literature, the legalization of Cordyceps collection seemed to affect yak farming in Bhutan. Nevertheless, majority of older generation yak herders preferred yak farming over Cordyceps despite earning huge cash income from Cordyceps. They believe yak herding to be a reliable source of livelihood (Wangchuk and Wangdi 2015) and want their children to continue yak farming (Dorji et al. 2020b). In a perception study of Wangdi (2016), 88% of the respondents (yak herding families) wanted to continue yak farming despite having access to alternative economic activities indicating their trust and confidence in yak farming. Choden et al. (2020) found increased adaptive capacity scores in highland communities due to their capacity to collect Cordyceps. However, the existing way of Cordyceps collection is not a long-term sustainable approach (Dorji et al. 2020a). Huge influx of collectors each year would affect Cordyceps habitats (Wangchuk et al. 2012). The amount of Cordyceps in the region has already started to decline due to over-harvesting and warming of the region (Thapa

2020). This suggests that the herders need to rely on yak farming for their livelihood in the future. Tourism is another alternative source of income for yak rearing families across Bhutan (Dorji et al. 2020b). The mountainous landscapes along with the pristine environment and unique culture of highland communities attracts tourists. The well-organized tourism in yak rearing areas could allow yak farming communities to improve their income (Wangda 2016). However, tourism is found to compete for labour for yak herding.

3.3 Resilience capacities of the TYPS

3.3.1. Robustness of the system

Robustness, adaptability and transformability are three resilience capacities of a farming system (Meuwissen et al. 2019). The ability of the yak herding communities to deal with fluctuations in forage availability through production of almost comparable quantity of feed and fodder can be considered as the robustness toward forage shortage. Due to forage shortage and its shock, yaks might undergo a period of starvation leading to loss of live weight (Ren et al. 2017), milk yield (Shikui et al. 2003) and fertility (Zi 2003). However, the yaks reportedly recover from starvation during the summer months indicating that the robustness of the TYPS is partially due to intrinsic robustness of an animal itself. Robustness of animals could be improved by breeding for distinctive traits adapted to various contexts and perturbations (Casadebaig et al. 2014; Knap 2005). Feeding yak herds with stored forage and concentrates is another option to cope with forage shortage shocks. As per Dorji et al. (2020a), majority of herders (west, 86% and central, 75%) supplement their weak yaks with concentrates purchased from market. Besides, the winter forage shortages are prevented by keeping yaks close to the villages where they can feed on crop residues. Further, the herders grow fodder plants such as turnip or radish which can be fed to yaks while they are around the village (Wangchuk and Dorji 2008). Yaks have been herded in migratory pattern, taking yak herds from one grazing area to another which is an adaptive strategy (Dorji et al. 2020a). From forage shortage point of view, prevention of overgrazing through grazing management like rotational grazing might be a key to strengthening the resilience of TYPS in Bhutan.

The yak herders in eastern region reportedly sell their yaks as to cope with forage shortage rather than providing supplementary feed and forage. The independence from feed markets is a good choice of the TYPS as it keeps away from feed price fluctuations that might make access to concentrates difficult. To increase the resilience (or reduce vulnerability) relating to feed scarcity, it could be better to improve fodder production (Feroze et al. 2019; Paul et al. 2010). As per Dorji et al. (2020a), different stakeholders like herders, livestock professionals and forest professionals also opined to encourage herders to improve pastures by allowing them to clear twigs and branches of shrubs on rangelands. Similar views were gathered and reported in Wangdi (2016). Wangchuk et al. (2013) recommends prescribed burning to restore shrub dominated rangelands once every six years.

Although the herders may temporarily reduce their yak herd size, it might have an impending consequences, especially to regain the initial herd size because yaks have a low reproductive rate (Zi 2003). The resilience capacities of TYPS reduces due to limited options to deal with the forage shortage shocks. Therefore, respecting their traditional practices and allowing controlled burning of grasslands with conditions to stay within its safe or existing operating rangeland space is crucial. Nonetheless, culling unproductive animals can reduce forage competition with

productive herds (Sherpa and den Hertog 2002). Wangchuk et al (2013) recommends crossbreeding yaks with cattle breeds to produce yak-cattle crossbreds commonly called as Dzo and Zhom to enhance economic benefits through increased (milk) productivity. This practice also enables the herders to take their animals to lower altitudes during the winter months to cope with forage shortages in the high altitude areas, thereby increasing the resilience of the yak farming system. Nevertheless, the sustainability of yak-cattle crossbreeding is dependent on different prerequisites, for instance, continual access to adequate pure breeding stocks (Leroy et al. 2015). The crossbreeding is deemed as a threat to the maintenance of genetic resources (Lauvie et al. 2008; FAO 2015). The yak-cattle crossbreeding may lead to depletion of yak genetic resources in the long run.

Yak herders withstand fluctuating labour demand by going through periods of more intensive work. While reduced yak herd size might demand less labour and forage requirements, collaborating with neighboring yak herders to combine their yaks may resolve issues related to labour shortage. To some extent, herders might seek help from relatives to look after their yaks. Therefore, for both forage shortage and labour shortage, risk management capacities, knowledge (both traditional and conventional), and decision-making capacities are key elements of the robustness of TYPS as these allow herders to prevent or withstand those shortage by taking decisions. For example, the timing of migration could be displaced.

3.3.2. Adaptability of the system

Capacity to change the composition of inputs, production, marketing and risk management in response to shocks and stresses without changing the structures and feedback mechanisms of the farming system is adaptability (Meuwissen et al. 2019). The TYPS in Bhutan is a low-input system. Although access to additional inputs may be impeded due to improper infrastructures and topography, fertilizers, new seeds or machinery could be used for pasture production in the rangelands (Derville and Bonnemaire 2010). Simultaneously, ways to optimize the potentials of the existing native rangeland pasture species may be explored for improving its productivity. Besides, yak herds may be supplemented with small quantities of concentrates, particularly during harsh lean season. The RGoB may support herders with commercial feeds as a part of cost sharing mechanism modality (CSM) under the highland development program to encourage and engage yak herders in yak herding.

A production system's adaptability is linked mainly to indigenous knowledge and education (Wu et al. 2014). Traditional knowledge is important for traditional breeding, conservation of local breeds and use of ethno-veterinary practices (Singh 2009), and for grazing management (Singh et al. 2020). For example, transhumant routes can be modified using traditional knowledge to lower risks of forage shortage (Wangchuk and Wangdi 2018). Nevertheless, based on how we understand the TYPS in Bhutan from the available scientific papers, there is no study carried out on how the traditional knowledge of yak farming (informal education) is passed down to their children. Therefore, there is a need for a study on this as well. A formal education is also important to improve the knowledge about risk management. However, access to modern education seemingly led to labour shortage (Dorji et al. 2020a). Reducing yak herd size is another adaptive measure towards labour shortage as it would reduce workload demand. However, this would result in reduced outputs as well. According to Dorji et al. (2020a), about 30% of the herders interviewed reportedly sell their live yaks to

deal with labour shortage. Another option is to continue rearing yaks in parallel with the other economic activities.

3.3.3 Transformability of the system

The capacity to change the internal structure and feedback mechanisms in response to either severe shock or enduring stress is transformability (Meuwissen et al. 2019). Based on our understanding from literature, the transformability capacity of the TYPS is high because there are possibilities to transform the yak rearing system. For instance, if the forage and labour availability continue to decline as reported by Dorji et al. (2020b), the yak farming can no longer take place as usual because these two pressures are already a major concern for the TYPS. Knowing the shrinkage of pasture lands and deterioration of pasture quality (Moktan et al. 2008), increasing pasture productivity would be difficult without changing the land use system. One option to transform the TYPS could be to focus more on draught power production to replace horses and take advantage of emerging ecotourism and Cordyceps collection. However, complete shift towards ecotourism and Cordyceps collection would increase the vulnerability of the herders since ecotourism and Cordyceps collection are only seasonal income sources. Besides, this would also lead to increased competition with the people already involved in these activity fields.

4 CONCLUSION & RECOMMENDATION

The yak farming communities in Bhutan face challenges which demands attention of the government to conserve yak farming. The main challenges for yak herding in Bhutan are inadequate forage and decreasing number of successors for yak herding. Factors that influence forage shortage and labour shortage are socioeconomic developments, national regulations, education system and climate change impact on highland ecosystem. The forage availability has reduced due to policy developments (conservation policies) and increasing grazing competition from livestock species especially horses and wild animals. In addition, availability of labour for yak herding had declined due to access to education and other income sources. Thus, every development initiated by the RGoB for the Highland communities in Bhutan had both positive and negative effects on the yak farming communities. Therefore, there is a need to assess holistically and explore ways to balance and sustain the traditional culture of yak herding in the country. The resilience of TYPS in Bhutan may further be strengthened through review and development of enabling policy, improved social services and creation of economic opportunities for highland residents. Besides, downsizing the number of Cordyceps collectors each year is vital for its sustainability as Cordyceps collection is found to increase adaptive capacity of highland communities.

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