sustainability

MDPI

Article

The Future of Yak Farming from the Perspective of Yak Herders and Livestock Professionals

Nedup Dorji [1,2,3,*], Marjolein Derks [1], Peter W.G. Groot Koerkamp [1] and Eddie A.M. Bokkers [2]

1 Farm Technology Group, Wageningen University & Research, P.O. Box 16, 6700AA Wageningen, The Netherlands; marjolein.derks@wur.nl (M.D.); peter.grootkoerkamp@wur.nl (P.W.G.G.K.)

2 Animal Production Systems Group, Wageningen University & Research, P.O. Box 338, 6700AH Wageningen, The Netherlands; eddie.bokkers@wur.nl

3 Department of Animal Science, College of Natural Resources, Royal University of Bhutan, Lobesa, Punakha 1264, Bhutan

* Correspondence: nepdorpion186@yahoo.com or nedupi@cnr.edu.bt

Received: 7 April 2020; Accepted: 24 April 2020; Published: 21 May 2020

Abstract: The declining number of yak farming families is perceived as a socio-political and economic concern in Bhutan. However, there is limited understanding of what influences herders' plans and decisions on yak farming. We studied factors determining future perspectives of yak farming by interviewing yak herders and livestock professionals. We analysed relationships between herders' characteristics and level of concerns, and future plans related to yak farming. Furthermore, relationships between level of concern and future plans were analysed. Most of the herder characteristics did not influence their future plans with yak farming. Age and level of perceived concern of the herders was associated with their wish for their children to continue yak farming in the future. Nevertheless, they expect that the number of yak farming families will decline in the next ten years. Additionally, most of the livestock professionals believe that the number of yak farming families will decline in the future. No differences were observed between the aggregated score of concern of herders and livestock professionals. The most important factors threatening the future of yak farming in Bhutan according to herders and livestock professionals are forage shortage, predation and no successor to take up yak farming.

Keywords: yak farming; future; opinions; perceived concern; sustainability

1. Introduction

Yak is the main source of livelihood for transhumant pastoralists residing 2500 m above sea level in 10 northern districts of Bhutan. In transhumance systems, herders migrate with their yak herds between summer and winter rangelands to maximize forage availability, while their families remain in permanent villages [1]. Yaks are kept mainly for milk and meat purposes, and in some areas yak bulls are used as a draft animal to plough agricultural fields. Besides, the transhumance pastoralism system maintains socio-cultural landscapes, which often have spiritual importance to the wellbeing of the community and is assumed to preserve biodiversity in the mountains [2]. Furthermore, the unique cultural identity of yak-based communities supports tourism, which generates high revenues to Bhutan [3]. However, there are numerous challenges that yak herders face, such as declining labour availability, low forage availability in the rangeland, yak mortality, and limited access to the market to sell yak products [4–6]. The numerous challenges to yak farming have continued to increase over the years due to socio-economic developments, changing policies [4,5,7] and climate change [8].

Socio-economic developments have impacted yak-based transhumant pastoralists at family level. While acknowledging that modern education for younger pastoralists is important to develop skills

and knowledge to improve living standards, a lack of awareness and incentives for them to stay in their village to take over yak farming means they will migrate from villages to urban areas where they can find better services and facilities [5,9]. In addition, both young and adult family members prefer to be engaged in other activities than yak farming, such as collecting the mushroom cordyceps (*Cordyceps sinensis*) and medicinal plants, which gives them a relatively high economic return [5,7,9]. In addition, the policy to increase food safety in Bhutan has led to the import of cheap dairy products and to non-yak dairy development. Both are mentioned as threats to the sale of yak products [10].

Policy developments and climate change affect forage availability. For example, regulations that prohibit herders from burning and removing shrubs on rangelands (Forest and Nature Conservation Act of 1995), a method that was effective to control shrubs and maintain forage production on the rangelands in the past [10], were instated. This has become more urgent due to climate change which causes shrub proliferation due to warming and lengthening of the growing season [8]. Other regulations related to nature conservation affect yak farming by an increase of human-wildlife conflicts [7].

Hence there are many reasons to expect yak farming to decline in the near future. Policy makers perceive the decline in yak farming as a socio-political and economic concern to Bhutan. In order to find a solution within the context of these socio-economic developments and regulations to maintain yak farming in Bhutan, interventions to support these communities may be needed. In order to understand where to target the new policies, the perceived level of concern regarding these factors affecting the yak farming practices from yak herders' and livestock professionals' perspective need to be known. Since there are regional differences in yak farming, constraints and level of concern on factors might be different. Moreover, demographic factors including age, gender, education, herd size, source of income are used to assess management practices of farmers and decisions in farming [11–13]. We hypothesized that the perceived level of concerns of factors that affect yak farming practices is likely to be associated with herders' demographics and regional differences. We also hypothesized that herders who are more concerned about factors that affect yak farming are more likely to quit yak farming in the future. Therefore, this study builds on the previous efforts of Dorji et al. [7], and assesses the factors that determine the future of yak farming from the perspective of yak herders and livestock professionals.

2. Materials and Methods

2.1. Study Area

Bhutan has 10 districts with in total 25 *geogs* (blocks) where yak farming is operated [14]. Yak-based communities in Bhutan can be classified into three regions based on specific types of yak cheese produced, cattle–yak hybridisation practice, and source of income [6]. Three yak farming blocks matching the different yak farming regions were visited: Merag (eastern region), Saephu (central region), and Laya (western region) as shown in Table 1. In Bhutan, blocks are the local administrative unit. One block consists of several villages. These three blocks were maximal one day walk from the nearest road and they were located over 3000 m above sea level (masl). Hereafter, we will use the name of the regions (east, central, west) instead of the name of the blocks for the sake of convenience. Detailed information required about villages and yak herders to be visited in each block was gathered either from local livestock extensionists or obtained from Livestock Statistic [14].

Table 1. Descriptions of yak farming regions.

Region	Block	Altitude (masl)	Coordinates	Source of Income	Yak Dairy Products
East	Merag	3215	27°17′49.20″ N 91°50′6.00″ E	Yak, cattle and cattle–yak hybrids, sheep, medicinal plants	Butter, cheese (fermented and fresh)
Central	Saephu	3500	27°29′10.14″ N 89°53′56.94″ E	Yak, cattle and cattle–yak hybrids, cordyceps, medicinal plants, vegetables (potatoes, cabbages)	Butter, cheese (dried and fresh)
West	Laya	3800	28°04′00.00″ N 89°41′00.00″ E	Yak, horse, tourism, cordyceps, medicinal plants, agriculture (buckwheat, mustard)	Butter, cheese (dried and fresh)

2.2. Data Collection

During the field visit, a verbal consent was obtained from the yak herders taking part in the study. Sixty-seven herders (east, n = 25; central, n = 20; west, n = 22) were interviewed face to face using a semi-structured questionnaire. In the western and central region, the Bhutanese national language was used to interview the herders, which was translated from English by a qualified local translator. In the eastern region the local dialect called *sharchopkha* was used, which was translated by the interviewer, who is a native speaker of this dialect. The semi-structured questionnaire consisted of two sections (Table 2):

- Respondent's perceived level of concern about factors related to yak farming challenges.
- Respondent's future plans with developing yak herd size in the next 10 years, their wish for their children to continue yak farming, and their opinion on the number of yak farming families in the next 10 years.

Besides yak herders, 2 yak researchers and 26 local livestock extensionists working with yak-based communities were interviewed face to face (n = 2) or using email (n = 26). The questions included the respondents' perceived level of concern of factors and opinions on the number of yak farming families in the next 10 years (Table 2). Details about the data collection procedure can be found in non-published material (Dorji et al. unpublished).

Table 2. Variables and descriptions used to determine the factors affecting the herders' future plans and decisions on yak farming.

Variables	Description of Topics Addressed
Independent	
Yak farming region	East, central, west.
Respondent's sex	Male, female.
Respondent's age	Years
Respondent's education	Illiterate (cannot read and write), literate
Number of yak herders	One, more than one person involved in yak farming
Size of yak herd owned	Total number of yaks owned by the herder.
Preferred source of income	Yak farming, other (cordyceps collection, tourism, cattle and cattle–yak hybrid farming, small business)
Dependent	
Concern factors related to yak farming [1]	Are you concerned about [a concern factor] in relation to yak farming practices? 4-point Likert-scale: 1 = not at all concerned, 2 = to a small extent concerned, 3 = to a moderate extent concerned, 4 = to a large extent concerned, 0 = I don't know. Concern factors questioned are: yak population size in the community, summer forage availability, winter forage availability, water availability, access to a high-quality breeding bull, conception rate of yak cows, yak body size, milk yield, prevalence of diseases and parasites, access to veterinary and extension services, predation, market situation, labour availability, successor to continue yak farming, number of yak farming families, and training availability to improve yak farming.
Future plan with herd size	What is your plan with respect to the yak herd size in the next 10 years? Binary variable: 0 = definitely decrease, probably decrease, or maintain the same, 1 = probably increase, or definitely increase.
Wish for their children to continue yak farming	Do you wish your children to continue yak farming? Binary variable: 0 = definitely no, probably no, or unsure, 1 = probably yes or definitely yes.
Future trend of yak farming families	How do you see the number of yak farming families developing in the next 10 years? Binary variable: 0 = definitely decrease or probably decrease, 1 = or remain same, probably increase, or definitely increase.

[1] Also used as independent variable for yak herders' future plans and decisions on yak farming.

The questionnaire for the yak herders was tested with three yak herders of the *Tsento* yak farming block (which were not included in the analysis), while the questionnaire for livestock professionals was tested with two BSc students of College of Natural Resources who worked with yak-based communities to check for problems in the questionnaire design, such as unclear wording, sensitive questions, and misinterpretation of questions. The revised version of the questionnaire was used to interview yak herders and livestock professionals.

2.3. Characteristics of the Herders

The proportion of male/female respondents was 76%/24% (east), 40%/60% (central), and 34%/56% (west). The age of respondents (mean ± SEM) was 49.1 ± 3.1 (east), 41.9 ± 2.8 (central) and 39.7 ± 3.1 (west) years. The majority of the herders were illiterate (east, 73%; central, 80%; west, 88%) Dorji et al. (unpublished). The average yak herd size was 54.6 ± 5.8 (east), 47.4 ± 4.7 (central) and 49.8 ± 8.6 (west). More than half of the respondents preferred choice of livelihood was yak farming (east, 54%; central, 71%; west, 65%) Dorji et al. (unpublished).

2.4. Data Processing and Analysis

All statistical analyses were performed in R-Studio (version 3.5.0). The characteristics, perceived concerns on factors affecting yak farming practices (called concern factors hereafter), and future plans and decisions on yak farming of the yak herders used in the analyses are shown in Table 2. The internal consistency of the 16 concern factors affecting yak farming was checked using Cronbach's alpha. The Cronbach's alpha coefficient ($\alpha = 0.81$) showed that the question items had an acceptable internal consistency [15].

Descriptive statistics were computed for all variables. Medians were determined for the 16 factors of concern related to yak farming. Next, deviations from the medians were calculated by subtracting the median from the individual rates of each respondent. The aggregated score was computed by summing the deviations from the median of 16 concern factors. A 'zero' value was used when the original response was 'don't know', to prevent an effect of this answer on the aggregated score. The aggregated score of concern was calculated because we expect that some respondents have more concerns than others, which may be explained by personality traits and attitudes and perceived risk of the respondents [16]. For example, herders with a neurotic profile tend to be nervous, easily depressed, fearful, highly sensitive, and insecure [17] and therefore they might potentially be more concerned. The aggregated score of concern was tested for normality and homogeneity of variance. The quantile-quantile plot and Shapiro–Wilk's test showed that the aggregated score of concern was normally distributed ($p > 0.05$). Additionally, the Levene's test indicated that the aggregated score of concern met the assumption of homogeneity of variance ($p > 0.05$). Multiple linear regression was used to examine whether the characteristics of the respondents or region influenced the aggregated score of concern. The residual plots did not indicate evidence of poor fit of the model. In regression modelling, correlation among explanatory variables is undesirable because the standard errors of coefficients can be overestimated, which may affect the regression results [18]. Thus, variance inflation factors (VIFs) were used to detect multicollinearity between explanatory factors [19] using the package "vif" in R. VIFs more than 5 were considered unfavourable [18], and were removed from the final model.

The Likert-type items used to get insight into the herders' future plans and decisions on yak farming were converted to a binary variable (Table 2) because there were only a few respondents who selected a specific answer option. For example, only 4 of 67 herders planned to decrease their herd size in the next 10 years (detail in Appendix A Figure A1). The response 'don't know' was excluded from the analysis. Binary logistic regression was used to test the relationships between the respondent's characteristics and their future plans and decisions on yak farming (plans with developing yak herd size in the next 10 years, their wish for their children to continue yak farming, and their opinion on the number of yak farming families in the next 10 years). The Hosmer–Lemeshow goodness of test was used to assess the model using the package generalhoslem [20] and a confusion matrix was used to check the model accuracy using the package caTools in R [21]. Furthermore, model fitness was

assessed by calculating McFadden's pseudo R^2 [22]. Further, the point-biserial correlation [23] was used to test whether the aggregated score of concern was associated with the herders' future plans and decisions on yak farming. The Fisher exact test was used to evaluate the association between herder's plans with developing yak herd size in the next 10 years and their wish for children to continue yak farming, and the opinion on the number of yak farming families in the next 10 years.

The Wilcoxon–Mann–Whitney test was used to examine the differences between yak herders' and livestock professionals' aggregated score of concern, while the Fisher exact test was used to check if the opinion of herders on the number of yak farming families differed from the opinion of livestock professionals.

3. Results

3.1. Concern Factors Related to Yak Farming

The majority of the herders expressed that the forage availability in rangelands (86.6%), predation on yaks (88.0%), and presence of a successor (72.6%) are concern factors to yak farming. Regional differences were found for availability of high-quality breeding bulls (central, 75%), smaller body size of adult yaks over generations (east, 80.0%; central, 75.0%), prevalence of diseases and parasites (east, 76.0%; west, 68.0%), and access to veterinary services (east, 84.0%). Similarly, livestock professionals perceived forage shortage (83.0%), availability of high-quality breeding bulls (89.3%), predation on yaks (92.9%), labour availability to herd yaks (92.8%), and lack of training to improve yak farming (89.3%) as concern factors to yak farming. The yak herder's and livestock professionals' perceived level of concerns of factors related to yak farming is included in Appendix A. Although no difference was observed between the aggregated score of concerns of herders and livestock professionals ($z = 1.86$, $p = 0.06$) (Figure 1), the concern level for individual factors to yak farming practices is different.

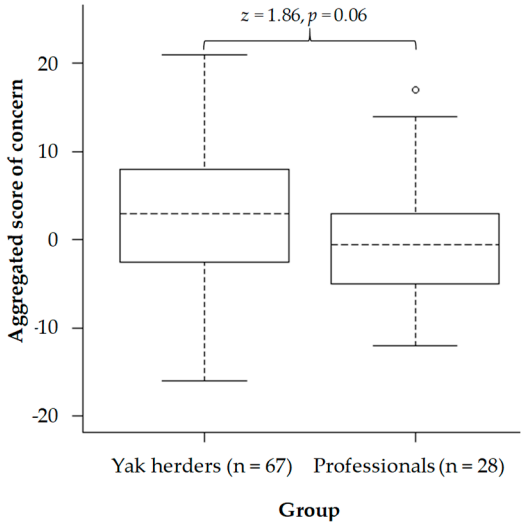

Figure 1. Respondents' aggregated score of concern factors to yak farming.

The herders' sex, education, age, and the region did not influence their aggregated score of concern ($p > 0.05$), but size of the herd owned was positively related with the aggregated score of concern ($p = 0.04$). The herders' aggregated score of concern to yak farming is likely to increase (odds ratio = 1.07) with a unit increase in current yak herd size (Table 3).

Table 3. Multiple linear regression results for variables influencing the aggregated score of concerns related to yak farming.

Variable	Coef.	SE	*t* Value	$p > \|t\|$	Odds Ratio	VIF
Region east (intercept)	2.34	5.51	0.42	0.67	10.39	
Region central	−2.29	2.46	−0.93	0.35	0.10	1.36
Region west	−2.97	2.63	−1.13	0.26	0.05	
Sex female	−0.07	2.35	−0.03	0.97	0.93	1.47
Age	−0.04	0.09	−0.49	0.62	0.96	1.69
Education literate	−1.56	2.94	−0.53	0.60	0.21	1.46
Size of the herd owned	0.07	0.03	2.13	0.04*	1.07	1.13
More than one herder involved in herding	0.61	2.15	9.28	0.78	1.84	1.20
Prefer source of income (others)	−0.11	2.10	−0.05	0.96	0.89	1.10

Number of observations = 67; R^2 = 0.12; * significance at $p < 0.05$. Coef. = coefficient; SE, standard error; VIF, variance inflation factor.

3.2. Herders' Future Plan with Herd Size

Half of the herders planned to increase the current yak herd size in the next 10 years. The reasons they mentioned were earning more income through sales of yak products (e.g., cheese, meat, sell live animals, hair products) and that it is a reliable source of income while other activities such as cordyceps collection are not (Table 4). Some herders plan to maintain the current herd size because it is able to meet the family daily household requirements, family labour is sufficiently present, and there is no successor to take over yak farming. A few herders responded to decrease the current yak herd size because of experiencing forage and labour shortage (Table 4).

Table 4. Yak herders' (n = 67) plans on the development of their herd size in the next 10 years.

Plan	Reasons	Respondents (n)
Increase herd size (n = 39) [1]	Yak has multiple functions and generates therefore more income	27
	Yak farming is a traditional way of life	6
	Other (measure to cope with high mortality due to predation, if more rangeland is available, social status)	8
Maintain same herd size (n = 21) [1]	Selling yak products meet the daily household requirements	12
	Family labour is sufficient present	10
	Rangeland owned by family is sufficient for current herd size	7
	No successor but yak farming is the main livelihood	5
	Yak farming is a traditional way of life	1
Decrease herd size (n = 4)	No successor	3
	Forage shortage	1
Not sure (n = 3)		3

[1] Respondents could give multiple reasons.

The characteristics of the herders had no effect on their future plans with regard to herd size (Table 5), but the association between region and herders' plans on the development of their herd size was stronger in the western region than the eastern and central regions (average marginal effect, AME = 0.43). Moreover, the herders' plans on the development of their herd size in the next 10 years was not associated with the aggregated score of concern ($t = -0.28$, $r_{pb} = -0.04$, $p = 0.78$).

Table 5. Binary logit model results for variables influencing the herders' plans on the development of their herd size in the next 10 years.

Variable	Coef.	SE	*z* Value	$p > \|z\|$	Marginal Effects		VIF
					Average	SE	
Region east (intercept)	1.40	1.45	0.97	0.33			
Region central	0.33	0.65	0.48	0.63	0.08	0.16	1.44
Region west	2.27	0.87	2.61	0.01*	0.43	0.13	
Sex female	−0.80	0.72	−1.11	0.27	−0.15	0.13	1.53
Age	−0.03	0.02	−1.20	0.23	−0.01	0	1.44
Education literate	−0.29	0.77	−0.37	0.71	−0.05	0.15	1.21
Size of the herd owned	0	0.01	0.32	0.75	0	0.32	1.11
More than one herder involved in herding	0.05	0.62	0.08	0.93	0.01	0.12	1.18
Prefer source of income (others)	−0.45	0.62	−0.71	0.48	−0.09	0.13	1.10

Number of observations = 64; Hosmer and Lemeshow test $\chi^2(8) = 4.31$ ($p = 0.83$); Correct prediction = 70.31%; McFadden Pseudo $R^2 = 0.15$; * significance at $p < 0.05$. Coef. = coefficient; SE, standard error; VIF, variance inflation factor.

3.3. Herders' Wish for their Children to Continue Yak Farming

The majority of the herders (82%) wish their children to continue yak farming in the future because they consider yak farming a reliable source of income and give importance to the traditional way of life (Table 6). Some herders also mentioned that the children have to make their own choice or should not continue yak farming in the future, with the argument that yak farming is a tough way of living and the herders usually have to endure a lonely life when at the summer rangelands. A few herders were unsure whether they wish their children to continue yak farming in the future.

Table 6. Yak herders' (n = 67) wish for the children to continue yak farming in future (yes/no) and their opinion on number of yak farming families in the next 10 years.

Opinions	Reasons	Respondents (n)
	Wish for the children to continue yak farming in the future	
Yes (n = 55) [1]	Yak farming is a reliable source of income	38
	Yak farming is a traditional way of life	17
	Children are interested to continue yak farming	1
Not sure (n = 8)	Depends on children as it is a challenging occupation	3
	Depends on children as it is a challenging occupation	8
No (n = 4)	Forage shortage	1
	Yak farming is a challenging occupation	3
	Number of yak farming families	
Increase (n = 13) [1]	Yak herd division among family members	7
	Yak farming is a reliable source of income	4
	Government support to yak farming	3
	Children are interest to continue yak farming	1
Remain same (n = 8)	Yak farming is a traditional life style	4
	Rangeland owned by a family is sufficient	3
Decrease (n = 39) [1]	Yak farming is a reliable source of income	1
	Easy lifestyles at towns (challenging occupation)	37
Don't know (n = 7)	Others (forage shortage, yak mortality, alternate income)	7

[1] Respondents could give multiple reasons.

The age of the herder had a significant positive effect on the wish for their children to continue yak farming in the future ($p = 0.03$), but sex, education, size of the herd owned, and region did not (Table 7). This relation indicates that when the herder's age increases their wish for children to continue yak farming is likely to increase (AME = 0.01). Moreover, the association between region and herders' wish for their children to continue yak farming was stronger in the western region than in the eastern and

central region (AME = 0.25). Additionally, the herders' wish for their children to continue yak farming was positively associated with their aggregated score of concern (t = 2.89, r_{pb} = 0.34, p = 0.01).

Table 7. Binary logit model results for variables influencing the herder's wish for their children to continue yak farming.

Variable	Coef.	SE	z Value	$p > \|z\|$	Marginal Effects		VIF
					Average	SE	
Region east (intercept)	−3.54	2.21	−1.60	0.11			
Region central	0.02	0.81	0.03	0.98	0	0.13	1.60
Region west	2.44	1.19	2.04	0.04 *	0.25	0.11	
Sex female	−0.42	0.84	−0.50	0.62	−0.05	0.11	1.45
Age	0.08	0.04	2.13	0.03*	0.01	0	1.53
Education literate	−0.17	0.90	−0.19	0.85	−0.02	0.12	1.31
Size of the herd owned	0.03	0.02	1.34	0.18	0	0	1.22
More than one herder involved in herding	0.67	0.80	0.83	0.40	0.08	0.09	1.22
Prefer source of income (others)	0.03	0.82	0.04	0.97	0	0.10	1.28

Number of observations = 67; Hosmer and Lemeshow test $\chi^2(8)$ = 7.20 (p = 0.51); Correct prediction = 82.09%; McFadden Pseudo R^2 = 0.22; AIC = 69.44; * significance at $p < 0.05$. Coef. = coefficient; SE, standard error; VIF, variance inflation factor.

3.4. Number of Yak Farming Families in 10 Years

Of the herders 58% of the herders believed that the number of yak farming families will decline in the next 10 years, because young and adult family members will continue to migrate to towns looking for better economic opportunities and easy lifestyles (Table 6). Another reason mentioned by herders was a decreasing forage availability and an increasing predation on yaks, which might discourage yak farming families to continue in the future. In contrast, youth outmigration from their villages (p = 0.00) is believed by most livestock professionals (96%) to negatively affect the number of yak farming families in the next 10 years. A few herders also think that the number of yak farming families will remain the same in the future because current yak farming families are those who own adequate rangeland. Some herders (east, n = 7) think that the number of yak farming families will increase in the future because of traditional practices of dividing the yak herd among the family members in these communities (Table 6). In addition, a few herders of the central (n = 1) and western (n = 2) regions think that governmental support might encourage yak farming and increase the number of yak farming families in the future.

Table 8 shows that the herders' characteristics and the region did not influence their opinion on the number of yak farming families in the next 10 years ($p > 0.05$). Moreover, the herders' aggregated score of concern was not associated with their view on the number of yak farming families in the next 10 years (t = −0.38, r_{pb} = −0.05, p = 0.70). In contrast, a negative association was observed for the livestock professionals' aggregated score of concern and their opinion on the number of yak farming families in the next 10 years (t = −2.15, r_{pb} = −0.39, p = 0.04). The result indicates that when the livestock professionals' aggregated score of concern increases, the odds of thinking that the number of yak farming families will decline in the next 10 years increases. The herders' opinion on the number of yak farming families in the next 10 years differed from livestock professionals (p = 0.00).

3.5. Association between the Herders' Plans and Decisions on Yak Farming

Herders' plans on the development of their herd size was not associated with their wish for their children to continue yak farming and their opinion on the number of yak farming families in the next 10 years ($p > 0.05$). Additionally, no association between the herders' wish for their children to continue yak farming and their view on the number of yak farming families in the next 10 years was observed ($p > 0.05$).

Table 8. Binary logit model results for variables influencing the herders' opinion on the number of yak farming families in the next 10 years.

Variable	Coef.	SE	*z* Value	$p > \|z\|$	Marginal Effects		VIF
					Average	SE	
Region east (intercept)	−0.50	1.33	−0.38	0.71			
Region central	−1.07	0.71	−1.49	0.13	−0.24	0.15	1.54
Region west	−1.03	0.81	−1.27	0.20	−0.23	0.17	
Sex female	0.32	0.68	0.47	0.64	0.07	0.14	1.44
Age	0	0.02	−0.09	0.92	0	0	1.48
Education literate	0.96	0.80	1.20	0.23	0.21	0.18	1.41
Size of the herd owned	0.01	0.01	0.88	0.38	0	0	1.23
More than one herder involved in herding	0	0.62	0	1	0	0	1.20
Prefer source of income (others)	−0.39	0.63	−0.06	0.53	−0.08	0.13	1.11

Number of observations = 60; Hosmer and Lemeshow test $\chi^2(8) = 3.76$ ($p = 0.88$); Correct prediction = 66.67%; McFadden Pseudo $R^2 = 0.06$; AIC = 91.92. Coef. = coefficient; SE, standard error; VIF, variance inflation factor.

4. Discussion

This study aimed to deepen our understanding of the relationship between (perceived) level of concern, future plans and herders' characteristics for yak farming in Bhutan.

Herders' characteristics, the region, and the herders' aggregated score had no relation with herders' opinion on the number of yak farming families in the next 10 years, which contradicts with our expectation. Our hypothesis on the decreasing number of yak farming families comes from Wangchuk and Wangdi [5]. Wangdi [9] further reports that the age of herders affects the opinion on future of yak farming. The fact that no relation between the age of herders and their opinions was found in this study may be explained partly by the differences in analysis approach. The age of the herders was treated as a continuous variable in the logistic regression, while Wangdi [9] probably used age as categorial variable (young and elderly) to investigate whether age and their opinion on future of yak farming was related. In addition, we took into account more than one factor that may be associated with the opinion of the herders on the number of yak farming families in the future, so logistic regression is an appropriate approach [24,25]. If the aggregated score of concerns and characteristics of the herders do not appear to affect the opinion on the number of yak farming families in the future, then possibly the motivation of a person [26–30], risks perceived by a person [16,28], and/or current situation and constraints [29] do. Therefore, further analysis is required to examine relationships between aforementioned variables to deepen our understanding on future trends of yak farming. Furthermore, the R^2 and pseudo R^2 of the models are low but significant (Tables 3 and 5). They indicate that even if the dependent variable was associated with the predictor when other predictors in the model are held constant [31], there are other potential important factors affecting the herders' plan and decision on yak farming that were excluded in the model such as personality traits. The pseudo R^2 of 0.22 (in Table 7) indicates a good model fit [32].

A substantial number of yak herders (east, 48%; central, 70%; west, 55%) said that the number of yak farming families will decrease in the next 10 years. Except for one, livestock professionals agreed that outmigration of the villages to towns and cities is the main reason. We single out the youth outmigration from the villages as the main potential threat to yak farming in the future due to access to education for children of yak-based communities and economic opportunities. In other studies by Dorji et al. [7] and Phuntsho and Dorji [10], it was shown that the younger generation of the yak-based families indeed had less interest to take up yak farming and prefer to migrate to towns and cities, which offer better amenities. Another study reported that the number of yak farming families has declined by approximately 31% from 1400 in 1996 to 968 in 2013 in Bhutan [9]. They indicate that this is probably due to outmigration leading to no successor and labour shortage. A similar decline in the number of the transhumance families by 35 to 50% was reported in Nepal [33]. The increasing youth outmigration from the villages was also reported in other parts of Bhutan [34,35] and other

transhumant communities in other countries [4,33,36–38], affecting rural development and also leading to the loss of unique cultural traditions of the yak-based communities. Thus, a decreasing number of successors to take over yak farming is a policy issue, which requires governmental interventions when one wants to stop this process. One strategy is to provide good facilities (e.g., communication services, health services, upgrade schools) that should encourage younger literate pastoralists to stay in the yak farming business. However, some interventions by the government would also have to identify priorities of different stakeholders in addition to yak herders. For instance, yak farming communities request to revise the Forest Act by allowing them to conduct prescribed burning of rangelands to control shrub proliferation [9], while the Department of Forest and Park Services aims to strengthen conservation of biodiversity in protected areas and does not want to allow burning of rangelands.

Although more than half of the herders think yak farming will decline, most herders wish their children to continue yak farming in the future. The reason given by herders was that they view yak farming more like a traditional way of life than a profession, which was also the feeling expressed by transhumant herders in other countries [39,40]. Herders said that yak farming is their culture and tradition and so it is their and their children's responsibility to keep yak farming alive. Younger generations, however, were not interviewed to ascertain that they are not interested in yak farming. Bernués et al. [41] indicated that having children in the farming family and successors willing to take over farming should be the core focus when assuring the sustainability of transhumant pastoralism systems. Moreover, the positive association between herders' aggregated score of concern and their wish for children to continue yak farming in the future perhaps explains the confidence herders have in yak farming as a reliable source of income and the perceived responsibilities to maintain their unique culture and tradition.

We also found that herders of the western region had a stronger wish for their children to continue yak farming and planned changes in herd size in the next 10 years than in the other two regions. This observation is interesting because cordyceps collection (western and central region) and horses used in tourism and transportation (western region) are a very lucrative occupation compared to yak farming [9], which has less economic return and is a challenging occupation. Two reasons probably explain why most herders in the western region wish their children to continue yak farming. First, the Bhutanese government has legalised cordyceps collection in 2004 to encourage yak-based communities to stay active in the mountains and maintain keeping yaks, which might be a successful strategy in this region. Second, herders of the central and western region expressed that cordyceps yield and quality has declined compared to the past and they view yak farming as a reliable source of income, which was consistent with previous studies in Bhutan [5,9]. The decreased cordyceps quality and quantity was also reported in other Himalayan countries because of over exploitation of the resources [42,43], so the perception of the herders could be accurate. This implies that the government should explore novel alternative livelihoods for yak-based communities and assure better prices for their yak products to encourage pastoralists to stay in yak farming business, but it does not necessarily guarantee sustainable yak farming. For future research, we suggest studying the willingness of the younger generation of yak-based communities to take up yak farming in the future, and the related requirements.

The present study observed a very weak association between the herders' wish for their children to continue yak farming in the future and their plan on the development of herd size in the next 10 years. This could be because the herders' plans on the development of herd size greatly depend on other important factors, such as forage availability [44] (p. 191), the social purpose of keeping yaks (e.g., social symbol of the family), or for the future generation [45] than the herder's characteristics in our study. From our survey, some herders mentioned that they would expand their yak herd size to cope with losses due to predation which they mentioned has increased over the years. A similar increase of wild predation on yaks was reported in the Ghunsa valley in Nepal [46]. A few herders (n = 3) also stated that whether they keep a small or large herd size, they should look after them anyway, so they plan to expand their herd size in the next 10 years. Elsewhere, the expansion of herd size is

a strategy to reduce risk under the challenging living environment and climate change, such as in the Saami reindeer herders in Norway [47] and pastoral herders in northern Kenya [48]. Nevertheless, probabilities of yak herders to remain with yak farming are higher when they plan to expand their herd size, based on the assumption that they do not experience resource and management constraints, such as labour and forage shortage. Ondersteijn et al. [49] reported that the age is negatively related to growth of dairy herd size. The young farmers who have just taken over the farms are in effort to meet their financial needs, while the experienced farmers have a stable herd size that maintains a stable income.

Our cross-sectional analysis indicated that the herders' aggregated score of concern was positively associated to the size of herd owned. A possible explanation is that herders become more concerned to meet forage and labour requirements and other management with increasing herd size [50,51]. In this context, it is important to get insight into which factors require immediate attention or even an intervention. For example, our survey results showed that the forage availability in rangelands (east, 86%; central, 87%; west, 91%), predation on yaks (east, 84%; central, 85%; west, 95%), and presence of a successor (east, 72%; central, 80%; west, 68%) were a concern in all visited regions.

Although herders' aggregated score of concern did not differ from livestock professionals', their opinions on the number of yak farming families in the next 10 years differed. It could be that many herders will continue yak farming for another 10 years as their average age was 41 years. Whereas livestock professionals might have learnt and/or heard during meetings that the younger pastoralists have no interest in yak farming and they think that number of yak farming families will decline in the future because of no successors. Nonetheless, more than half of the respondents (herders and livestock professionals) view that the number of yak farming families will decline in the future.

5. Conclusions

To our knowledge, this is the first kind of study unravelling the factors that affect the future for yak farming in Bhutan from the perspective of herders and livestock extensionists. We conclude that not many herders' characteristics were associated with perceived concerns and the future plans and decisions on yak farming as was hypothesized, but probably there are other factors such as the motivation of a person in farming and risks perceived by a person. Nevertheless, our work underscores that policy makers should consider and incorporate factors that associate with perceived concerns such as forage shortage, predation, and decreasing successor to take up yak farming. This would contribute to the chances for sustaining yak farming in Bhutan. In addition, development policies should aim for financial security by helping yak farmers selling their products for a good price and by looking for novel alternate livelihoods. Besides, they should also provide better local infrastructures, communication services, health services, and upgrading the existing schools to give opportunities for young people to stay in the local communities having a good future perspective.

Author Contributions: Conceptualization, N.D., M.D., P.W.G.G.K. and E.A.M.B.; methodology, N.D., M.D., P.W.G.G.K. and E.A.M.B.; software, N.D.; validation, N.D., M.D. and E.A.M.B.; formal analysis, N.D., M.D. and E.A.M.B.; investigation, N.D.; writing—original draft preparation, N.D.; writing—review and editing, N.D., M.D., E.A.M.B. and P.W.G.G.K.; visualisation, N.D., M.D. and E.A.M.B.; supervision, M.D., P.W.G.G.K. and E.A.M.B.; project administration, P.W.G.G.K., N.D., M.D. and E.A.M.B.; funding acquisition, P.W.G.G.K., E.A.M.B. and N.D. All authors have contributed to discussion, read and agreed to the published version of the manuscript.

Funding: This project was funded by The Netherlands University Foundation for International Cooperation (NUFFIC). The study is a part of the PhD thesis of the first author (N.D.).

Acknowledgments: The authors are grateful to the local livestock extensionists for their logistic support to the first author (N.D.). The authors wish to thank all the respondents for their valuable time. We further thank the College of Natural Resources, The Royal University of Bhutan for the support during data collection in Bhutan.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Yak herder's (n = 67) and livestock professionals' (n = 28) perceive level of concerns of factors related to yak farming.

Aspects	Level of Perceived Concern (%)				
	Not at All	To Small Extent	To Moderate Extent	To Large Extent	Don't Know
Forage availability in winter rangeland					
Yak herders	11.9	13.4	25.4	47.8	1.5
Livestock professionals	10.7	25	28.6	28.6	7.1
Forage availability in summer rangeland					
Yak herders	10.5	17.9	23.9	47.8	0
Livestock professionals	0	25	28.6	64.4	0
Water availability					
Yak herders	53.7	10.4	19.4	14.9	1.5
Livestock professionals	14.3	3.6	46.4	21.4	14.3
Quality breeding bull availability					
Yak herders	59.7	13.4	17.9	9	0
Livestock professionals	7.1	25	25	11	3.6
Conception rate of yak cow					
Yak herders	61.2	11.9	17.9	1.5	7.5
Livestock professionals	17.9	28.6	28.6	14.3	10.7
Milk yield of yak cow					
Yak herders	34.3	11.9	26.9	25.4	1.5
Livestock professionals	21.4	28.6	32.1	14.3	3.6
Body size of adult yak					
Yak herders	38.8	23.9	25.4	10.4	1.5
Livestock professionals	21.4	35.7	21.4	3.6	17.9
Prevalence of diseases and parasites					
Yak herders	32.8	23.9	14.9	23.9	4.5
Livestock professionals	7.1	39.3	32.1	21.4	0
Access to veterinary and extension services					
Yak herders	46.3	29.9	13.4	9	1.5
Livestock professionals	17.9	14.3	25	42.9	0
Predation on yaks					
Yak herders	9	10.5	19.4	58.2	3.0
Livestock professionals	0	14.3	7.1	71.4	7.1
Market for selling yak products					
Yak herders	79.1	13.4	6	0	1.5
Livestock professionals	17.9	14.3	32.1	28.6	7.1
Labour availability to herd yaks					
Yak herders	49.3	22.4	17.9	9	1.5
Livestock professionals	3.6	28.6	25	39.3	3.6
Successor (youth) to yak farming					
Yak herders	22.9	17.9	26.9	28.4	4.5
Livestock professionals	10.7	14.3	21.4	39.3	14.3
Yak population in the community					
Yak herders	44.8	19.4	20.9	14.9	0
Livestock professionals	17.9	42.9	17.9	21.4	0
Number of yak farming families					
Yak herders	49.3	17.9	13.4	19.4	0
Livestock professionals	21.4	17.9	35.7	21.4	3.6
Training to improve yak management practices					
Yak herders	52.2	29.9	6	7.5	4.5
Livestock professionals	7.1	14.3	46.4	28.6	3.6

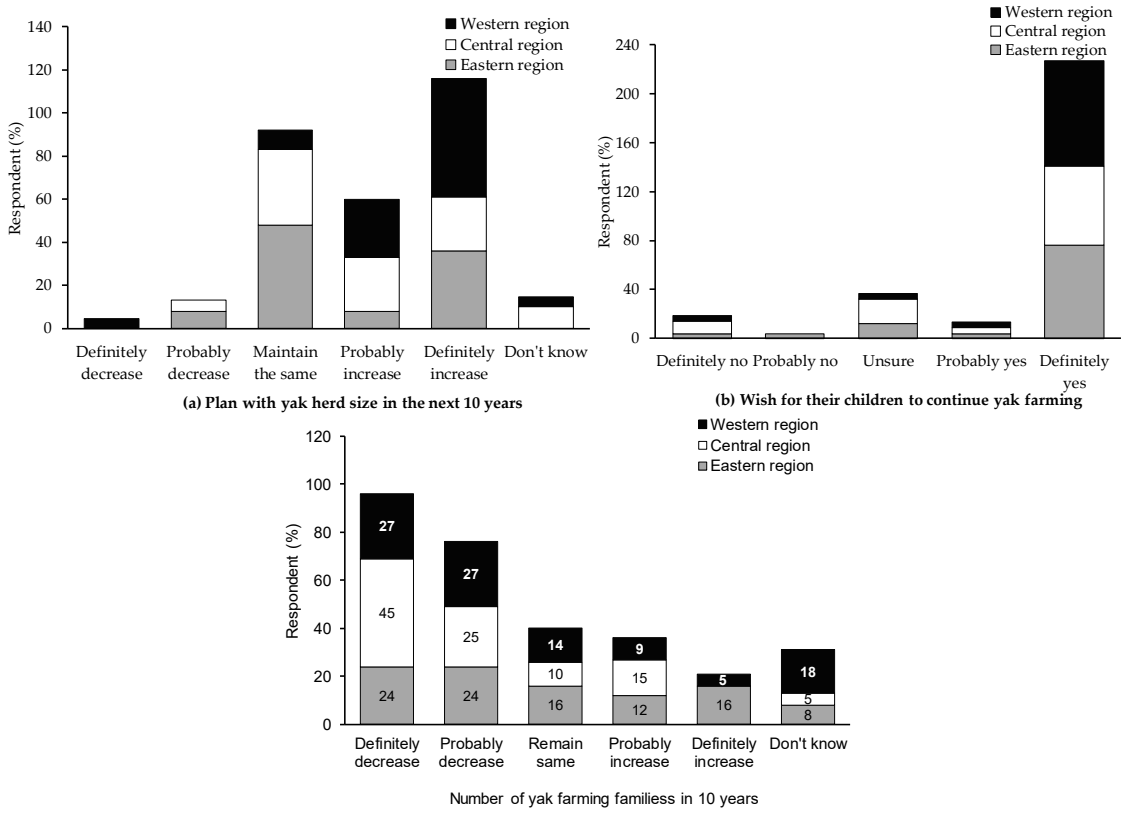

Figure A1. Herders' future plans and decisions on yak farming.

References

1. Allen, V.G.; Batello, C.; Berretta, E.J.; Hodgson, J.; Kothmann, M.; Li, X.; McIvor, J.; Milne, J.; Morris, C.; Peeters, A.; et al. An international terminology for grazing lands and grazing animals. *Grass Forage Sci.* **2011**, *66*, 2–28. [CrossRef]
2. Gyamtsho, P. Economy of yak herders. *J. Bhutan Stud.* **2000**, *2*, 1–45.
3. Suntikul, W.; Dorji, U. Tourism development: The challenges of achieving sustainable livelihoods in Bhutan's remote reaches. *Int. J. Tour. Res.* **2016**, *18*, 447–457. [CrossRef]
4. Joshi, S.; Shrestha, L.; Bisht, N.; Wu, N.; Ismail, M.; Dorji, T.; Dangol, G.; Long, R. Ethnic and cultural diversity amongst yak herding communities in the Asian highlands. *Sustainability* **2020**, *12*, 957. [CrossRef]
5. Wangchuk, K.; Wangdi, J. Mountain pastoralism in transition: Consequences of legalizing Cordyceps collection on yak farming practices in Bhutan. *Pastoralism* **2015**, *5*. [CrossRef]
6. Derville, M.; Bonnemaire, J. *Marginalisation of Yak Herders in Bhutan: Can Public Policy Generate New Stabilities that can Support the Transformation of Their Skills and Organisations? And Bonds to Territories: A Case Study in France and Brazil*; ISDA: Montpellier, France, 2010; p. 10.
7. Dorji, N.; Derks, M.; Dorji, P.; Groot Koerkamp, P.W.G.; Bokkers, E.A.M. Resilience of yak farming in Bhutan. In *70th Annual Meeting of the European Federation of Animal Science*; Book of abstracts, 25; Wageningen Academic Publishers: Wageningen, The Netherlands; Ghent, Belgium, 2019; p. 426.
8. Wangchuk, K.; Wangdi, J. Signs of climate warming through the eyes of yak herders in northern Bhutan. *Mt. Res. Dev.* **2018**, *38*, 45–52. [CrossRef]
9. Wangdi, J. The future of yak farming in Bhutan: Policy measures government should adopt. *Rangel. J.* **2016**, *38*, 367–371. [CrossRef]
10. Phuntsho, K.; Dorji, T. Yak herding in Bhutan: Policy and practice. In *Transboundary Challenges and Opportunities for Yak Raising in a Changing Hindu Kush Himalayan Region*; Wu, N., Yi, S., Joshi, S., Bisht, N., Eds.; International Centre for Integrated Mountain Development: Kathmandu, Nepal, 2016; pp. 147–163.

11. Corner-Thomas, R.A.; Kenyon, P.R.; Morris, S.T.; Ridler, A.L.; Hickson, R.E.; Greer, A.W.; Logan, C.M.; Blair, H.T. Influence of demographic factors on the use of farm management tools by New Zealand farmers. *N. Z. J. Agric. Res.* **2015**, *58*, 412–422. [CrossRef]
12. Myeni, L.; Moeletsi, M.; Thavhana, M.; Randela, M.; Mokoena, L. Barriers affecting sustainable agricultural productivity of smallholder farmers in the eastern free state of South Africa. *Sustainability* **2019**, *11*, 3003. [CrossRef]
13. Cornish, A.; Raubenheimer, D.; McGreevy, P. What we know about the public's level of concern for farm animal welfare in food production in developed countries. *Animals* **2016**, *6*, 74. [CrossRef]
14. DoL. *Livestock Statistics 2007*; Livestock, D.O., Ed.; Ministry of Agriculture and Forests: Thimphu, Bhutan, 2007; p. 131.
15. Gliem, J.A.; Gliem, R.R. Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. In *Midwest Research to Practice Conference in Adult, Continuing, and Community Education*; The Ohio State University: Columbus, OH, USA, 2003.
16. Adler, F.; Christley, R.; Campe, A. Invited review: Examining farmers' personalities and attitudes as possible risk factors for dairy cattle health, welfare, productivity, and farm management: A systematic scoping review. *J. Dairy Sci.* **2019**, *102*, 3805–3824. [CrossRef]
17. Willock, J.; Deary, I.J.; McGregor, M.M.; Sutherland, A.; Edwards-Jones, G.; Morgan, O.; Dent, B.; Grieve, R.; Gibson, G.; Austin, E.; et al. Farmers' attitudes, objectives, behaviors, and personality traits: The Edinburgh study of decision making on farms. *J. Vocat. Behav.* **1999**, *54*, 5–36. [CrossRef]
18. Daoud, J.I. Multicollinearity and regression analysis. *J. Phys. Conf. Ser.* **2017**, *949*, 012009. [CrossRef]
19. O'brien, R.M. A caution regarding rules of thumb for variance inflation factors. *Qual. Quant.* **2007**, *41*, 673–690. [CrossRef]
20. Jay, M. Goodness of Fit Tests for Logistic Regression Models. 2019, p. 10. Available online: https://cran.r-project.org/web/packages/generalhoslem/generalhoslem.pdf (accessed on 6 January 2020).
21. Tuszynski, J. Package 'caTools'; 2020. Available online: https://cran.r-project.org/web/packages/caTools/caTools.pdf (accessed on 31 January 2020).
22. Hu, B.; Shao, J.; Palta, M. Pseudo-R2 in logistic regression model. *Stat. Sin.* **2006**, *16*, 847–860.
23. Cureton, E.E. Rank-biserial correlation. *Psychometrika* **1956**, *21*, 287–290. [CrossRef]
24. Peng, C.-Y.J.; Lee, K.L.; Ingersoll, G.M. An introduction to logistic regression analysis and reporting. *J. Educ. Res.* **2002**, *96*, 3–14. [CrossRef]
25. Cassidy, L.D. Basic concepts of statistical analysis for surgical research. *J. Surg. Res.* **2005**, *128*, 199–206. [CrossRef]
26. Ryan, R.M.; Deci, E.L. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemp. Educ. Psychol.* **2000**, *25*, 54–67. [CrossRef]
27. Bukchin, S.; Kerret, D. Food for hope: The role of personal resources in farmers' adoption of green technology. *Sustainability* **2018**, *10*, 1615. [CrossRef]
28. Warren, C.R.; Burton, R.; Buchanan, O.; Birnie, R. Limited adoption of biomass energy crops: The role of farmers' socio-cultural identity in influencing practice. *J. Rural Stud.* **2016**, *45*, 175–183. [CrossRef]
29. Kollmuss, A.; Agyeman, J. Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* **2002**, *8*, 239–260. [CrossRef]
30. Edwards-Jones, G. Modelling farmer decision-making: Concepts, progress and challenges. *Anim. Sci.* **2006**, *82*, 783–790. [CrossRef]
31. Frost, J. How to Interpret Regression Models that Have Significant Variables but a Low R-Squared. Available online: https://statisticsbyjim.com/regression/interpret-coefficients-p-values-regression/ (accessed on 23 April 2020).
32. McFadden, D. Quantitative methods for analysing travel behaviour of individuals: Some Recent developments. In *Behavioural Travel Modelling*; Hensher, D.A., Stopher, P.R., Eds.; Croom Helm.: London, UK, 1979; pp. 279–318.
33. Tiwari, K.R.; Sitaula, B.K.; Bajracharya, R.M.; Raut, N.; Bhusal, P.; Sengel, M. Vulnerability of pastoralism: A case study from the high mountains of Nepal. *Sustainability* **2020**, *12*, 2737. [CrossRef]
34. Lorway, R.; Dorji, G.; Bradley, J.; Ramesh, B.M.; Isaac, S.; Blanchard, J. The drayang girls of Thimphu: Sexual network formation, transactional sex and emerging modernities in Bhutan. *Cult. Health Sex.* **2011**, *13* (Suppl. 2), S293–S308. [CrossRef] [PubMed]

35. Walcott, S. Urbanization in Bhutan. *Geogr. Rev.* **2009**, *99*, 81–93. [CrossRef]
36. Aryal, S.; Maraseni, T.N.; Cockfield, G.J. Sustainability of transhumance grazing systems under socio-economic threats in Langtang, Nepal. *J. Mt. Sci.* **2014**, *11*, 1023–1034. [CrossRef]
37. Oteros-Rozas, E.; Ontillera-Sánchez, R.; Sanosa, P.; Gómez-Baggethun, E.; Reyes-García, V.; González, J.A. Traditional ecological knowledge among transhumant pastoralists in Mediterranean Spain. *Ecol. Soc.* **2013**, *18*. [CrossRef]
38. Jurt, C.; Häberli, I.; Rossier, R. Transhumance farming in Swiss mountains: Adaptation to a changing environment. *Mt. Res. Dev.* **2015**, *35*, 57–65. [CrossRef]
39. Oteros-Rozas, E.; Martín-López, B.; López, C.A.; Palomo, I.; González, J.A. Envisioning the future of transhumant pastoralism through participatory scenario planning: A case study in Spain. *Rangel. J.* **2013**, *35*, 251–272. [CrossRef]
40. Bhasin, V. Pastoralists of Himalayas. *J. Hum. Ecol.* **2011**, *33*, 147–177. [CrossRef]
41. Bernués, A.; Ruiz, R.; Olaizola, A.; Villalba, D.; Casasús, I. Sustainability of pasture-based livestock farming systems in the European Mediterranean context: Synergies and trade-offs. *Livest. Sci.* **2011**, *139*, 44–57. [CrossRef]
42. Winkler, D. Steps towards Sustainable Harvest of Yartsa Gunbu (Caterpillar Fungus, Ophiocordyceps sinensis). In Proceedings of the 7th International Medicinal Mushroom Conference, Beijing, China, 25–29 August 2013; pp. 635–644.
43. Hopping, K.A.; Chignell, S.M.; Lambin, E.F. The demise of caterpillar fungus in the Himalayan region due to climate change and overharvesting. *Proc. Natl. Acad. Sci. USA* **2018**, *115*, 11489–11494. [CrossRef] [PubMed]
44. Nawaz, M.A.; Din, J.U.; Buzdar, H. Chapter 14–Livestock husbandry and snow leopard conservation. Subchapter–The ecosystem health program: A tool to promote the coexistence of livestock owners and snow leopards. In *Snow Leopards*; McCarthy, T., Mallon, D., Eds.; Academic Press: New York, NY, USA, 2016; pp. 179–195.
45. Mulder, M.B.; Fazzio, I.; Irons, W.G.; Bowles, S.; Bell, A.V.; Hertz, T.; Hazzah, L. Revisiting an old question: Pastoralism and wealth inequality. *Curr. Anthropol.* **2010**, *51*, 35–48. [CrossRef]
46. Sherchan, R.; Bhandari, A. Status and trends of human-wildlife conflict: A case study of Lelep and Yamphudin region, Kanchenjunga Conservation Area, Taplejung, Nepal. *Conserv. Sci.* **2017**, *5*, 19–25. [CrossRef]
47. Næss, M.W.; Bårdsen, B.-J. Environmental stochasticity and long-term livestock viability—herd-accumulation as a risk reducing strategy. *Hum. Ecol.* **2010**, *38*, 3–17. [CrossRef]
48. McPeak, J. Individual and collective rationality in pastoral production: Evidence from Northern Kenya. *Hum. Ecol.* **2005**, *33*, 171–197. [CrossRef]
49. Ondersteijn, C.J.M.; Giesen, G.W.J.; Huirne, R.B.M. Identification of farmer characteristics and farm strategies explaining changes in environmental management and environmental and economic performance of dairy farms. *Agric. Syst.* **2003**, *78*, 31–55. [CrossRef]
50. Gargiulo, J.I.; Eastwood, C.R.; Garcia, S.C.; Lyons, N.A. Dairy farmers with larger herd sizes adopt more precision dairy technologies. *J. Dairy Sci.* **2018**, *101*, 5466–5473. [CrossRef]
51. Gray, C.L. Rural out-migration and smallholder agriculture in the southern Ecuadorian Andes. *Popul. Environ.* **2009**, *30*, 193–217. [CrossRef]