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REVIEW ARTICLE

SMALL RUMINANTS BREEDING IN MOUNTAIN REGIONS OF NEPAL: CHALLENGES AND OPPORTUNITIES

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ABSTRACT

Small ruminants (sheep and goat) are essential components of the mixed farming system of Nepal. About 13.6 million small ruminants in the country contributing to the food, nutrition, and economic security has been integral part of the mountain ecosystem and rural economy. Despite of their large population, country is facing great trade deficit in products like meat, milk, wool and fibres. Low production is associated with impoverished productive potential of indigenous breed that are reared under abysmally managed subsistence farming. This study has tried to review the existing breeds, breeding system and opportunities within the challenges to enhance production and productivity of small ruminants. The findings revealed that genetic improvement through selection and crossbreeding with enhance feeding and management practices can be powerful tool in increasing production efficiency of the animal. Crossbred of native breed of sheep Baruwal with exotic breed Polworth and Merino and native breed of goat Khari with exotic breed Boer and Jamunapari gave better performance of many production and reproductive traits. The increased productivity of small ruminants will not only be a boon for small holders but will also greatly contribute to the national economy.

KEYWORDS

artificial insemination, breeding, crosses, indigenous, exotic.

1. INTRODUCTION

Agriculture is one of the most indispensable sources of livelihood and income for most Nepalese people. About 60.4% of the Nepalese population are engaged in agriculture that contributes 27.64% to the national gross domestic product (GDP) (MoALD, 2021). Livestock farming is one of the principal agricultural sub-sector in Nepal that contributes about 11.5% to the GDP and 32% to the Ag GDP (CBS, 2018). Small ruminants (goats and sheep) are the indispensable components of livestock farming in Nepal with the population of 13.6 million accounting 51.7% of total ruminant population (MoALD, 2021). Small ruminants are reared as the source of food, nutrition, and economy that provides both tangible benefits like cash from sale, meat, manure, wool and intangible benefits like insurance against emergencies, cultural and ceremonial purposes (Rege, 1996; Jaitner et al., 2001). The population of sheep is nearly static whereas the population of goat has increased by 3.74% per annum in the past decade. However, the present population of goat and sheep do not meet country's demand of meat and wool. Nepal produced 2714 Mt. mutton, 67706 Mt. chevon and 594312 Kg of wool and in the same year imported 494755 Kg of meat and 14780815 kg of wool and animal fibre (DLS, 2020). This shows huge gap in the country's small ruminant production and the national demand.

The Mountain region has been the hubs of small ruminants as they have inherent ability to utilize mountain terrain that otherwise are unsuitable for crop production (Ghimire, 1992). With the share of only 35% of the total geographical area, 43.68% of total sheep populations and 11.57% of total goat populations are found only in the mountain region (DLS, 2020). They are reared under either a sedentary or migratory system. Small ruminant have lower feed and capital requirements has ability to utilize a wide range of feedstuff and marginal land, making it suitable source of livelihood for small holder and rural people of the mountainous region (Neupane et al., 2018).

There are four major indigenous breeds of goats in Nepal namely Chyangra, Sinhal, Khari and the Terai goat. Chyangra, Sinhal and Khari are mostly concentrated in the mountain and high hill ecosystems. Boer, Jamunapari, Saanen, Barbari and Beetal are the popular exotic breeds of goat. Similarly, there are four major indigenous breeds of sheep namely Bhyanglung, Bharuwal, Kage and Lampuchhre. Out of this Bhyanglung and Bharuwal are mostly found in mountain and High hill regions of Nepal. Merino, Rambouillet, Polworth, Scottish blackface and Border Leicester are the most common exotic breeds of sheep in Nepal (Ghimire, 1992). Indigenous breeds have genetic ability to adapt to the extreme high altitude in Himalayan region (Gorkhali et al., 2016) but their production and productivity potential is low as compared to exotic breed. Overall performances can be enhanced by improved husbandry practices, better plane of nutrition, preventive health care and breeding programmes using genetically superior animals (Ghimire, 1992; Singh & Acharya, 1981). Of these, genetic improvement is the powerful tool of increasing efficiency of animal production (Solkner et al., 1998).

Selection within the breed utilizing indigenous breeds offers sustainable improvement in production (Kosgey, 2004). However, within-breed selections are limited by low heritability of the reproductive traits usually ranging from 0.05 to 0.15 and slow gaining process (Notter, 2012). Crossbreeding with exotic breeds with higher genetic potential is expected to increase productivity within a shorter period (Ghimire, 1992).

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However, Kosgey (2004) reported that crossbreeding in most of the cases has been unsuccessful in low-input traditional production system. When exotic breeds are used, it is important to consider the effect and magnitude of genetic and environmental interactions (Baker et al., 2004; Holst, 1999).

Small holder farmers in mountainous region due to their economic pressure are practicing indiscriminate breeding for short term benefits. Unsystemic and indiscriminate breeding are responsible for loss of valuable indigenous germplasm (Kiwuwa, 1992). In Nepal, organized breeding is restricted in some research stations only. Small holders in mountainous regions are less access to exotic breeds, extension services and technologies like Artificial insemination and Embryo transfer. So, breeding programmes should be planned and operated integrating traditional knowledge and practices. The general objective of this study is to assess the status of small ruminants breeding in mountainous region of Nepal along with their challenges and opportunities.

2. Materials and Methodology

The study is based on the information gathered from various sources including scientific publications and journals, annual progress reports of various national institutions, bulletins and statistical reports, books and research findings, etc. The chapter covers the general introduction, materials and methodology, breeds of small ruminants, reproduction and mating system of small ruminants, strategies for genetic improvement, breeding system and their challenges and opportunities in the mountain region of Nepal. Quantitative information in this chapter was taken from various authentic journals and reports including from the agriculture and livestock development ministry, finance ministry, central bureau of statistics, Department of livestock services, annual reports of the goat research centres, research institutions and universities, Nepal Agriculture Research council, etc.

3. Breeds of Small Ruminants

3.1 Indigenous breeds of goat

3.1.1 Chyangra

Chyangra goat is originated in Tibet and is mostly found in mountain and higher hills. They are medium-sized goats weighing around 25 to 40 kg. Mostly they are black in color and brown and gray are not uncommon. Horns are long, curved, twisted backward and upward and thick. They are famous for meat as well as Mohair (Pashmina).

3.1.2 Khari

This breed of goats is found in the Mahabharat, the mid-hill range of Nepal. They are small with low height, weighing about 25 kg for adult females and 35 kg for adult males. The head is small and ears are erect. The color is white, black and gray but red are not uncommon. They generally produce twins twice a year or three times in two years (ILRI, n.d.).

3.1.3 Sinhal

This breed is found in the mountain and high hills of Nepal. The male and female goats are on average weighing about 45-50 kg and 30-40 kg respectively. They are generally black with white and brown patches.

3.1.4 Terai goat

This breed is found in the southernmost plains (Terai). Coat colors vary from black, white, brown mixed with red, black with white marking, ash color and black and white on-ear. The average adult body weight of male. Terai goat is 30 – 35 kg and that of the female is 18 – 32 kg. (MoALD, 2021)

3.2 Exotic breeds of goat

3.2.1 Barbari

The barbari breed is a dairy-type goat that is said to have originated in the city of Berberi in British Somaland in East Africa. The goats have short legs, short hair, a straight facial line and prick ears. The goats are preferably white with fawn or tan spots but sometimes black spots are found. Average weight of the male is 40 to 50 kg and that of the female is 30 to 40 kg.

3.2.2 Jamunapari

These are dual-purpose goats, combining milk and meat qualities. They are generally white or yellowish fan with light brown spots on the neck and face. They have long folded pendulous ears and a prominent Roman nose. The average weight of a full-grown buck varies between 60 to 90 kg and the female weighs 50 to 60 kg.

3.2.3 Beetal

The beetles have no standard color or markings but generally, they are black, tan white, brown, often heavily spotted on white. The males have beards, but not the females. The average male goat weighs about 50 to 75 kg and the female 40 to 50 kg.

3.2.4 Boer

The Boer goat was probably bred from the indigenous South African goats. The body is white while the head and sometimes the neck are red. They possess long and pendulous ears. The Boer goat has a fast growth rate and excellent carcass qualities, making it one of the most popular breeds of meat goats in the world. The mature buck weighs between 110-135 kg and does between 90-100 kg. (Bhattarai et al., 2019)

3.3 Indigenous breeds of sheep

3.3.1 Bhyanglung

This breed was originated in Tibet and available at an altitude of 2500 to 4000 meters in the northern part of Nepal. This breed is strong and stout with short legs weighing about 60-90 kg and is maintained in a transhumance system according to the season. Wool of this breed seems fine and soft in caparison to other Nepalese breeds.

3.3.2 Baruwal

They are found in the mountain and high hills of Nepal. The animals weigh 25-30 kg on average. Completely black color is also found while complete white is rare. The ears are very small (rudimentary) to medium in size but the nose is very prominent (Roman nose). Transhumance system of Baruwal sheep farming is more common in the Mountain region (Bhatt et al., 2018).

3.3.3 Kage

This is considered to be the purest Nepalese breed and is generally found in mid hill. The body weight is only 16-24 kg on average. They are usually white but black and white or black or white with red patches are also prevalent. They have erect ears.

3.3.4 Lampuchhre

This breed is reared in the Terai region only because of its extreme heat tolerance capacity. The body characteristics are similar to Kage but their length of the tail ranges from 10-13 inches. Wool of very inferior quality and the production is 0.4 kg/shearing. (MoALD, 2021)

3.4 Exotic breeds of sheep

3.4.1 Merino

A merino breed of sheep is originated in Spain. It is known as golden-footed sheep and the most popular fine wool breed in the world. The merino is a white-faced sheep. The rams possess horns, and whereas, ewes are polled. Merino rams weigh about 90 kg and ewes weigh about 70 kg at the time of maturity.

3.4.2 Rambouillet

The breed Rambouillet originally came from Spain. It is the largest fine wool breed. They have a large head with white hair around the nose and ears. The rams may have horns or polled but ewes are polled. The breed is large, with mature rams averaging about 110 kg and ewes weighing up to 90 kg.

3.4.3 Polworth

The Polworth breed originated at Victoria, Australia. They are predominately poled and reared for both meat and wool purpose. They have a fairly level frame, clear eyes soft face, pink nose but sometimes mottled, and are free from skin folds. Adult ram weighs 66-80 Kg and adult ewe 50-60 Kg on an average. They produce mutton of a most desirable quality.

3.4.4 Border Leicester

Border Leicester is British breed of sheep. It is poled, docile and dual purpose breed that is reared ofr meat and wool. The adult body weight of

ram ranges from 140-175 Kg and ewe 90-120 Kg. They are white with black roman nose and dark feet.

4. Reproduction and Mating Practices of Small Ruminants in The Mountain Region

Most of the farmers in the mountain region practice the subsistence farming system of small ruminants (Rijal & Paudel, 2011). The rearing of small ruminants entirely depends on their indigenous knowledge and years of experience.

4.1 Some reproductive parameters

- Small ruminants exhibit a seasonal cycle of reproduction, in which succession of estrous cycle usually begins in summer or early autumn (Abecia et al., 2012).
- Does are bred when they are 18-24 months and ewes are bred when they are 14-18 months depending on their physical conditions.
- The estrous period is repeated every 16-17 days on average for does and every 15-16 days in ewes.
- The estrous periods last for about 29(24-48) hours in ewes and 40(16-40) hours in does
- The gestation period is about 148 days for ewes and 150 days for does (MoALD, 2021). Pregnant is ensured when ewes/does do not return to estrous after mating.

4.2 Estrous sign is detected by

- Redding and swollen vulva
- Mucus discharge from vulva
- Tail wagging
- Frequent bleating
- Standing reflex (Standing for mating)

4.3 Mating methods

4.3.1 Hand mating

Females are allowed to mate one by one with males. Ram/Buck is not allowed to mate more than three ewes/does in a day.

4.3.2 Pen mating

In this mating system ewes/does are divided into batches of 20-25 and males are turned to flock only during the night

4.3.3 Flock mating/ pasture mating

In this system, males are allowed to run along with the females throughout day and night. It is more common in the migratory system of farming in the mountain region.

4.3.4 Artificial insemination

Artificial insemination (AI) is the oldest and most widely used assisted reproductive technology (Faigl et al., 2011). However, this method is less popular in mountain regions as people are less access to it and as it has a lower reproductive rate (40%). It is the best means of distributing germplasm from the nucleus breeding flock to many small flocks. It has ability to maximize superior sires for genetic improvements (Omontese, 2018).

5. Strategies for Genetic Improvement of Mountainous Small Ruminants

Conventionally two main pathways are considered for genetic improvement.

Selection (within the breed or between the breed) ii. Cross-breeding. Selection is popular among many farmers. People usually select superior individuals based on phenotypic traits (visual selection) with economically important traits (meat, wool, milk, pashmina, etc). Mountainous goats (Chyangra) are being selected for pashmina however there is a great possibility of developing Chyangra as dual-purpose (meat and pashmina). People usually consider the traits like adult weight, regular kidding and twinning, resistance to disease and parasites, kids/lamb survivability, carcass yield and quality, quantity and quality (fineness, length, color, free from kemp) of wool, etc as selection parameters. Pokharel & Neopane (1999) reported that body weight at marketed age can be increased substantially by strategic selection. However, selection within-breed is rather a slow gaining process and indigenous animal has low production and productivity potential. So, introduction and use of exotic breeds with higher genetic merit could be the logical alternative to increase productivity within shorter period (Ghimire, 1992).

6. Breeding System

6.1 Pure breeding

This system of breeding is commonly practiced in the mountain region of Nepal. Superior individuals within the breed are bred to maintain the genetic purity of the breed. However, it may lead to inbreeding depression. To increase the productivity of Sinhal and Chyangra, the intensive selection and buck exchange program should be implemented to reduce the inbreeding depression problems (Poudel & Paudel, 2018).

6.2 Cross-breeding

Crossbreeding is the crosses involving different breeds to exploit hybrid vigor/ heterosis (Nugroho et al., 2019). Genetic improvement thorough efficient and systemic crossbreeding can boost output and profitability within short time. Success of crossbreeding depends highly on the genetic compatibility of the breeds. In Nepal, several introduced exotic breeds of small ruminants are used in crossbreeding programmes and crossbreeding within native breeds is also not uncommon.

Crossbreds of Sheep

Exotic breeds like Polworth, Meriono are extensively used in crossbreeding of native breeds. Besides breeds like Rambouillet, Scottish blackface, Border Leicester, Romney Marsh, Dorset and Dormer are also introduced and occasionally used in crossbreeding programmes (Kharel & Pradhan, 1986). The Polworth and Merino breed of sheep has been principally crossed with Baruwal breed of Nepal. The performance of different crossbreds at Pansayakhola Sheep farm (PSF) and Karnali Sheep Research Farm (KSRF) is presented in Table 1 and 2 respectively.

Table 1: Performance of exotic breeds Merino (M) and Polworth (P) and native breed Baruwal (B) and their crosses at Pansayakhola sheep farm, Nuwakot

Traits	Pure breed			Cross breed	
	B	M	P	M × B	P × B
Birth weight (kg)	3 ± 0.09	3.3 ± 0.17	3.1 ± 0.18	3.23 ± 0.16	3.1 ± 0.78
Age at frst lambing (days)	757 ± 22	617 ± 117	568 ± 64	770 ± 85	701 ± 44
Lambing interval	373 ± 4	331 ± 27	365 ± 15	384 ± 25	374 ± 8
Lambing percentage	83.5	95	90	93	84
Multiple birth rate (%)	2	5	-	-	-
Lambs weaned/year	0.6	0.68	0.7	0.81	0.71
Weaning weight at 120 days (kg)	160 ± 0.7	16.6 ± 0.89	12.33 ± 1.0	15.72 ± 0.95	13.62 ± 0.41
Growth rate upto 120 days (g/d)	100 ± 3.7	94.35 ± 6.34	80.7 ± 6.9	100 ± 5.8	87.6 ± 5.06
Yearling weight (Kg)	28.3 ± 0.81	27.3 ± 1.8	20.0 ± 2.15	27.54 ± 0.5	23.0 ± 08
Adult weight at 2 years (kg)	40.9	45.2	37	36.9	38.6
Lamb mortality (%)	5	24	25	5	9
Average wool production (kg)	0.85 ± 0.01	2.36 ± 0.09	2.21 ± 0.12	1.44 ± 0.12	1.54 ± 0.06
Staple length (cm)	8.0	7.8 ± 0.15	9.9 ± 0.25	12.0 ± 0.36	11.4 ± 0.2

Source: (Upreti, 1991)

The study shows the growth rate of crossbred (87 - 100 gram per day) was higher than pure exotic breed (80.7 - 94.35 g/d). Wool production of crossbred (1.54 kg) was nearly double than that of native breed (0.85 kg). The crossbred has better weaning ability (0.8 for M × B and 0.71 for P × B) than pure exotic breed (0.68 for M and 0.7 for P) and native Baruwal breed (0.6). The report indicates crossbred of Baruwal with both Merino and Polworth performs better in many traits compared to local Baruwal and crossbred has better survivability than exotic breed.

Table 2: Performance of different blood levels crosses of Baruwal (B) with Polworth (P) and Merino (M) at Karnali Sheep Research Farm

Crosses	Annual wool yield (kg)	Lambing %	Litter size	Birth wt. (kg)	Wt. at one yr (kg)	Adult wt. (kg)
B × P (25% P)	1.23	67.8	NA	NA	NA	31.6
B × P (50% P)	1.54	67.6	0.85	2.64	18.5	32.2
B × P (62.5% P)	1.13	NA	1.0	2.51	NA	29.0
B × P (75% P)	1.66	NA	0.87	2.7	22.2	44.4
B × M (50% M)	0.81	NA	0.66	2.33	25.0	31.5

NA: Not Available
Source: (KSRF, 1990)

The results of this crossbreeding work have indicated that wool production can be almost doubled even though body size is hardly affected. The increase in wool production was significant, even at a level of only 12.5% exotic blood. Crossbred of Baruwal with 50% blood level of merino had highest weight at one year of age whereas adult body weight was higher for crossbred with higher blood level of Polworth. However, the reproductive efficiency, especially lambing percentage and lambing interval, was adversely affected by increasing the Polworth blood level.

Rasali (1995) reported that Crossbred of Border Leicester (25%) and Baruwal (75%) had significantly higher lamb weight at birth (2.87±0.09 kg), growth rate (49.2±006 g/d), fleece, and weight at one year of age (550.3±25.4 g) than pure Baruwal (2.44±0.09 kg, 47.6±0.6 g/d, 459.4±23.3 g respectively).

Crossbreds of goats

Traditionally, indiscriminate breeding of native goats have been practiced by small holder farmers. Khanal et al. (2002) reported that crossbred of indigenous breed Khari and Sinhal could not show comparative advantage over the pure breeds. The birth weight of Khari × Sinhal crossbred was found to be 2.14 kg, and that of pure Khari breed was 2.03 kg. Similarly, twining percentage was higher for pure khari breed (27.07) than that of Khari × Sinhal crossbred (19.05). Pure Khari breed received first service at 229.2 days whereas Khari × Sinhal crossbred received first service at 367.6 days.

Exotic breeds like Jamunapari, Barberi, Kiko, and Boer are highly used in crossbreeding of native goats. Table 3 presents performance of different genotypes of goat.

Table 3: Performance of different genotypes of goat at Bandipur goat research station,Tanahu

Traits	Khari	Sinhal	Barberi	Jamunapari × Khari	Barberi × Khari	Kiko × Khari
Age at first kidding (days)	533.4±20.1	686.1±58.1	553.1±48.1	749.9±22.9	537.1±42.7	582.8± 48.1
Kidding interval (days)	298.9±3	347.1±8.3	330.8±9.9	346.7±8.2	311.5±12.6	347.2±12.3
No of kidding/yr	1.22	0.98	1.1	1.05	1.17	1.05
Kidding%	148.4	110.9	159.8	148.3	156.4	138.0
Weaning%	113.9	97.0	117.1	107.9	91.9	102.1
Weight gain/yr (kg)	21.76	17.42	20.39	19.14	16.15	18.37
Survivability%	91.7±1.0	92.2±1.1	89.9±1.6	92.1±1.5	93.6±0.8	95 ±1.1

Source: (Tamrakar & Shah, 2009)

The study revealed that the age at first kidding and kidding interval was lowest for Khari (533.4 and 298.9 days, respectively) followed by Barberi × Khari crossbred (537.1 and 311.5 days, respectively). No of kidding per year was higher for native breed Khari (1.22) followed by Barberi × Khari crossbred (1.17). The Kiko × Khari crossbred had higher survivability followed by Barberi × Khari crossbred. The overall performance of crossbred were good however, native breed Khari show better performance for most of the traits at Bandipur goat research station.

With the introduction of Boer goat it has been extensively used to cross indigenous breed in different research stations as well as Farmers level. Crossbreeding Khari with Boer would give better results with respect to growth rate and maintain twining ability (Bhattarai et al., 2019). The growth rate of 25% Boer goat cross with Khari goat depicted that with 1 unit increase in a month there is 2.73 unit increment in the Boer meat production (Sapkota et al., 2016). The growth performance of Khari and its crossbred with different blood levels of Boer and Jamunapari is shown in table 4.

Table 4: Growth performance of indigenous and crossbred goats at Bandipur goat research station, Tanahu.

Fixed factors	Numbers	Birth (BWT)	Pre-weaning (PWW)	Weaning (WWT)	6 months (SMW)
25%Boer: 75%Khari: 0% JP	232	2.38 ± 0.04^{b}	7.03 ± 0.14^{ab}	11.72 ± 0.26^{ab}	20.70 ± 0.15^{b}
25%Boer: 50%Khari: 25% JP	10	2.21 ± 0.09^{c}	6.37 ± 0.30^{b}	10.53 ± 0.55^{c}	20.63 ± 0.90^{b}
50%Boer: 50%Khari: 0% JP	218	2.69 ± 0.04^{ab}	7.68 ± 0.14^{a}	13.45 ± 0.26^{a}	23.40 ± 0.19^{a}
50%Boer: 25%Khari: 25% JP	16	2.86 ± 0.10^{a}	7.55 ± 0.33^{a}	13.62 ± 0.60^{a}	23.91 ± 0.58^{a}
0%Boer: 100%Khari: 0% JP	296	2.26 ± 0.04^{b}	6.58 ± 0.15^{b}	11.11 ± 0.27^{bc}	18.05 ± 0.11^{c}
Grand mean	772	2.48 ± 0.03	7.04 ± 0.12	12.09 ± 0.22	20.52 ± 0.16
Significance		***	***	***	***
CV		9.73	10.30	11.12	9.34
R^2		0.61	0.53	0.54	0.58

Source: (BGRS, 2011)

The research shows a significant difference ($p<0.001$) between crossbred kids of different blood levels concerning birth, pre-weaning, weaning, and 6 months weight. As reported the crossbred kids of a three-way cross with 50% Boer:25%Khari:25%Jamunapari blood level has the best result of weight traits at different stages than other blood levels.

However, cross breeding of mountainous goats like Chyangra and Sinhal is not gainful so far. Crosses of Indigenous breed Sinhal and Khari showed higher growth rate up to 6 months of age but the growth rate was slower after that, it may be due to Sinhal are raised under the migratory system in mountain and its crossbred may be unable to perform well in on-station Lumle Agriculture Research Centre (Khanal et al., 2005).

7. Opportunities and Challenges of Small Ruminants Breeding in the Mountain Region

As goat and sheep meat is accepted by all ethnic groups and these animals are also important for religious purposes, the demand for sheep and goat meat is large. The existing population of small ruminants can fulfill only about 22% of the total sheep and goat meat required by the country (CBS, 2018). So, large numbers of live animals have to be imported from India and Tibet. Indigenous breeds though have high adaptability are poor at production. So there is a huge opportunity for genetic improvement through cross-breeding with the exotic breed to meet country's demand. Improvements can be made on several economic traits including

production, reproduction, health and fitness and stress tolerant. There is opportunity of developing research institutions, agro-vets, breeding farms, marketing stakeholders, cooperatives, etc. Small holders with economic pressure are ready to adopt improved breeds for higher profitability. Small ruminant farming is easy and can be handled by women and children in absence of young male members (Neupane et al., 2018). Mountain region is only the region with surplus feed and it is geographically highly suited for small ruminant farming (Rajbhandary & Pradhan, 1991). Sustainable breeding programs can make significant contribution on food security and socio-economic upliftment by rural poverty alleviation.

However, it has some challenges too. Small holder farmers with their economic pressure are practicing indiscriminate breeding. So, there is increased risk of erosion of valuable indigenous germplasm. The mountain region is less access to exotic breeds, extension services, technologies like Artificial insemination and Embryo Transfer, transportation and other infrastructures. The research institutions are few and only concentrated on hills and terai. Besides, few researches on cross-breeding in mountainous goats are also not found to be gainful (Bhattarai et al., 2019). More research on breeding programs should be planned and operated involving small holder farmers so as to narrow gap between demand-supply of small ruminants' products in the country.

8. Conclusions

Small ruminant farming has high economic importance and is livelihood of many rural farmers. The existing population of small ruminants is unable to meet the country's demand. There is the opportunity of improving productivity through selection and cross-breeding with exotic breeds. Breeding plans of sheep should not only be focused on its meat purpose but also aim to meet the wool quality laid by carpet factories. At the same time, not only the production, survivability and performance of crossbred under local ecosystem must be ensured. Along with breeding management feeding, health and marketing management of small ruminants is very crucial for enhancing production. Crossbred of native goat with exotic breed like Boer and native sheep with exotic breeds like Merino and Polworth are giving better performances. However further study and research is needed for valid conclusion.

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