Glance 2014

GLobal Animal Nutrition ConferencE

Climate Resilient Livestock Feeding Systems for Global Food Security

Invited Papers

Editors

A K Samanta • R Bhatta • V Sejian • A P Kolte
P K Malik • S K Sirohi • C S Prasad

Global Animal Nutrition Conference 2014

NIANP

भाकृअनुप ICAR

CLFMA OF INDIA

Global Animal Nutrition Conference 2014

Climate Resilient Livestock Feeding Systems for Global Food Security

20-22nd April 2014

Invited Papers

Editors

A K Samanta • R Bhatta • V Sejian • A P Kolte
P K Malik • S K Sirohi • C S Prasad

Organized by

Animal Nutrition Society of India

in collaboration with

National Institute of Animal Nutrition and Physiology | Indian Council of Agricultural Research
Compound Livestock Feed Manufacturers Association of India | VIV India

Recommended citation

Samanta, A. K., Bhatta, R., Sejian, V., Kolte, A. P., Malik, P. K., Sirohi, S. K. and Prasad, C. S (2014). Invited Lectures: Climate Resilient Livestock Feeding Systems for Global Food Security. Global Animal Nutrition Conference, April 20-22, 2014, Bangalore, India, 286pp

Editors

A. K. Samanta
R. Bhatta
V. Sejian
A. P. Kolte
P. K. Malik
S. K. Sirohi
C. S. Prasad

Cover Photographs

Sample seal demonstrating significance of animals during Indus Valley Civilization

Feed, Nutrition, Animal Health and Changing Climate in the Mid-Hills Region of Nepal

D.D. Poudel[1], H. A. DeRamus[2], R.P. Thakur[3], A. Singh[4]
[1]Environmental Science Program, School of Geosciences, University of Louisiana at Lafayette, Louisiana, USA
[2] Department of Biology, University of Louisiana at Lafayette, Louisiana, USA
[3]Animal Health Division, Nepal Agriculture Research Council, Khumaltar, Lalitpur, Nepal
[4]CARE-Nepal, Lalitpur, Nepal

Key words: Animal feed; health; smallholder; mixed-farming

Email: ddpoudel@louisiana.edu

The South Asian region, which includes Bangladesh, Bhutan, Nepal, India, Pakistan, Afghanistan, Sri-Lanka and Maldives, is home to over one and one-half billion people. With a high annual population growth rate of approximately 1.8%, the human population in this region is expected to reach over 2 billion within the next 30 years. In recent years, the South Asian region has been experiencing rising temperatures, increased rainfall variability, declines in crop yields, ecosystem changes, glacial retreat, increased variability in water resources, and increased flood events (IPCC, 2007). The Climate Change Vulnerability Index (CCVI) developed by the Maplecroft group ranks Bangladesh, India, Nepal, Pakistan and Afghanistan in the highest risk category because of high levels of poverty, high population density, a high degree of exposure to climate change related events, and the non-resiliency of regional agricultural production systems (Maplecroft, 2010).

The UNEP, SAARC and DA (2009) predict a likely retreat of nearly 15,000 glaciers in the South Asian region from their 500,000 sq. km. area at present to 100,000 sq. km. by 2035. This level of glacial retreat will cause an unprecedented level of hydrological change which will severely impact water supplies, agricultural production, wildlife habitat, and livestock production, affecting millions of people in the region. The occurrence of severe floods due to the melting of glaciers, as well as other climate change impacts including sea level rise, salt-water intrusion, biodiversity loss, adverse human health impacts (due to increase incidence of diarrhea and other diseases), as well as deterioration of infrastructure are predicted (IPCC, 2007).

Livestock production systems in the South Asian region support the livelihoods of more than 200 million people (Ibrahim, 2007) and contribute heavily to the national and agricultural GDPs. The livestock sector contributes 18% to the national GDP and 31.5% to agricultural GDP in Nepal. In Bangladesh, its contribution to agricultural GDP is 9% without the value of traction and manure and 14% with the value of traction and manure (Ibrahim, 2007), and its share is increasing (Tareque and Chowdhury, 2010). The livestock sector contributes 25% to the agricultural GDP in India, 10% to national GDP in Bhutan, and 11.4% to national GDP in Pakistan (Ibrahim, 2007; Agri Hunt, 2012). Because human populations are increasing, there is a rising demand for livestock products in the region.

The livestock production systems in the South Asian region can be divided into two main systems: the mixed-farming livestock production system and the solely livestock production system (Thornton et al., 2002; Teufel et al., 2010). The mixed-farming livestock production system is further divided into two categories: irrigated and non-irrigated (rainfed) production systems. Thus, considering the climatic zones in the region, there are nine livestock production systems in South Asia, which are: 1) mixed irrigated arid/semi-arid, 2) mixed irrigated humid/sub-humid, 3) mixed irrigated tropical highland, 4) mixed rainfed arid/semi-arid, 5) mixed rainfed humid/sub-humid, 6) mixed rainfed tropical highland, 7) livestock only grassland-based arid/semi-arid, 8) livestock only grassland-based humid/sub-humid, and 9) livestock only grassland-based tropical highland livestock production systems (Thornton et al., 2002; Teufel et al., 2010). The mixed-farming livestock production system is the dominant agricultural production system in the South Asian region. Meanwhile, there is a growing concern about the sustainability of this production system due to climate change impacts, population growth and land-use changes.

Livestock production is an integral part of the smallholder mixed-farming system in Nepal. In 2009-2010, the estimated increase in the number of livestock was 0.34% cattle, 3.25% buffalo, 3.4% goat and 1.72% pig (MoF, 2010). Thus, the trend for increasing the herd and flock sizes instead of enhancing livestock productivity to meet the rising demands of increased population (Goletti et al., 2001) appears to be continuing. The livestock sector depends on the forest for an estimated 42% of the total fodder requirement. As forests are an integral part of the farming system in Nepal (Acharya and Dangi, 2009), deforestation and forest degradation has created many problems including shortages of fodder, grass, livestock bedding and compost for farming, as well as increased landslides, floods, and forest fires (Joshi et al., 2011). Land use changes, deforestation and declining agricultural productivity in the recent years have resulted in the shortages of feed and fodders for livestock. In addition, climate change impacts such as degradation of resource and ecosystem services, shrinking water storehouses, earlier snowmelt and shorter winters, and natural hazards (Schild, 2007) as well as a rise in mean maximum temperature. Also, the changes in the dates for the beginning and the end of the monsoons (Hua, 2009) take a great toll on livestock production systems. According to MoF (2010), the untimely rain in mid-September in 2009 destroyed about 19,000 hectare of land by inundation, riverbank erosion, and sand deposition, and 75,000 hectare of paddy could not be planted due to abnormal rainfall. The changes in the reliability of stream flow, erratic monsoons, and flooding have caused a decline in crop and livestock production in Nepal (Timsina, 2011). Complex problems related to deforestation and forest degradation, opening of new unfertile land for agricultural production, increased cropping intensity, soil erosion, land degradation, low agricultural productivity, food scarcity and impacts of climate change (Shrestha, 1992; Abington and Clinch, 1992; Regmi and Zoebisch, 2004; Dhital, 2009; MoF, 2010; Feed The Future, 2011) have severely weakened the resiliency of livestock production system to climate change impacts in Nepal.

Nepalese ruminants have traditionally been maintained on roughage based diets. However, supplementing these animals with small amounts of concentrate during their production phase, especially during lactation, is a common practice. Further, these concentrate is of domestic origin and farmers don't seem to pay enough attention to the adequacy of these feeds in meeting the nutrient requirements to support the potential production level so that maximum profit could be obtained per unit of animal in a farm. In addition, the practice of cultivating crops for animal feed in Nepal is not common and therefore there has always been a deficit of animal feed (Pariyar, 2005). The overall deficit in the country is more than one-third of the total required TDN. The ecological zone of the mid-hill region suffers most and is able to supply less than half of the required total digestible nutrients (TDN). The situation in the Terai is a bit less alarming since the deficit is only 17.5% of the total requirement (Pariyar, 2005). Though there has not been any reported future projections of the feeds balance for ruminants available, the trend in the trade deficit with neighboring countries shows that the situation in the days to come would be even more alarming if not enough attention is paid to the production of more animal feed in the country.

Requirements of nutrients for ruminants vary with the stage of their growth and development as well as the different environmental living conditions. Selection of feeds or fodders to meet these requirements is very crucial and is chiefly based on their availability, nutrient content, preference of animals to feed resources and perhaps the amount available to feed the number of animals in the farm. Hence, a careful study of available feed resources, their use, prospects of incorporating new feed resources in an animal's diet and exploration of methods to efficiently use the low-cost and non-conventional feed resources is of utmost important. Livestock productivity is affected by the nutritional management of the animals. Providing adequate energy for livestock production is challenging when resources are limited. Without quality measurements, the quantity or volume measurement of available food does not represent the overall nutritional status. However, estimating the quality of forage consumed by grazing animals is difficult. First, the quality of forage changes seasonally and decreases with maturity. Second, in rangeland environments, animals can choose from numerous plant species and select specific plant parts. This selectivity frequently changes the diet composition and makes it difficult to tell exactly what these animals are eating.

In addition to lack of sufficient feed supply, diseases due to internal parasites are another important cause of low livestock productivity and animal death in Nepal (Morel, 1985; Thakuri, 1996). Currently, farmers are treating their livestock without any plan due to lack of information on the epidemiological pattern of internal parasites. They refer to treatment after seeing the of symptoms of endo-parasitism such as diarrhoeic faeces, debilitated body condition and less body weight gain. Often they run out of time to save their livestock, as by this stage the internal parasites may have caused considerable loss in the productivity of the livestock. Understanding livestock diseases is important from the zoonotic point of view.

This study was conducted as part of a larger study on capacity-building for strengthening livestock production system while adapting to climate change impacts in Nepal. The specific objectives of this study were to assess: 1) the status of feed, nutrition and animal health, and 2) livestock climate change adaptation. Information generated from this study will enhance livestock climate change adaptation by developing resilient feed and nutrition systems.

Methodology

Study area

The study area, the Thulokhola watershed, is located 2.5 km south of Devighat in the Nuwakot district of Nepal (Figure 1). The elevation of the Thulokhola watershed extends from less than 440 m aslat the Trishuli river to 1,585 m aslat, faces north, and drains directly into the Trishuli river. The watershed in an estimated area of 10 km^2 and contains 359 households. Buffalo, goats and cattle are the major livestock in the watershed. Rice (*Oryza sativa*), maize (*Zea mays*), wheat (*Triticum aestivum*), finger millet (*Eleusine coracana*), potato (*Solanum tuberosum*), ginger (*Zingiber officinalis*), and vegetable crops are the major crops grown in the watershed. The Thulokhola watershed has very limited forest areas due to deforestation. The total annual precipitation in Nuwakot district has seriously declined especially during the past 10 years (Figure 2).

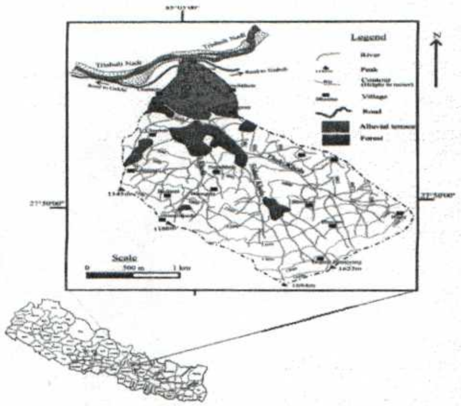


Figure1: Study area of the Thulokhola watershed in Nuwakot district, Nepal.

Community livestock groups (CLGs)

Nine informal Community Livestock Groups (CLGs) were formed across the three elevations of the Thulokhola watershed in June 2012. Groups 1, 2, and 3 represented the lower elevation (< 640 m asl), groups 4, 5 and 6 represented the middle elevation (640 m asl – 1,150 m asl), and the groups 7, 8 and 9 represented the upper elevation (1,150 m asl – 1,585 m asl). There were 81 households in the lower elevation, 159 households in the middle elevation, and 119 households in the upper elevation. The CLG participants included 26 men and 25 women, consisting of nine students, two part-time teachers and part-time students, two teachers, and 38 farmers. Elevation wise, there were 15 CLG members (6 male and 9 female) in the lower elevation, 21 CLG members (13 male and 8 female) in the middle elevation, and 16 CLG members (8 male and 8 female) in the upper elevation. The CLG members were invited to a workshop on July 3, 2011 where they learned about the goals and objectives of the project, as well as their roles. We conducted one two-day CLG training on goat production and management on October 15-16, 2011. In the workshop, the CLG members were trained for water quality monitoring and livestock record keeping and were provided with record forms and weighing machines. The CLG members kept daily records for several variables such as feed types and source, feeding events, and feed amount. A monitoring team of two members visited the CLG members every two weeks in their homes and checked their record keeping.

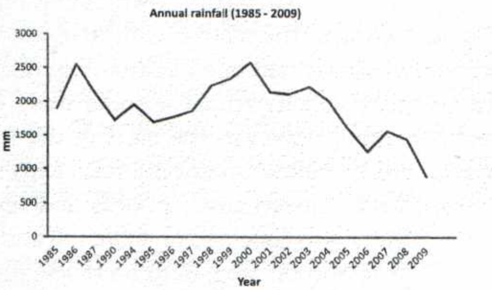


Figure 2: Total annual precipitation from 1985 to 2009 in Nuwakot, Nepal.

Fodder, feed and cow pie analyses

Sixty eight fodder samples of selected species were collected from late November to early December, 2011, and mid-January 2012. Approximately 2 kg of green material consisting of twigs and leaves per fodder tree was collected considering sunny side and shadow side as well as the top, bottom and the middle portion of the tree. Samples were composited, and a 500 gram representative composite green sample per fodder tree was collected for laboratory determination. In addition, fifteen 100g corn feed samples were also obtained from selected households for nutritional analyses. Samples were brought to the NARC fodder and nutrition laboratory in Khumaltar. Samples were dried at 105°C for 6 hours and were ground to pass through 1-mm sieve. Laboratory determinations for CP, total Ash, OM, NDF, ADF, ADL, CF, cellulose and hemicellulose were done following standard methods.

A set of cattle were identified to evaluate their diet quality and productivity status based on the "Forage Quality Photo Guide" (Lyons et al., 2000). Photos of 18 cows and their droppings obtained on 13 Oct 2011 from the Thulokhola watershed were used to appraise current diets and to project needs for supplements to improve overall livestock productivity. The body condition scores were scaled between 1 – 9 (1-3 thin, 4-6 moderate and 7-9 fat cows). The cattle with the higher condition scores had been consuming fodder of sufficient quality to allow some body fat accumulation. However, the diets of the thin cows were below maintenance, causing weight loss. Eleven cow's photos and fecal photos were also collected on March 16 and 17 and April 15 and 16, 2012; but due to the poor quality of the fecal photos only animal body scoring was done for this batch.

Fecal analyses

A total of 1,467 fecal samples (cattle 455, buffalo 523, and goats 489) were collected on a monthly basis from August 2011 to July 2012 in the Thulokhola watershed and were analyzed for gastrointestinal parasites. Fecal samples were collected from the three different elevations representing high altitude, mid altitude and low altitude in the watershed.

Altogether, one hundred fifty animals (50 each for cattle, buffalo and goats) of different age groups were identified. The farmers were asked not to treat these animals with anthelmintics and also not to sell the selected animals during the study period, which they agreed. All the experimental animals were tagged for identification purposes. The name of the farmer, altitude of the farm and age and sex of the animals were recorded. A five-gram sample of fresh fecal matter was collected from all the selected animals directly from the rectum on a monthly basis. The collected samples were dispatched to the Animal Health Research Division (AHRD) laboratory in Khumaltar, which had been treated with 10% formalin in sealed bag to prevent hatching and development of eggs of internal parasites. In the laboratory the faecal samples from cattle and buffalo were analyzed to determine if they were positive for trematode parasites (Fasciola and Paramphistomes) while samples from goats were examined quantitatively (Egg per Gram of Feces, EPG) on a monthly basis for different species of parasites by using the McMaster method (Urquhart et al.,1987). In addition to EPG count, one pooled sample from each site was cultured for larvae development using Baerman's technique (Urquhart et al.,1987) in order to identify the parasites present. Similarly, a post mortem autopsy of a goat having high faecal egg count was also carried out to identify the adult parasites in the gut.

Household surveys

A total of 97 households were surveyed in May 2012. Survey questionnaires were developed, pre-tested and the survey was conducted by trained enumerators. Of the total respondents, 57.7% were female and 42.3% were male. The survey questionnaire contained questions in relation to the livestock composition, fodder and forages, exposure to climate change, climate change impacts, awareness and perceptions of farmers on climate change, women's empowerment, capacity-building, and livestock climate change adaptation.

Data analyses and synthesis

For fecal data, monthly mean of EPG count of parasites were calculated, and also species wise graphs were developed for the watershed. For survey data and livestock records analyses, simple statistics such as mean, standard deviation, frequency, and range were done in JMP 8.0. In order to calculate daily dry matter (DM) supply at barn to livestock, DM percent for fodder and forages were estimated based on available literature (Malla, 2005; Shinners et al., 2007) and the consultation with experts. Dry matter percentages used for the calculation included fodder 34%, napier (*Pennisetum purpureum*) 17%, oats (vegetative) (*Avena sativa*) 17%, NB21 grass 70%, green corn forage 55%, waste of vegetable crops 10%, corn (*Zea mays*) stover 85%, rice (*Oryza sativa*) straw 90%, wheat (*Triticum aestivum*) straw 93%, finger millet (*Eleusine coracana*) straw 85%, legume residue 90%, natural grass 20%, and concentrate feed 90%. Average body weight of the livestock was estimated by farmers (n=7) as follows: adult cattle 272 kg, young cattle 168 kg, adult buffalo 422 kg, young buffalo 286 kg, adult goat 42 kg, young goat 26 kg, adult sheep 37 kg, and young sheep 23 kg. Similarly, on average, an estimated percent waste (not eaten) of fodder and forages while feeding by livestock was: fodder 20%, napier 4.3%, oats (green) 3.2%, NB21 green 0.7%, green corn forage 37.2%, vegetable crops waste 2.9%, corn stover 22.7% (dry stalk 42.2%,and corn husk 2.9%), wheat straw 27.9%, finger millet straw 27.9%, legume residue 15.7%, and natural grass 17.6%.

Results and discussion

Fodder and forages

The survey results showed the predominance of *kutmiro* (*Litsea polyantha* Juss.) and *khanayo* (*Ficuscunia* Buch.-Ham. ex Roxb) trees in the farmlands of the upper elevation while ipilipil (*Leucaena leucocephala*), *khasreto* (*Ficus hispida* L.) and *pipal* (*Ficus religiosa* L.) trees were dominant in the lower elevation (Table 1 and 2). The middle elevation showed the mixture of *Litsea polyantha* Juss., *Ficus cunia* Buch.-Ham. ex Roxb, *Ficus hispida* L., *Ficus religiosa* L., and other fodder and forage trees. On average, the number of large *Litsea polyantha* Juss. trees per household in the upper, middle, and lower elevations were *7.53, 4.29, and 1.84*, respectively. Similarly, the second most common fodder tree species was *Ficuscunia* Buch.-Ham ex Roxb with an average number of 9.05, 2.95 and 1.58 trees per household, respectively for the upper, middle and the lower elevations. Farmers in the upper elevation had planted, on average one *ropani*(i.e. 1 ropani = 508 sq. m.) of land under oats (*Avena sativa*) and 0.19 *ropani* under napier (*Pennisetum purpureum*), whereas farmers in the middle and lower elevations, on average had just 0.5 *ropani* of land under nappier, oats, and stylo (*Stylosanthes quianensis*). Farmers in the lower elevation, however, had a significantly higher number of small ipilipil (*Leucaena leucocephala*) trees in their farmlands compared to those in the middle and upper elevations. Besides fodder and forages, farmers used crop residue such as corn (*Zea mays*) stovers, rice (*Oryza sativa*) straw, and finger millet (*Eleusine-coracana*) stalk, and collected grasses from their farmlands including terrace risers and edges for their livestock. According to the household survey results, 88% of the respondents utilized community forest resources. On average, the number of grazing days per household in the community forest for the upper, middle and lower elevations, respectively, were 61.2 (±22.0), 115.9 (±28.4), and 60.5(±22.6).

Nutritional analyses for major fodder trees and feeds in the Thulokhola watershed are presented in Table 3. In one study, Mandal and Gautam (2012) emphasized that farmers assess *Ficus cunia, Litsea polyantha* and *Ficus hispida* as a good quality fodder. However, except for *Ficus hispida*, laboratory determination of NDF for these fodder species, on average, ranged between 54.14% to 71.65% suggesting very poor digestibility which limits intake of these fodder species to livestock.

Daily dry matter intake by livestock at barn

Based on the livestock record kept by the CLG members from August, 2011 to July, 2012, the average daily dry matter intake of livestock (i.e. cattle, buffalo, goats and sheep) ranged from 23.3 g kg^{-1} for the month of October to 53.5 g kg^{-1} for the month of January, and declined consistently from January to October (Table 4). This is similar to the study of Hendy et al. (2000) who found that feed composition rates (daily DM intake as a percentage of live weight) in Nepal are commonly in the range of 2.0 to 4.5% for bovines and 2.5-5% for goats, depending on the composition of diets, age and productive status of animal. These results clearly indicate that the livestock production system is intricately related with the agricultural crop production in this watershed. Study by Hayashi et al. (2005) in Chitwan, Nepal revealed the average daily dry matter (DM)

Table 1. Average number of fodder trees per household in the upper (n=38), middle (n=28) and lower (n=31) elevation zones of the Thulokhola watershed, Nuwakot, Nepal.

		Leucaena Leucocephala	*Bauhinia purpureaL*	*Ficus roxburghii*	*Bauhinia* Wall.*variegataL*..	*Artocarpus lakoocha*Roxb	*Litsea polyantha*Juss
Upper							
	Large	0.05(±0.05) ns*	3.79(±2.93) ns	0.05(±0.05)ns	0.03(±0.02)ns	0.27(±0.23) ns	7.53(±2.15)a
	Medium	0.00(±0.00) ns	0.94(±0.37)ns	0.00(±0.00)ns	0.00(±0.00)ns	0.16(±0.08) ns	4.63(±1.81)ns
	Small	0.05(±0.05) y	0.42(±0.16) ns	0.00(±0.00)ns	0.05(±0.03)ns	0.29(±0.26) ns	2.07(±1.57)ns
Middle							
	Large	0.29(±0.28) ns	0.53(±0.32) ns	0.04(±0.03)ns	0.04(±0.03)ns	0.18(±0.09) ns	4.29(±1.70) ab
	Medium	0.64(±0.26) ns	1.17(±0.37) ns	0.00(±0.00)ns	0.14(±0.11)ns	0.57(±0.27) ns	3.17(±0.91)ns
	Small	0.21(±0.15)y	1.25(±0.89) ns	0.00(±0.00)ns	0.00(±0.00)ns	0.07(±0.05) ns	3.04(±2.14) ns
Lower							
	Large	0.42(±0.23) ns	0.35(±0.17) ns	0.13(±0.10)ns	0.00(±0.00)ns	0.29(±0.14) ns	1.84(±0.93) b
	Medium	1.16(±0.96)ns	0.74(±0.39)ns	0.22(±0.22)ns	0.00(±0.00)ns	0.13(±0.07) ns	2.19(±1.60)ns
	Small	3.06(±1.22)x	0.29(±0.14) ns	0.06(±0.06)ns	0.06(±0.06)ns	3.32(±3.22)ns	0.97(±0.67) ns

*Large a,b,c; and small x, y, z. Category in a column significantly different with different letters. Numbers in parentheses are ± standard error of mean

Table 2. Average number of other fodder trees in upper (n = 20), middle (n=23) and lower (n=24) elevation of the Thulokhola watershed, Nuwakot, Nepal

	Upper	Middle	Lower
Ficus racemosa	0.00(±0.00) ns*	0.09(±0.08)ns	0.37(±0.33)ns
Ficus cunia Buch.-Ham ex Roxb.	9.05(±2.51)a	2.95(±0.79)b	1.58(±1.10)b
Ficus hispida L.	0.00(±0.00)b	1.48(±0.54)ab	1.75(±0.79)a
Morus alba L.	0.00(±0.00)ns	0.00(±0.00)ns	0.54(±0.40)ns
Mallotus philippinensis Muell Arg.	0.00(±0.00)ns	0.00(±0.00)ns	0.04(±0.04)ns
Ficusc lavata Wall ex. Miq.	0.00(±0.00)ns	0.00(±0.00)ns	0.37(±0.33)ns
Melia azedarcha L.	0.00(±0.00)ns	0.00(±0.00)ns	0.21(±0.20)ns
Ficus religiosa L.	0.00(±0.00)b	0.17(±0.12)ab	0.62(±0.28)a
Ficus nfectoria Roxb.	0.50(±0.32)ns	0.61(±0.31)ns	0.33(±0.18)ns
Toonaciliata	0.60(±0.60)ns	0.00(±0.00)ns	0.17(±0.17)ns
Desmodium microphyllum	1.00(±0.77)ns	0.30(±0.30)ns	0.25(±0.25)ns
Fraxinus floribunda Wall.	0.05(±0.05)ns	0.00(±0.00)ns	0.00(±0.00)ns

*Different letter across a row shows means significantly different at 0.05 probability level. Numbers in parentheses are ± standard error of mean

Table 3. Percent average crude protein (CP), organic matter (OM), total ash (T. Ash), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), hemicelluloses, and cellulose content of major fodder species and corn (*Zea mays*) grains in the Thulokhola watershed, Nuwakot, Nepal

	n	CP	T. Ash	OM	NDF	ADF	ADL	HC	Cellulose	CF
Ficus cunia	24	12.96	17.72	82.28	56.04	47.82	26.74	15.71	21.08	nd[1]
Ficus hispida	18	11.94	24.03	75.97	42.41	34.11	16.81	15.77	17.29	nd
Litsea polyantha	23	13.21	7.14	92.86	71.65	63.46	42.35	14.89	21.11	nd
Bauhinia purpurea L.	2	11.18	16.49	83.51	54.14	39.81	19.95	34.18	19.85	nd
Artocarpus lakoocha Roxb.	1	8.13	4.91	95.10	83.71	80.64	60.22	23.49	20.41	nd
Corn (*Zea mays*) grain	15	7.77	1.79	98.21	nd	nd	nd	nd	nd	4.28

[1]nd = not determined

intake for lactating Murrah-cross buffaloes in the month of August, November and March in the tune of 19.3, 16.0, and 17.3 kg day^{-1}, respectively, and the corresponding figures for lactating Holstein-cross and Jersey-cross cows were 11.4, 14.0, and 15.8 kgday^{-1}. In our study site, the Jersey-cross cows and the Murrah-cross buffaloes are common livestock breeds. Amounts of feed dry matter (fodders and concentrate) offered to different types of livestock were recorded higher than the expected (30-43 g kg^{-1} for bovines and 66 g kg^{-1} for goats) based on the quality of digestibility (Hendy et al., 2000). The usual pattern of roughage intake as a percentage of animal

Table 4. Average daily dry matter (DM) intake (g kg^{-1}) by livestock (goats, buffalo and cattle) in barn and its sources in smallholder mixed-farming livestock production system in Thulokhola watershed, Nuwakot, Nepal

	Dry matter intake (gkg^{-1}live weight)	Napier	Oat	NB21 grass	Green maize	Maize stover	Rice straw	Wheat straw	Millet straw	Legume residue	Maize grain	Kitchen waste	Natural grass	Concentrate
Jan	53.5	0.6	0.8	0.0	1.4	3.7	18.6	6.1	2.2	5.2	6.5	0.1	0.3	8.0
Feb	45.8	0.0	0.0	0.4	22.3	3.5	8.4	0.3	0.0	0.0	3.2	0.1	3.7	3.8
Mar	39.6	0.0	0.0	0.0	0.8	4.5	12.6	0.0	5.4	1.7	6.2	0.1	1.5	6.8
Apr	36.4	0.0	0.0	0.0	1.5	3.1	11.3	0.0	9.8	2.3	3.3	0.1	1.4	3.7
May	36.6	0.5	0.6	0.0	6.9	2.7	13.1	1.1	0.5	0.5	5.1	0.1	0.0	5.7
Jun	27.9	0.1	0.1	0.0	0.1	3.1	10.4	0.8	0.3	0.7	5.6	0.0	0.9	6.0
Aug	28.4	0.3	0.5	0.0	2.9	2.2	9.9	2.1	0.9	1.1	3.8	0.1	0.1	4.5
Sep	23.5	0.1	0.0	0.0	2.5	0.9	0.6	0.0	0.6	0.0	1.9	0.1	13.9	2.8
Oct	23.3	0.1	0.0	0.5	3.0	1.3	2.2	0.0	0.7	0.4	2.2	0.1	10.2	2.6

Table 5. Relationship of elevation and diet availability to animal productivity using body condition scores (BCS) and excreta photos

	Upper	Middle	Lower
Average BCS* (October)	5.8 (n=1)	6.2 (n=15)	5.3 (n=2)
Average BCS (March)	4.5 (n= 2)	5.3 (n= 3)	6.0 (n=6)

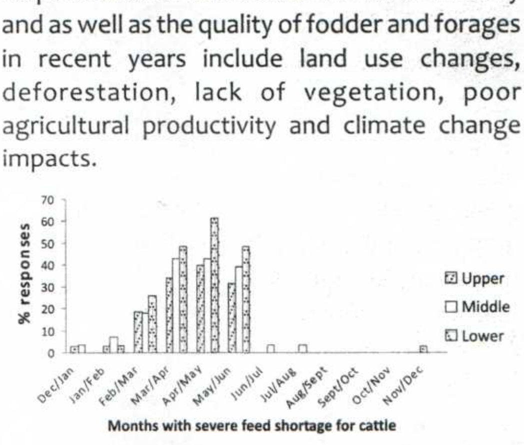
*Average fecal scores were widely different among cows, average of all was very low quality

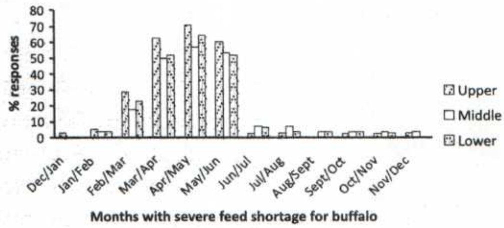
Table 6. Prevalence of helminthes parasites in buffalo, cattle, and goats in the Thulokhola watershed, Nuwakot, August 2011 to July, 2012

	Upper		Middle		Lower	
	n	Prevalence %	n	Prevalence %	n	Prevalence %
Buffalo	204	27.45	154	19.48	165	22.42
Cattle	186	34.95	129	27.91	140	29.28
Goats	193	49.74	145	61.4	151	51.6

body weight declines with decrease in digestibility due to slower movement of feed through the digestive tract. Crampton (1957) found that the extent of voluntary consumption of a forage is limited primarily by the rate of digestion of its cellulose and hemicellulose rather than by contained nutrients or the completeness of their utilization.

While assessing feed and nutrition for livestock, it is important to take into account the year round feed supply and feed shortages. Based on the household survey results, March through June were the months with severe feed shortages for livestock in the Thulokhola watershed (Figure 3). These months are hot, lack rainfall, often have drought conditions, and have decreased water availability. Thus, adverse weather conditions, water availability and feed shortages put livestock in hardship especially in those months when they have severe feed shortages. According to survey results, fodder and forages availability and their qualities have declined severely over the past 20 years in the watershed (Figure 4). In the survey, nearly 70% of the respondents expressed that they have lower availability of fodder and forages, and 60% expressed moderate quality, and 36% expressed lower quality fodder and forages now compared to 20 years ago. Major reasons cited by the respondents for this decline on the availability and as well as the quality of fodder and forages in recent years include land use changes, deforestation, lack of vegetation, poor agricultural productivity and climate change impacts.





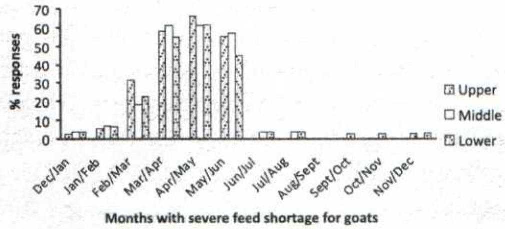


Figure 3: Months with severe feed shortages for livestock in the three elevation zones of the Thulokhola watershed, Nuwakot, Nepal.

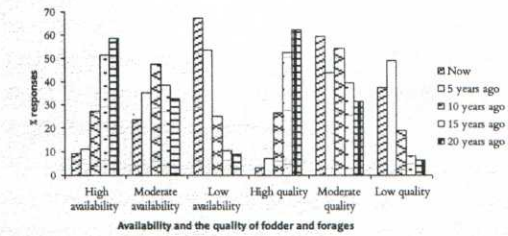


Figure 4: Farmers' perception on the availability and quality of fodder and forages over the past 20 years in the Thulokhola watershed, Nuwakot, Nepal.

Animal health and diet quality

One way of evaluating animal health and diet quality is with the use of a grazing animal's excreta to estimate the digestibility and protein level of their diet. Forage quality changes seasonally and the diet composition may change with varying plant or plant part availability. For some time, it has been recognized that a relationship exists between forage quality and the physical appearance of the feces of grazing cattle. New plant growth, mostly young leaves contains high levels of easily digestible compounds such as proteins, sugars and lipids. New plant growth with very little fibrous material and cellulose, is highly digestible and produce a somewhat shapeless, dark, round faecal pile. Therefore, grazing animal droppings that result from the consumption of immature, high quality forages tend to fall to the ground in relatively shapeless deposits. As grasses mature the fibrous content increases and the appearance of the cattle dropping reflects a lower quality diet high in fiber with faeces that may be hard and stacked, showing waves or grooves. Color, consistency, and texture of the faecal pile can be correlated to the NIRS analysis to predict the forage quality of the diet. Numerous review articles on postpartum reproduction in cattle indicate that body condition scoring (BCS) is a useful indicator of energy status and subsequent reproductive performance (Dunn and Kaltenbach, 1980; Dziuk and Bellows, 1983; Randel, 1990). Body condition of primiparous cows at calving is a reliable indicator of subsequent reproductive performance. With a beef cattle body condition scoring of 1 to 9, Rae, et al. (1993) found that cows with a BCS ≤ 4 had a pregnancy rate of 59%; while those with a BCS ≥ 5 had a pregnancy rate of 90%. Lyons et al. (2000) developed a forage quality photo guide to evaluate diet quality of grazing beef cattle. Forage quality estimates were obtained using near infrared reflectance spectroscopy (NIRS) faecal analysis. The guide categorizes forage quality on a crude protein basis because this approach provides the clearest relationship to visual changes in droppings. In this study, the cow photos and pie results indicated that there is lack of nutrition among cows in the Thulokhola watershed (Figure 5).

The proportion of the fat, moderate and thin cows in October were 39%, 50% and 11%, and in March 36%, 55%, and 9%, respectively. The faecal pile photos indicate that most of the cows were consuming relatively low quality fodder (< 10% protein and < 55% digestibility). Hendy et al. (2000) noted that the average nutrient contents of diets in the mid-hill zones of Nepal were similar for cattle, buffaloes and

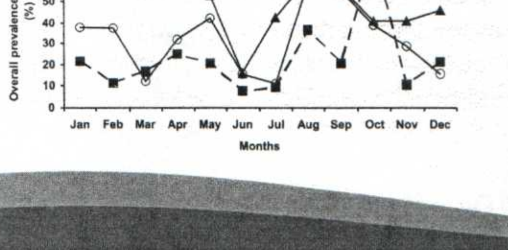
Figure 5: Cow pie showing poor digestibility and low protein vs. one higher in quality; both in protein and with less fiber- thus higher digestibility. Examples of different body conditions: Grey cow, BCC of 8; Jersey cow, BCC of 4.

oxen (108-110 g CP and 8.8 MJ ME/kg DM) but were higher for goats (130 g CP and 9.9 MJ ME/kg DM) due to high content of tree fodders in their diets.

Although average daily grass and forage supply as well as cow pie analyses indicated low diet and nutrition, however, the average body condition score for the cows that we studied was not terribly low. Further investigation is required to understand why the average BCS on cows appear to be reasonably high while feed and forage quantity and quality are low. One of the reasons can be feeding cows with cooked kitchen by-products such as vegetables, leftover food and rice bran, which is a common practice in Nepal. This is applicable to smallholder farmers only having one or two cattle or other livestock.

Prevalence of helminthes

Out of 1,467 faecal samples cattle, buffalo and goats examined, goats showed the highest prevalence of helminthes (53.8%), while buffalo showed the lowest prevalence (23.52%) followed by cattle (31.21 %) as presented in Figure 6. Buffaloes at the upper elevation showed the highest prevalence (27.45%) of helminthes while buffaloes at the middle elevation showed the lowest prevalence (19.48%) followed by in the lower elevations (22.42%). Similarly, cattle in the upper elevation showed the highest prevalence (34.95%) followed by cattle at the middle elevation (27.91%) and the lower elevations (29.28%). In the upper elevation, even though buffaloes are stall fed and cattle are grazed, buffalo and cattle are placed in the same place increasing the chances of parasitic contact to buffaloes. In the middle and lower elevations, buffaloes and cattle are stall fed. Goats in the middle elevation, which are largely grazed, showed the highest prevalence (61.4%) of helminthes, while goats at the upper and lower elevations showed the prevalence of 49.74% and 51.6%, respectively. These results show that while cattle and buffalo have relatively higher prevalence of helminthes at the upper elevations, goats have relatively higher prevalence of helminthes at the middle and lower elevations, and it seems that the prevalence is associated with grazing. Monthly analysis of the prevalence of helminthes in buffalo, cattle and goats showed August, September and October to be the months with higher prevalence of parasites in buffalo and cattle (Figure 6). This indicates that the highest prevalence may be due to high temperature and humidity during these months. From the months of January through May goats were found with a high prevalence of parasites, with the highest levels in April. Although the mean fecal egg count of the goats was highest in August (363.63) and the lowest in June (51.2), the months of January through May had higher FEG counts corresponding to the higher level of parasite prevalence on goats.



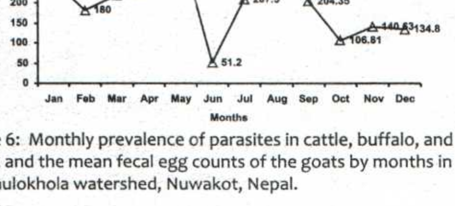


Figure 6: Monthly prevalence of parasites in cattle, buffalo, and goats, and the mean fecal egg counts of the goats by months in the Thulokhola watershed, Nuwakot, Nepal.

Liver flukes (buffalo, cattle, goat), round worm (goat), and tape worm (goat, pig) were common livestock parasites in this watershed. In buffalo, the major parasites found were Trematode parasites (Fasciola and paramphistomes) followed by a few cases of stongyle and Moneizea. The losses caused by the trematode parasites are more severe than other nematode parasites in buffalo. Similarly, the major parasites found in cattle were Trematode parasites (Fasciola and paramphistomes). The most common parasites in goats in the Thulokhola watershed are gastro-intestinal parasites (Stongyles) and Tape worms (Moniezea). The strongyles worms have been reported to be highly pathogenic, causing severe diarrhea and weight loss in goats. Based on information collected from the CLG members, the goat morality rate in this watershed was as high as 22%, this rate was high enough to cause economic hardships by itself. Major causes of goat death included gastrointestinal parasites, *peste des petits* ruminants (PPR), a highly contagious and infectious viral respiratory disease of domestic and wild small ruminants, Orf (also known as "sore mouth"), a virus that causes sores but typically not death, Foot and Mouth Disease (FMD) and flukes. Many of these diseases were exacerbated due to very poor living conditions for goats. We observed goat pens which were very poorly ventilated, foul smelling, and in many cases the cows and goats were penned together.

Livestock climate change adaptation

Farmers in the Thulokohola watershed have perceived and are aware of the impacts of climate change on livestock production in recent years. With the climate changes, farmers are experiencing an increase in the emergence of new invasive fodder and forage species that are more competitive with the native species. Many of these invasive species lack the level of nutrient value to support the current livestock stocking rates in addition to their increased amount of antinutreint factors such as tanin, lignin and saponin which cause indigestion/or digestion problem in ruminant animals. This lowered level of nutrition and the increased amount of antinutrient factors in fodder and forages lead to the disruption in normal reproduction, resulting in an extended breeding season, and increased incidence of repeat breeding and anoestrus conditions in their livestock. In addition, the reduced nutrition has also resulted in an increased incidence of respiratory diseases, changes in epidemiological pattern of livestock diseases such as fascilosis and infectious diseases as well as gastro-intestinal parasites. Farmers also noted an increased resistance to the anthelmintics and antibiotics being used in the livestock which was another major concern in the watershed.

Various measures undertaken by local communities for coping with climate change impacts on feed and nutrition include: collecting fodder and forages from forest and community forest, purchasing fodder and forages, feed, rice straw and other feed stock for their animals, collecting small grasses from terrace risers and edges of the fields (if available), and bringing animals (especially cattle and goats) to graze on more distant pastures. According to the household survey results, 88% of the surveyed households rely on community forest to supplement fodder and forages. Figure 7 shows average backloads of fodder, grasses, firewood and leaf litter harvested from community forests by a household in the watershed. While firewood is used for cooking, leaf litter is used for mulching vegetable and cash-crop fields. Farmers in the upper elevation collected significantly lower amounts of leaf litter annually as compared to farmers in the middle and lower elevations. Leaf litter is used as bedding material for their livestock as well as mulch for the production of commercial crops such as ginger, chilies, onions and garlic. Farmers also graze their animals to reduce the pressure from their fodder and forages. The average number of grazing days per household in the community forest for the upper, middle and lower elevations respectively were 61.2 (±22.0), 115.9 (±28.4), and 60.5(±22.6).

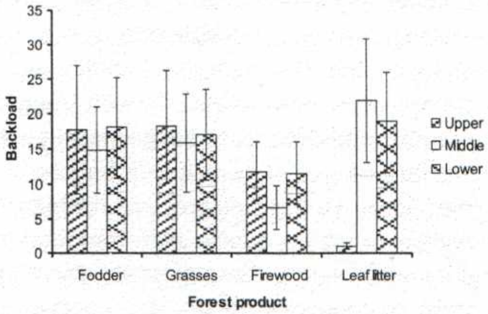


Figure 7: Average backloads of forest product collected from community forests by a household in the upper, middle, and lower elevations in a year in the Thulokhola watershed, Nuwakot, Nepal.

In terms of the volume of forest products harvested, 76% of the respondents in the upper elevation, 82% in the middle and 85% in the lower elevation stated that their amount of forest harvest is decreasing every year due to the poor condition of their community forests. Seventy-six percent respondents in the upper elevation, 82% in the middle and 77% respondents in the lower elevation mentioned that the condition of their community forests had been degraded in recent years. Reasons cited for the poor condition of community forests included overgrazing, excessive use of forests, logging, deforestation, road construction, drought conditions, forest fire and the lack of enforcement of forest rules and regulations. Respondents have noticed changes such as appearance of invasive plants such as *nilogandhe* (*Ageratum spp.*) and *banmara* (*Lantana camara*) and the disappearance of *sal* (*Sorearo busta*), *champ* (*Michelia champaca*) , *tanki* (*Bauhinia purpurea*), *chilaune* (*Schima wallichii*), *titepati* (*Artemesia vulgaris*), *katus* (*Castanopsis indica*) and wildlife such as tigers and deer from their community forest. They have also experienced an absence of understory vegetation in their community forest in recent years.

Farmers also keep rice straw and corn husk leaves for the shortage period. Some farmers also destock their animals during these lean seasons. Planting fodder trees and forages e.g. napier (*Pennisetum purpureum*), stylo (*Stylosant hesguianensis*), and oats (*Avena sativa*) fodder were also mentioned as potential measures to overcome these shortages. They also ensure future planting of corn, wheat, and millet crops so that livestock get crop residue as feed. They admitted that they had fed low quality feed to their livestock during these seasons. To augment feed supply, farmers have planted fodder trees, preserved fodder trees such as tanki (*Bauhinia purpurea* L.), kutmiro (*Litsea polyantha* Juss.), khanayo (*Ficus cunia* Buch.-Ham. ex Roxb.), etc. in terrace risers despite crop loss, planted oats in the winter for forages, planted trees in farm land, destocked animals and purchased feedstock.

While limited measures have been instituted to prevent and control livestock diseases and parasites, farmers have collected fecal samples for animal parasite testing and have vaccinated or have administered drugs to their animals. The implementation of such practices was largely limited to the lower elevation which had better access to roads. For instance, farmers only in the lower elevation (with road access) reported the vaccination of goats for PPR (*Peste des Petits*). Farmers have given frequent baths to buffalo to protect them against heat and have developed shaded areas for daytime resting.

Conclusion

Livestock production in the smallholder mixed-farming system in the mid-hills region of Nepal, which is a largely based roughages-based feed system, has experienced serious shortages of fodder and forages in recent years. Major fodder species that farmers have in their farmlands are poorly digested by livestock. Crop residue such as rice straw, wheat straw, millet straw, corn stovers and legume make up the major feed source in this production system. It is necessary to improve both the quantity and quality of feeds offered to the livestock to increase animal productivity. Climate change has impacted feed and nutrition of livestock several ways including poor crop production due to drought, forest degradation, and drying-up of water sources. Prevalence of very high level of gastro-intestinal parasites on livestock has seriously affected livestock productivity including high degree of animal deaths. Implementation of appropriate measures for increasing fodder and forages supply such as agroforestry intervention, planting improved grasses in the terraces, growing winter fodder species such oats, inclusion of forage production in the cropping cycles, improved feed storage and feeding techniques, and enhancement of feed quality will enhance livestock feed and nutrition system in the smallholder mixed-farming system. Similarly, availability of veterinary services at the local level and timely administration of drugs against gastro-intestinal parasites is necessary to save livestock from deaths and to increase livestock productivity. Implementation of climate change adaptation measures to enhance the supply of fodder and forages, improve animal health, increase crop productivity, protect water sources, and conserve soils are critical for sustainable livestock climate change adaptation in the smallholder mixed-farming system of Nepal.

References

Acharya, K.P., Dangi, R.B., 2009. Case studies on measuring and assessing forest degradation: Forest degradation in Nepal- Review of data and methods, Forest Resource Assessment Program, FAO, Rome, Working Paper 163.

Agri Hunt, 2012. Comparison of livestock economy between Pakistan and India. http://agrihunt.com/livestock-industry/1375-comparison-of-livestock-economy-between-pakistan-and-india-.html, accessed on March 29th, 2012.

Crampton, E.W., Lloyd, L.E., MacKay V.G., 1957. The calorie value of TDN. J. Anim. Sci. 16, 541.

Goletti, F., Gruhn, P., Bhatta, A., 2001. Livestock production and productivity growth in Nepal, Agricultural Sector Performance Review TA 3536-NEP, Discussion Paper No. 3, Kathmandu, Nepal.

Hayashi, Y, Shah, S, Shah, S. K., Kumagai, H., 2005. Dairy production and nutritional status of lactating buffalo and cattle in small scale farms in Terai, Nepal. *Livest. Res. Rural Dev. 17, Article no. 64*.

Hendy, C.R.C., Vickers, B., Chhetri, R., Basukala, R.., Kharel, R., Regmi, B.N., Kiff, E., 2000. Seasonal composition and quality of livestock diets on small-holder mixed farms in the mid-hills of Nepal. In: National Level Workshop on Improved Strategies for Identifying and Addressing Fodder Deficit in Mid-Hills of Nepal, Kathmandu, September, 2000.

Ibrahim, M.N.M., 2007. Livestock sector training needs assessment report for South Asia. International Livestock Research Institute, Addis Ababa, Ethiopia.

IPCC, 2007. Climate Change 2007. In: Parry, M.L., Canziani, O.F., Palutokof, J.P., van der Linden, P.J., Hanson, C.E. (eds), Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, pp 976.

Joshi, A., Shrestha, K., Sigdel, H. 2011. Deforestation and participatory forest management policy in Nepal, World Rainforest Movement. http://www.wrm.org.uy /deforestation/Asia/Nepal.html.

Lyons, Robert, Richard, K., MachenV., Stuth Jerry W., 2000. Forage Quality Photo Guide. Evaluating Diet Quality Selected by Grazing Beef Cattle Using Photographic Guidelines. Texas A & M E-541 700.

Malla, S.M., 2005. Handbook of Animal Husbandry & Animal Health Care, Narayan Press, Kathmandu, Nepal.

Mandal, T.N.,Gautam,T.P.. 2012. Chemical analysis of fodder tree leaves found in Sunsari district, Nepal, BIBECHANA 8, 131-138.

Maplecroft. 2010. Big economies of the future – Bangladesh, India, Philippines, Vietnam and Pakistan – most at risk from climate change. http://maplecroft.com /about/news/ccvi.html.

Morel, A.M., 1985.The diseases situated in the eastern hills of Nepal and problems associated with their alleviations. In: Proceedings of the Workshop on Livestock in the hills of Nepal, Pakhribas, Nepal, 5-7 February, 1985. Pakhribas Agricultural Center, Pakhribas, Dhankuta, Nepal, pp. 65-94.

Ministry of Finance, 2010. Economic Survey, Fiscal Year 2009/2010, Vol. I. Ministry of Finance, Government of Nepal, Kathmandu, Nepal.

Pariyar, D., 2005. Fodder oats in Nepal, Pasture and Fodder Division, Khumaltar, Nepal.

Rae, D. O., Kunkle, W. E., Chenoweth, P. J., Sand R. S., Tran T., 1993. Relationship of parity and body condition score to pregnancy rates in Florida beef cattle. Theriogenology, 39:1143.

Randel, R. D., 1990. Nutrition and postpartum rebreeding in cattle. J. Anim. Sci., 68:853.

Shinners, K.J., Binversie, B.N., Muck, R.E., Weimer P.J., 2007.Comparison of wet and dry corn stover harvest and storage. Biomass Bioenerg. 31, 211-221.

Tareque, A.M.M, Chowdhury Ziqrul Haq Shah M.D., 2010. Agricultural Research Priority: Vision – 2030 and beyond, Bangladesh Agricultural Research Council, Farmgate, Dhaka. http://www.barc.gov.bd/documents/Final-prof.Tareque.pdf.

Teufel, N., Markemann A., Kaufmann, B., Valle Zárate, A. Otte, J. 2010. Livestock production systems in South Asia and the Greater Mekong sub-region, PPLPI Working Paper No. 48, FAO. http://www.fao.org /AG/againfo /programmes/en/pplpi/docarc/wp48.pdf.

Thornton, P.K., Kruska, R.L., Henninger, N., Kristjanson, P.M., Reid, R.S., Atieno F., Odero, A.N., Ndegwa, T., 2002. Mapping poverty and livestock in the developing world. Published by: International Livestock Research Institute (ILRI).

Thakuri, K.C., Mahato, S.N., Thakur, R.P., Giri R.K. 1985. A retrospective study of goat disease in the Eastern Hills of Nepal. Vet. Rev. 9-10.

United Nations Environment Programme, South Asian Association for Regional Cooperation, and Development Alternatives, 2009. South Asian Environment Outlook 2009, United Nations Environment Programme, Nairobi, Kenya..

Urquhart, G.M., Armourm, J., Doncon, J.L, Dunn, A.M., Jennings F.W., 1987. Veterinary Parasitology, English Language Book Society/Long Man. pp 100-109.