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Fodder consumption patterns under indigenous agroforestry systems in the rural landscape of Kosi Watershed, Kumaun Himalaya

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Abstract
Livestock are an integral component of hill farming. In central Himalayan region indigenous agroforestry is a prevalent practice to meet fodder requirement of growing livestock population. In the present study attempts were made to assess the contribution of agroforestry in meeting the total fodder requirement at village level of Kosi watershed. Questionnaire survey method and direct field observations were followed for the data collection. The research reveals that agroforestry contribute about 45-50 percent, surrounding forest 29-40 percent and the rest deficit fodder requirement was meeting out by purchased grass. The present study on fodder production and consumption at different altitude villages would be useful in designing appropriate policies and technologies for fodder production.

Keywords: Watershed, Kumaun Himalaya, Fodder, Indigenous Agroforestry, Forest, Livestock

1. Introduction
Agroforestry is a profitable land use practice that increases livelihood security (Regmi, 2003; Pandey, 2007; Rahman *et al*., 2012) [29, 19, 22] and reduces vulnerability to local climate and environmental changes (Verchot *et al*, 2007; Lasco *et al*., 2014) [37, 11]. In hilly region of north-western and central Himalaya, local farmers maintain naturally regenerating tree species, particularly on edges of the terraces without any significant inputs of manpower. Variety of multipurpose tree species are grown and managed to meet with subsistence requirements of indigenous communities (Maikhuri *et al*., 2000) [13]. This system is known as indigenous agroforestry system (Ram, Singh, 1996; Vishvakarma *et al.*, 1998) [23, 38].
Livestock are the backbone of hill agro-ecosystems (Farooquee *et al*., 1994; Palni *et al*., 1998) [6, 17] and only source of draught power and farmyard manure (Sharma, Singh, 1997; Rawat *et al.*, 1997) [32, 25]. In hilly regions, livestock population is largely dependent on forests due to age old pastoralism leading to heavy pressure on forests and consequent degradation of ecology and environment of the area. The non availability of sufficient crop residue in the hills results in greater dependency of livestock on forest in comparison to the plains (Kadekodi, 1996). Although the State of Uttarakhand is well endowed with biological resources, the past decades have seen an increase in pressure on the state's natural ecosystems (Rawat, 2010; Dobhal *et al.*, 2011) [26, 5]. To sustain a large livestock population, fodder in large quantity is required (Singh *et al*., 1984). The pressure on the fodder resources in the central Himalayan region is greater than the carrying capacity of the supporting systems (Pandey, Singh, 1984; Singh, Pande, 1988; Rawat *et al.*, 1997) [20, 33 25]. Increasing livestock population could significantly affect the natural forest ecosystem of this area in future because livestock management is one of the biggest problems of hilly region (Rawat *et al.*, 1996) [24]. To reduce pressure from forests, agroforestry is a way to address this issue by planting more fodder trees on agricultural fields. Looking the importance of fodder in Himalayan region, the present study was conducted on requirement and utilization pattern of fodder in different altitudinal gradients of Kosi watershed of Kumaun Himalaya.

2. Materials and Methods
2.1. Study area and climate
The present study was carried out in three villages of Kosi watershed (Figure 1) during November 2014 to June 2015. Kantli (1750 m), Dhaniyakot (1064 m) and Dabra-Saonral (769 m) representing three different types of agro-ecosystems, were selected as altitudinal gradients. They represent upper (>1500 m), middle (800-1500 m) and lower (<800 m) parts of Kosi watershed. These villages are distributed from 29^{0}50'55.06"N to 29^{0}32'36.84"N latitude and 79^{0}33'57.14"E to 79^{0}13'31.29"E longitude.

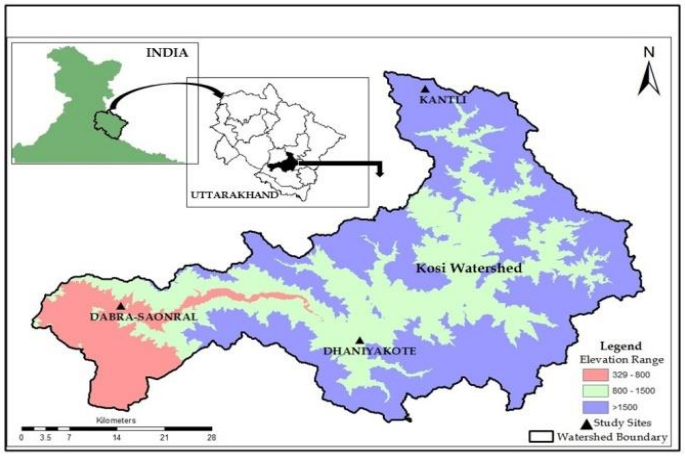

Fig 1. Location of study villages in Kosi watershed

Climate of Kosi watershed is temperate. The watershed has three seasons; summer, rainy and winter. Data obtained from meteorological station, Hawalbagh shows maximum temperature (32.1^{0}C) is in June and lowest in January (-0.8^0 C).

Average annual temperature is ~18^{0}C. The average annual rainfall is 1070 mm (Figure 2).

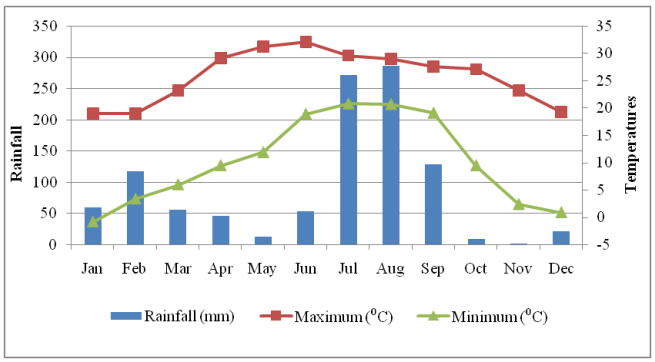

Fig 2: Rainfall and temperature conditions in Kosi watershed

2.2. Survey, sampling and measurement

The study was based on the primary survey and data collected through direct observations on the fields. Multistage sampling was carried out for this study. Stratified sampling was performed to categorised farmers into different groups according to their landholdings. Random sampling was followed to select 50% households from each category of farmer. Purposive sampling was performed to collect data on various aspects i.e., livestock population, fodder requirement etc. Data were collected through a semi-structured questionnaire and direct observations in the field. The sources of fodder were categorised into three broad categories, these are (A) agroforestry, (B) natural forest and (C) purchased grass. Agroforestry includes residue of agricultural crops, trees along the terraces and grass in between the interspaces of two terraces. Summation of total fodder produced from various sources was treated as total annual fodder production at village level. Livestock population in each village were documented with the help of questionnaire. Per animal per day fodder consumption pattern was measured for 24 h after providing a known amount of fodder to different animals. Leftover fodder was measured after 24 h. After subtracting the leftover from the total supplied known amount of fodder was assumed per day requirement of particular animal (Maikhuri, Ramakrishnan, 1990, 1991; Vishvakarma *et al*, 1998; Rawat *et al*, 2009) [38, 27]. Observation of fodder consumption was taken five times for each category of animal during summer and winter season, separately. Average value obtained in particular season was considered as fodder consumption by animal. Following formula was used for estimating fodder consumption.

Net fodder consumption for 24 h = Known amount of given fodder to livestock - leftover

Fig 3: A panoramic view of Kosi watershed

3. Results and Discussion

3.1 Livestock:

Cattle like ox, cow, buffalo, calf and goat were common domestic animals in all villages. Total 136 animals were recorded at Kantli, 370 at Dhaniyakot and 223 at Dabra-Saonral (Table 1). Cattle (except buffalo) were allowed to graze in near forests throughout the year and in harvested crop field. Oxen were used as drought power for land tillage. Cow and buffalo were important milk yielding animals. Few farmers had started keeping Jersey cow due to their ability of higher milk production as compare to *desi* cow (local breed). Mules were kept only in Dhaniyakot village for carrying goods and construction material. In Dabra-Saonral village, farmers kept a large number of goats to meet meat consumption and they were relatively higher in the number as compared to other animals.

Palni *et al* (2001) [18] indicated cattle, buffalo, sheep, goats, mules and yak are main livestock of central and north-western Himalaya. In central Himalayan region, 5.084 cattles unit is dependent on one ha of land for grazing which is about 2-3 times higher than the carrying capacity of the land. According to Uttarakhand livestock census 2007, livestock population has increased 49, 43, 329 to 51, 41, 011 from the year, 2003. To feed continuously growing livestock population, a large quantity of fodder will be needed in near future.

Table 1: Animal population in villages of Kosi watershed (Value in the parentheses are % of total animals)

S. No	Livestock	Kantli (n=56)	Dhaniyakot (n=106)	Dabra-Saonral (n=50)
1.	Ox	33 (24.26)	115 (31.08)	8 (3.58)
2.	*Desi* cow	43 (31.61)	61 (16.48)	14 (6.27)
	Milching	26	34	9
	Non-milching	17	27	5
3.	Jersey cow	2 (1.47)	5 (1.35)	6 (2.69)
	Milching	2	3	4
	Non-milching	0	2	2
4.	Buffalo	15 (11.03)	35 (9.45)	27 (12.10)
	Milching	10	19	12
	Non-milching	5	16	15
5.	Goat	30 (22.05)	111 (30)	160 (71.75)
6.	Calf	13 (9.55)	35 (9.45)	8 (3.58)
7.	Mule	--	8 (2.16)	--
	Total	136 (100)	370 (100)	223 (100)

n= village population, - data not available

3.2 Fodder consumption

After harvesting of the agricultural crops animals were allowed for open grazing on the fields, till field preparation for the next crop. It was observed that per day fodder consumption was slightly higher during summer season (April-September) than winter season (October-March); mainly due to availability of agricultural weeds and abundant grass during summer. Rawat *et al* (2009) [27] also reported the same consumption pattern in Lahaul valley of Himanchal Pradesh. Dhanai *et al* (2014) [4] observed fodder consumption was highest during rainy season and it was lowest during winters in Takoligad watershed of Garhwal Himalaya. In present study fodder consumption was recorded highest for buffalo in all villages. Fodder consumption by buffalo was 18.90 kg day^{-1} and 17.88 kg day^{-1} at Kantli, 18.58 kg day^{-1} and 18.46 kg day^{-1} at Dhaniyakot and 18.43 kg day^{-1} and 18.06 kg day^{-1} at Dabra-Saonral village during summer and winter, respectively followed by Jersey cow, Ox, *desi* cow, mule, calf and goat (Table 2). Per day fodder consumption by the same category of animal varied in all villages whereas feeding frequency at all the villages was found similar.

Total requirement of fodder was calculated by multiplying the number of each category of animals with its daily fodder consumption value (kg/day). It was calculated separately for both season *i.e*., summer and winter and added for total requirement. It was 6344.45q, 13883.22q and 6025.62 at Kantli, Dhaniyakot and Dabra-Saonral villages, respectively. While comparing two regions *i.e.* Garhwal and Kumaun, the highest green fodder consumption was reported at higher elevation in Garhwal while, the consumption level are more in middle altitudes of Kumaun (Pratap, Quereshi, 1992) [21]Further, Fodder consumption of a village dependents on livestock population, nature of fodder and size of animal. Limited fodder supply affects the health, productivity and working capacity of livestock (Nautiyal *et al*., 1987) [15].

Table 2: Fodder consumption pattern day^{-1} animal^{-1} in villages of Kosi watershed

Animal	Kantli		Dhaniyakot		Dabra-Saonral	
	Number (n)	Kg/day	Number (n)	Kg/day	Number (n)	Kg/day
1. Ox	33		79		08	
Summer		17.11		16.67		17.00
Winters		16.89		16.48		16.80
Feeding frequency		2		2		2
2. *Desi* cow (local breed)	43		61		14	
Summer		15.45		15.39		15.5
Winters		15.19		15.05		15.17
Feeding frequency		2		2		2
3. Jersey cow	02		05		06	
Summer		17.50		17.8		17.67
Winters		17.00		17.35		17.33
Feeding frequency		2		2		2
4. Buffalo	15		35		27	
Summer		18.90		18.58		18.43
Winters		17.88		18.46		18.06
Feeding frequency		2		2		2
5. Goat	30		111		160	
Summer		3.5		4.20		4.1
Winters		3.5		4.07		3.85
Feeding frequency		2		2		2
6. Calf	13		35		08	
Summer		7.63		7.32		7.88
Winters		7.50		7.57		7.83
Feeding frequency		2		2		2
7. Mule	--		08		--	
Summer				13.00		
Winters				12.00		
Feeding frequency				2		
Total number	136		370		223	
Fodder requirement (Q/yr)		6344.44		13882.22		6025.62

3.3 Fodder production:

In all three villages of Kosi watershed, there were three important sources of fodder production: agroforestry, natural forest and purchased grass. Agroforestry includes tree present on crop fields, by products and waste part (tender parts and green leaves) of traditional crops like paddy, wheat, maize etc. and cash crops like pea, potato and vegetables, grasses in interspaces of terraces and agriculture weeds. Agroforestry was the major contributor of fodder in all the study villages. Obtained results showed about 45% of required fodder at Kantli and about 50% of required fodder at Dhaniyakot and Dabra-Saonral was produced from agroforestry (Table 3). Under agroforestry, residue of food crops was a good source of fodder for livestock. In the larger part of north western Himalaya (Sharma, Minhas, 1993; Singh *et al*, 1997) [31, 34]. and the central Himalaya (Kuniyal, 1987; Semwal, Maikhuri, 1996; Kuniyal, Pandey, 1997; Maikhuri and Semwal, 1997; Maikhuri *et al*., 2001) [9, 30, 34, 12], two successive crops are harvested in a year and provide a substantial amount of forage to livestock. On the village level, it has been estimated that

indigenous agroforestry system contributes about 50.1% to 78.01 % of total fodder production (Vishvakarma *et al*, 1998; Rawat, Vishvakarma, 2011) [34, 28]. Apart from agroforestry, nearby forests also share a major portion of total required fodder. People of Kantli and Dabra-Saonral village relatively more dependent on forests for green forage and fodder, here forest share 40.30 % and 34.67% of the total fodder production. In Dhaniyakot, forest share 29.72% of total fodder production. Total extracted fodder from nearer forests range between 49%-87% in some studies (Pratap, Quereshi, 1992; Singh *et al*., 1998, Islam *et al*., 2015) [21, 36, 7]. Trees are excellent source of green fodder during winters and may provides 50-90% forage demand during lean periods (Negi, 1977) [16]. Shortage of fodder was found more in Dhaniyakot here 19.53 % fodder was purchased from external sources *i.e*., market and near villages. In Dabra-Saonral and Kantli village about 15% fodder was brought from external sources to meet out the shortage fodder. In hilly regions, availability of green nutritious fodder is low that is one of the major causes of low productivity of livestock (Debroy *et al*., 1980) [2]. The main reasons for low productivity may be less area under fodder crops, uncontrolled grazing, poor management practices, low quality fodder, heavy livestock population and unscientific management of fodder trees (Debroy, 1993; Dev, 2001) [3, 1].

Table 3: Annual fodder production (quintal) in villages of Kosi watershed

Source	Kantli	Dhaniyakot	Dabra-Saonral
	Production (q)	Production (q)	Production (q)
1. Agroforestry	2853.09	7045.23	3030.71
(a) Agriculture	138.30	326.16	37.01
• Traditional crops	122.38	152.19	11.10
• Cash crops	16.41	173.97	25.91
(b) Tree leaves	1669.85	4551.97	1898.10
(c) Grass from crop fields	1046.83	2167.01	1095.60
2. Grass/green leaves from forest	2556.80	4125.79	2089.56
3. Purchased grass	934.53	2711.19	905.35
Grand Total	6344.44	13882.22	6025.62

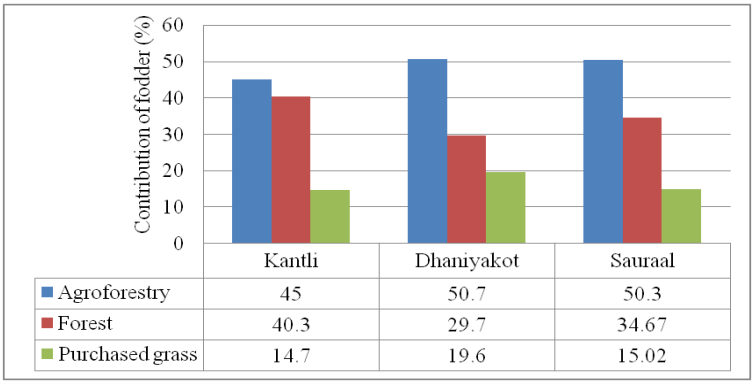

Fig 4: Contribution of various sources of fodder in meeting total requirement in villages of Kosi watershed

4. Conclusion

This study provides comprehensive information on livestock population, production and utilization of fodder along an altitudinal gradient of Kosi watershed. Indigenous agroforestry is the important, ideal and suitable practice for fodder production in this region. Attempt should be taken to increase area under agroforestry by government policies and social forestry programmes like afforestation, reforestation etc., to meet the fodder requirement of growing livestock population and reducing pressure on the valuable natural forests.

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