The Roles of Indigenous Knowledge in Managing Natural Pasture Land and Key Socio-Economic Drivers for Diminishing Grazing Land Holding

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ABSTRACT

This study was conducted in Kofele district, West Arsi Zone of Oromia Regional State, Ethiopia. It was aimed at describing the traditional livestock feed sourcing practices and highlight the roles of indigenous knowledge in managing natural pasture land and identifying the key socio-economic drivers for diminishing holding of grazing lands. The district was stratified in to highland (2500-3200 m.a.s.l) and midland (2200-2500 m.a.s.l) agro-ecologies. Household (HH) survey using semi-structured questionnaires, focus group discussions and key informant interviews were used to collect qualitative and quantitative data, which were analyzed using descriptive statistics and regression analysis. The results showed that majority of the farmers practice mixed crop-livestock farming. Average land holding per household was reported to be 2.24 hectares (ha) of which 1.27 and 0.92 ha are allocated for crop cultivation and natural pasture, respectively. Natural pasture, crop residues, enset by-products, agro-industrial by-products and improved forage represent about 56.5%, 29%, 9.5%, 2.3% and 1.1% of the available feed resource. About 93.3% of the respondents reported that the landholding per HH is declining through time. The area of grazing land is affected ($p<0.01$) by total land holding and the size of crop and forest land. The study revealed that the farmers in Kofele district have the tradition and many years of experience in livestock keeping and grassland management practices. Private enclosure, standing hay or kaloo, wet-land drainage and fencing of grazing land were found to be the traditional method of grassland management in Kofele district. Appropriate land allocation, grassland management practice such as controlled grazing and cut and carry feeding, proper feed conservation and empowering traditional grassland management practices should be considered. Future studies may show the grassland compositions, diversity and its impact on livestock production and productivity.

Keywords: Feed resources; mixed crop-livestock; indigenous knowledge; grazing systems

INTRODUCTION

The highlands of Ethiopia with altitudes of above 2000 m.a.s.l, cover 37% of the total land area of the country, but carried the majority of human and livestock population (CSA, 2018), where rain-fed mixed crop-livestock agriculture is the mainstay of smallholder farmers. Grasslands provide various ecosystem services in addition to serving as a cheap source of animal feed, and thus proper management and maintenance of grasslands is essential for the sustainable intensification of the smallholder mixed

agricultural production system in the highlands of Ethiopia. The mixed farming system in the highlands of Ethiopia is characterized by high integrations and competitions between crop and livestock production systems. Livestock serve as source of farm inputs, food, cash income and capital savings, while crop cultivation provides animal fodder in the form of crop residues (IBC, 2012; Amedie and Kirkby, 2004).

Natural pasture is the major feed resource in Ethiopia. However, its contribution has been declining from as high as 80-90% of the total feed supply in the 1980s (Mengistu et al, 2017) to about 56% (CSA, 2018). The increasing population pressure, and hence the need for more food crops forced the expansion of arable lands at the expense of grassland and forestlands. Coupled with the diminishing pasture area, the productivity of the available grasslands continued to decline due to land degradation, over grazing and climate change (Dejene, 2003; Mengistu, 2004; 2006; Bezabih, 2013). Currently, the country is facing critical feed shortage and hence depend on seasonally available feed resources and heavily relies on poor quality crop residues as animal feed (Tolera *et al.* 2012; Lemma, 2016).

Grasslands are important and cheap sources of livestock feeds. Therefore, keeping the grassland diversity and biomass is vital for sustainable growth. Sustainable use of grassland demands a context specific management strategy that takes into account traditional knowledge/practices (Mengistu et al., 2017). Indigenous knowledge plays paramount role in the sustainable use of grassland and other natural resources and builds on the existing knowledge towards improved management practices (Angassa *et al*., 2012; Otte and Chilonda, 2002). The current study aims to investigate the indigenous knowledge and practices of farmers in the study area as well as the trends and drivers of change in pasture land availability and livestock productivity.

MATERIALS AND METHODS

Description of Study Site

This study was carried out in Kofele district, West Arsi Zone of the Oromia Regional State, located at $7^0$9'60.00"N and $38^0$49'59.99"E (Fig 1). The district has a typical highland agro-ecology, with an altitude ranging from 2200 to 3200 m.a.s.l (Kofele Agriculture and Natural Resources Management Office, 2017; unpublished report). The area receives an average rainfall of 1800 mm per annum and has bi-modal rainfall distribution with small rains extending from March up to May and the main rainy season extending from June to September/October. The agricultural landscape in the district is dominated by two types of land use systems, small farmland around homestead usually dedicated for vegetable and Enset production and a relatively larger/main portion of the land away from the homestead in most cases, sometimes at distances as far as 20 km where cereal crops (notably wheat and barley) are grown in the midland villages, and also pastureland which is reserved for cattle.

Study Design

The study involved individual interviews on randomly selected farm households, focus group discussions and key informant interviews. To identify representative farm households, the district's rural *kebeles* (smallest administrative units) were grouped into two altitude groups, namely mid-land and highlands. The district has a total of 38 rural *kebeles*, of which 74% are located in highland (2500 to 3200 3200 m.a.s.l) and 26% in midland (2200 to 2500 m.a.s.l). Proportional to the size of the two agro-ecologies of

the district, four *kebeles* from high altitude and two from midland altitudes were selected randomly from the list. The participating household sample size of the selected *kebele* was determined using the formula suggested by Yamane (1967).

$$n = \frac{N}{1 + N(e)^2}$$

Where n= is the sample size; N= total HH size; e= marginal error.

Accordingly, the total sample size was 150 households, randomly selected from the two major agro-ecologies.

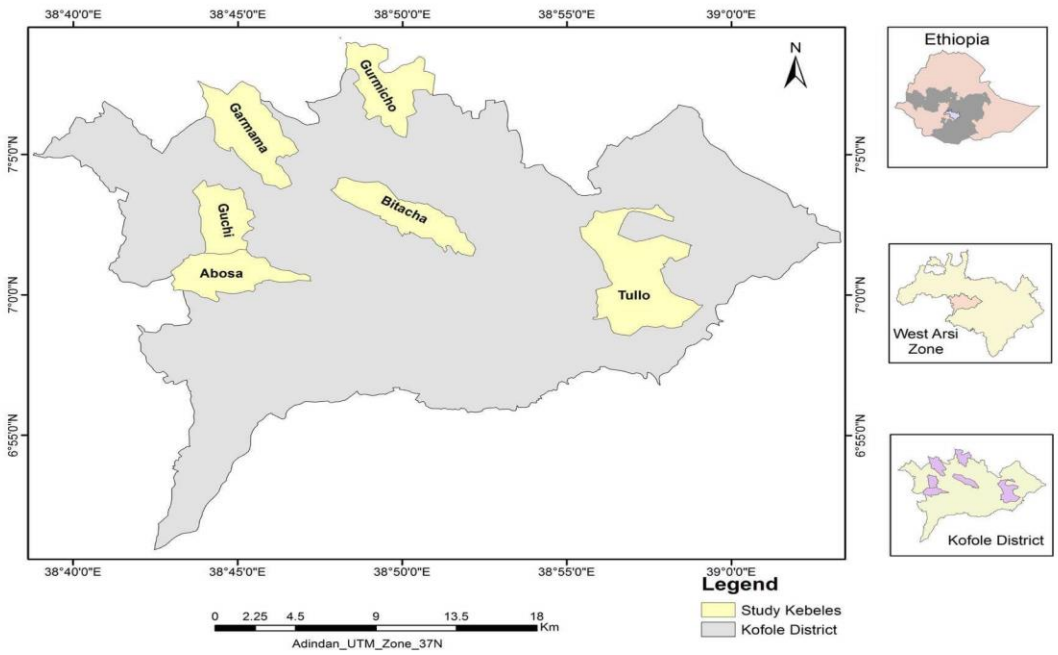

Figure 1.Map of the study area

Data Collection

A reconnaissance survey was conducted in the district and key informant interviews conducted with elderly farmers, development agents and district officials. This was followed by separate focus group discussions for each of the two agro-ecologies using a checklist of questions. For the individual interview, a semi-structured questionnaire was developed, pretested and refined before the tool was employed to generate primary data on household characteristics, farming practices, use patterns, traditional grassland management practices, access to services, and challenges in relation to feed sourcing and livestock production. For assessment of feed resources, feed assessment tool (FEAST) developed by Duncan et al (2012) was used to assess local feed resource availability and to estimate it's contribution/by proportion.

Data Analysis

A descriptive analysis was conducted to describe farm household socio-economic characteristics and traditional grassland management practices using SPSS. A Multiple Linear Regression Model (MLRM) was used to explore relationships between socio-economic characteristics of the participating households and proportion of pastureland at household levels.

Variables selection and hypothesis

The conceptual framework of the study and variables for MLRM were identified thorough literature reviews. The response variable was grazing land size (ha) at HH level and it was taken as continuous variable while seven independent variables namely crop land size (ha), livestock holding (TLU), total land holding (ha), family size, forest land size (ha), proximity to urban center (km) and amount of unsuitable land for agriculture (ha) were identified.

Grazing land size (Y): Grassland is assumed to be associated with the socio-economic factors, means of livelihood of farmers and interests of farmers to focus on livestock farming over other farm activities. The hypothetical associations between the response variables and independent variables are outlined as follows:

Livestock holding (X_1): is the total livestock holding (TLU) that was owned by the HH. According to the national livestock census, the total livestock population (cattle and small ruminants particularly) in the country is increasing while the per capita holding is declining. Famers reduce the stock size when they have small farmland holding (Emana *et al*., 2015). It was hypothesized that more livestock holding at household level means farmers have more pasture land allocated for their livestock as important source of feeds.

Crop Land Size (X_2): was the second explanatory variable expressed by a size of a land in hectare used for crop cultivation by each sampled HH in the area. It was hypothesized negative relationship between grazing land size and crop land size for this model, which implies that farmers increase the size of the cropland at the expense of pastureland (Tadesse *et al*. (2017).

Total Land Holding Size (X_3): According to Teshome (2014) in the highlands of Ethiopia household land per capita is decreasing over time and it affected grazing land size. Similarly, it is hypothesized that the total land holding per household and grazing land size are positively correlated.

Family Size (X_4): The IBC (2012) reported that an increase in family size has resulted in declining land holding as parents redistribute farmland for their children when they leave at maturity age.

Forest Land Size (X_5): Area of land (ha) used for private forest plantation for commercial purposes by each sample household. We hypothesized negative relationship between forest land size and land allocated for pasture.

Distance to Urban Center (km) (X_6): is the distance in kilometers by which each sampled households are settled from urban center. We hypothesized a negative relationship between grazing land sizes and proximity to urban center for this model.

Degraded Land Size (ha) (X_7): is the land size in hectare that is not suitable for agricultural activities in each sampled HH in the area. We hypothesized that the more unsuitable land a farmer owns he might allocate the land for livestock farming rather than for crop activities.

Model specification

According to Gujarati (2004) regression model used when the study involves more than two variables and the following MLRM equation was used:

$Yi = \beta0 + \beta1X1 + \beta2X2 + \beta3X3 + \beta4X4 + \beta5X5 + \beta6X6 + \beta7X7 + \varepsilon i.$

Where Yi = Grazing land size as a dependent variable

$\beta0$ = constant

Livestock holding (X1), crop land size (X2), total land holding (X3), family size (X4), forest land size (X5), distance to urban center (X6) and size of land unsuitable for farming (X7) were independent variables. The $\beta1$, $\beta2$, $\beta3$, $\beta4$, $\beta5$ $\beta6$ and $\beta7$ represents coefficients of the respective independent variables, whereas εi = the residual variance in Y after taking into consideration the effects of the Xi variables included in the model. Before fitting variables into the regression models for analysis, multicollinearity problem among variables was tested, to identify the separate effect of independent variables on the dependent variable because of existing strong relationship among them.

RESULTS

Land holding of the participating households

The land holding and land allocations for various farming practices of the participating households are shown in Table 1. The land holding in the study area ranged between 0.06 and 6 ha. However, most farmers own farmland in the rages of 1 and 2.5 ha per household, whereas the overall average land size in the study area was 2.24 (±1.41) (Table 2)

Table 1. Land holding per household in the study area

Land size categories (ha)	Agro-ecology (%)		Overall mean n=150
	High altitude n=93	Midland altitude n=57	
0.06-0.25	2.15	0.00	1.08
0.26-0.99	16.13	7.02	11.57
1-2.5	56.99	66.67	61.83
2.6-6	24.73	26.32	25.52

From the total land holding, farmland allocated for cropping activities was the highest followed by natural pasture. The average farmland holding varied between the two agro-ecologies; farmers in the highland had lower farmland size than their counterpart in the mid-altitude (Table 2).

Table 2. Mean (± SE) farmland holding (ha) and land allocations (ha) by farm households

Variables	Agro-ecology		
	Highland (n=93)	Midland (n=57)	Overall (n=150)
Grazing land	0.81±0.66	1.03 ±0.89	0.92±0.78
Crop land	1.18±0.73	1.35±0.86	1.27±0.80
Forest land	0.05±0.11	0.03±0.06	0.04±0.08
Overall land size	2.04±1.28	2.43±1.53	2.24±1.41

Table 3 shows how farmers first received farmland and their perceptions on the trends of farmland ownerships in the area. Majority of the farmers inherited their farmland from their parents and benefitted from farmland redistribution programs by the government. Over years, farmers realized/perceived that farmland holding is shrinking from generations after generations when inherited from their parents and even by the redistribution programs.

Table 3: Land source for both crop and grazing land in the study area (N=150)

Variables	Parameters	By agro ecology (%)		Overall (n=150)
		Highland (n=93)	Midland (n=57)	
Source of land	Land redistribution	41.94	24.56	33.25
	Inherited from parents	53.76	68.42	61.09
	Shared from relatives	4.30	7.02	5.66
Land holding trend	Decreasing	93.55	92.98	93.27
	No change	6.45	7.02	6.73

Feeding practices

Table 4 shows the common livestock feeding practices in the study area. The findings show that free grazing is the most common method of feeding ruminant livestock followed by tethering whereas the practice of stall feeding is very rare in the area. Feed availability and quality is low during the long dry and long rainy seasons. On the other hand, the incidence of feed shortage is much lower during the short rainy season.

Table 4. Feeding practices followed by farmers and main seasons feed scarcity in study area

Variables	Parameters	Agro-ecology (%)		Overall (n=150)
		Highland (n=93)	Midland (n=57)	
Method of animal feeding	Free grazing	63.40	57.90	60.65
	Tethering	24.80	29.80	27.30
	Herded grazing	7.50	8.80	8.15
	Stall feeding	4.30	3.50	3.90
Feed shortage season	Long dry season	44.00	52.60	48.30
	Long rainy season	33.30	26.30	29.80
	Short dry season	16.20	17.50	16.85
	Short rainy season	6.50	3.60	5.05

The major feed resources and its importance by month of the year are shown as Figures 2 and 3, respectively. Rotational grazing is practiced by only 8% of the households, in which the farmers allocate portion of pastureland (blocks), for 1-2 months particularly maintained for selected livestock species, like oxen and young stocks, which is locally termed as *Kaloo* (standing hay). As shown in Figure 3, natural pasture remains the dominant source of feeds for livestock, especially from June to November.

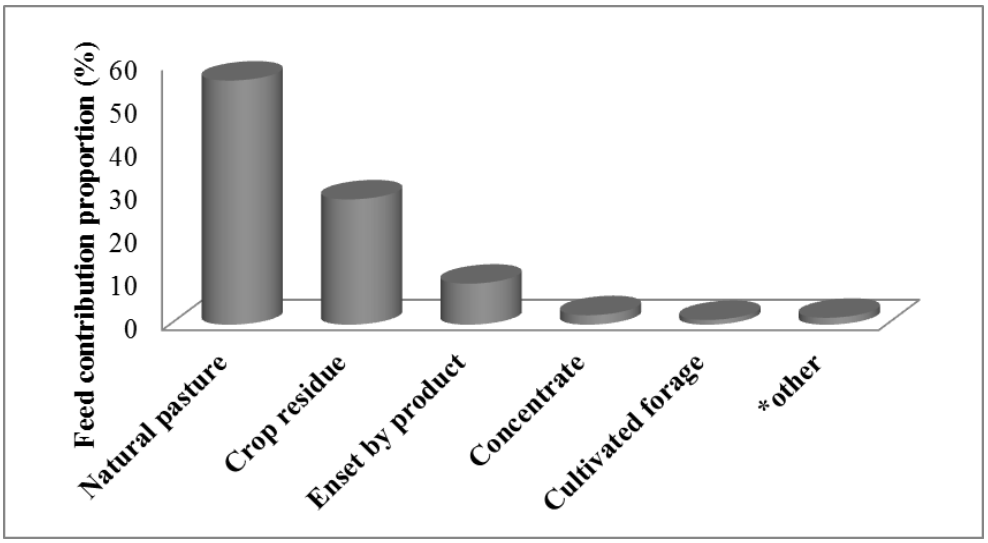

Figure 2: Major feed resources in the study area

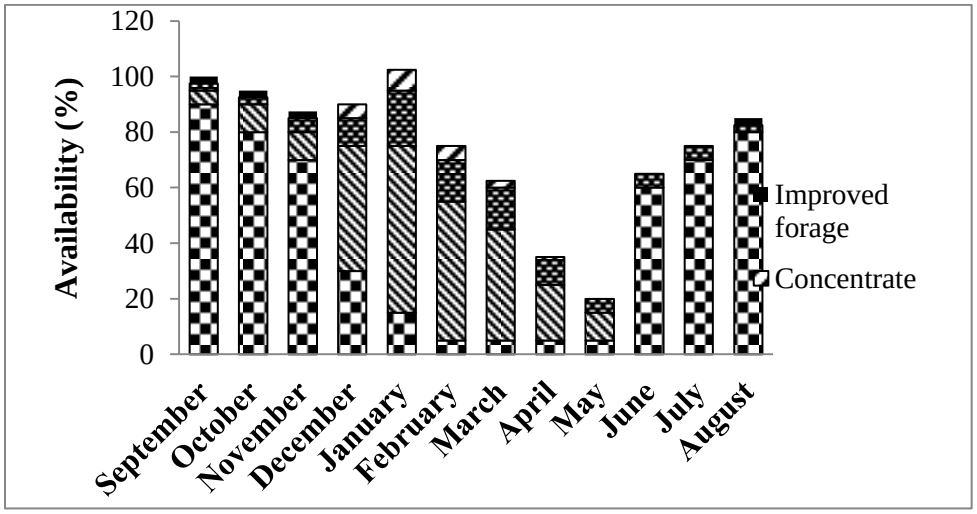

Figure 3: Major feed resources in the study area, its importance by months of the year

Feed conservation practices

Table 5 shows the feed conservation practices in the study area. Conservation of crop residues was the main strategy used to alleviate feed shortage during scarce seasons in the study area. Study result shows that crop residues are mainly conserved from own farmland. Farmers mainly judge the straw quality by qualitative organoleptic characteristics including color, type of straw itself, appearance and level of maturity. Among the cereals, barley straw is the most widely accepted crop residues preferred by most farmers, compared to teff (*Eragrostis tef*) and wheat straws.

Table 5. Crop residue conservation practices in the study area

Variables	Parameters	By agro ecology (%)		Overall (n=150)
		Highland (n=93)	Midland (n=57)	
Farmers' engagement in feed conservation	Yes	77.40	82.50	79.95
	No	22.60	17.50	20.05
Method of storage	Stacked out side	83.30	78.70	81.00
	Stacked under shade	13.90	6.40	10.15
	Baled out side	2.80	4.30	3.55
	Baled under shade	0.00	10.60	5.30
Indicators used by farmers to evaluate feed quality	Residue type	46.20	15.80	31.00
	Color	24.70	36.80	30.75
	Smell	10.80	33.30	22.05
	Appearance	15.10	10.50	12.80
	Maturity	3.20	3.60	3.40

Traditional Grassland Management

To maximize grassland productivity, the farmers traditionally use different management practices (Table 6). Fencing of private grazing land or enclosure is the main means of pastureland management strategy practiced by most of the farmers in the study area, which is more common in the midland than in the highland agro-ecology. Draining of swampy areas is the second most important management practice, which is more prevalent in the highland agro-ecology. About 60% of all the respondents perceive the purpose of enclosures as a means of overcoming feed shortage whereas the remaining about 40% of the respondents value it as a means of rehabilitating the pastureland.

Table 6. Traditional management practices in the study area

Variables	Parameters	By agro-ecology (%)		Overall (n=150)
		Highland (n=93)	Midland (n=57)	
Management strategies	Fencing	64.7	74	69.35
	Draining of swampy land	23.3	16	19.65
	Fire application	9.3	10	9.65
	Bush clearing	2.7	0	1.35
Do you use enclosure	Yes	69.9	82.5	76.20
	No	30.1	17.5	23.80
Farmer opinion on purpose of enclosure	Overcome feed shortage	58.06	63.16	60.61
	Rehabilitation	41.94	36.84	39.39

Table 7 shows the perceptions of farmers on the current condition of grazing land as compared with the condition of the grazing land about 30 years ago. Farmers rated the pasture conditions as poor, fair and good. In addition, the farmers strongly perceived that the current condition of the natural pasture is poor, mainly due to the weakening of customary management practices as compared to the previous years.

Table 7. Farmers perceptions on current grassland condition in the study area

Parameters		By agro-ecology (%)		
	Criteria	Highland	Midland	Overall (%)
Condition of grassland	Poor	90.30	87.70	89.00
	Fair	7.50	7.00	7.25
	Good	2.20	5.30	3.75
	Weak	93.50	87.70	90.60
Traditional management trend	Strong	5.40	7.10	6.25
	The same	1.10	5.20	3.15

Factors affecting grazing land size: a regression analysis

The adjusted R^2 value of for the regression analysis employed was found to be 0.98, showing that 98% of the variation in grazing land size at household level can be explained by the selected household socio-economic variables. Table 8 shows the significance test for regression among different variables. The result shows that total farmland size, land allocated for cropping activities as well as forest area have significant relationship ($p<0.011$) with pasture land size owned farm households.

Table 8.Regression coefficients and their significance for the variables used in the analysis

Variables	Unstandardized Coefficients (B)	Sig.	VIF
(constant)	0.001		
Livestock holding (TLU)	0.001	0.808	2.095
Crop land	-0.963*	0.000	5.709
Land holding size	0.982*	0.000	6.256
Forest land	-0.971*	0.000	1.116
Family size	-0.001	0.818	1.053
Urbanization	-0.001	0.524	1.160
Land degradation	-0.127	0.556	1.103

* indicates regression relationship is significant at 1%

DISCUSSION

Farm and Grazing Land Holding

The results of the current study showed that mean land holding of 2.24 ha per household is higher than the Ethiopian national average farmland size. According to Headey et al. (2014) the national average farmland size was reported to be 0.96 ha per household with variations among regions. Oromia Region has the largest 1.15 ha per household, while Amhara Region has 1.09 ha, whereas Tigray and Southern Peoples Regions having relatively smaller values each having 0.49 ha. Over 72.1% of the households are operating agricultural practices on smaller than 1 ha land. Therefore, study area is endowed with relatively larger land holding. However, farmers believe that as farm size is declining and larger portion of land is dedicated to the recently growing trends of cropland expansions, hence farmers are switching to crop residue feeding to their animals. The farmland dedicated for pasture development/grazing is declining and the productivity of existing grazing land is declining. The result of this study is in agreement with other findings such as Österle *et al.* (2012), who reported a higher tendency of converting a grazing land into cropland in the high lands of Ethiopia. The shrinkage of grazing land, due to expansion of cropland, leads to overgrazing and causes significant reduction in the availability and diversity grass biomass, favoring less productive grass species. For example, dominance of *Pennisetum sphacelatum* is a common indicator of overgrazed areas (Sylvia, 2014).

Feed Resources Availability and Livestock Feeding Systems

Natural pasture was reported to be the major feed resources in the study area, accounting for about 56.5% of the available feed resource. This is consistent with other findings in Ethiopia (Tolera *et al.* 2012; Mengistu et al, 2017; CSA, 2018) showing that natural pasture is still the dominant feed resources in the highlands of Ethiopia, although its contribution is declining over years. Crop residues are the second most important feed resources in the area, and play a pivotal role during the dry season. Their availability is closely related with type of farming system, types of crops produced and intensity of cultivation. The dominant crop residues used as livestock feed in the study area include wheat and barley straws and as well as *enset* by-products.

Feed availability and livestock feeding practices in the study area are greatly dependent on the growing season. There are also variations among households due to differences in land ownership, which also determines livestock holding. Key informants explained that feed shortage commonly occurs during the long dry season (December-February) and during the long rainy season (June-August). During the long dry season, there is no growth of pasture and the available pasture and other feed resources are depleted whereas during the long rainy season most of the available land is covered with crops and crop residues are depleted. However, the degree of the problem varies with agro ecologies; the problem being more serious in the highland agro-ecological zone. There are also variations among households, due to differences in farmland sizes, those farmers who have larger farmland could dedicate more land for pasture/grazing and hence can better sustain even during dry season by conserving standing hay. SIn the study area, communal land is converted to private land. Unlike in the past decades, communal grazing is on the verge of disappearing. In terms of pastureland management and use, farmers have priorities to cattle, particularly to calves, draft oxen and lactating cows in in that order.

The prevailing livestock feeding systems in the study area include communal grazing, herded grazing, tethering and cut-and carry indoor feeding (zero grazing). Unlike in the past decades, the area dedicated for communal grazing in various parts of the district is declining, hence farmers are relying more on privately owned grazing areas. The feeding method used varies with season i.e. free grazing was the main feeding strategy during dry season. Tethering was mainly practiced during heavy rainy season, which also overlaps with crop season and farmers restrict the movement of their animals to avoid trumping on their crop fields. In terms of pastureland management and use, farmers give priority for cattle, particularly for calves, draft oxen and lactating cows in in that order. Uncontrolled free grazing could lead to the depletion of feed resources through overgrazing which could contribute to low productivity of livestock (Mengistu, 2002; Gebremedhin *et al.*, 2004).

Traditional Grassland Management

To maximize grassland productivity, farmers traditionally uses different management strategies such as the use of private enclosure (*Kalo*), fencing and draining of marshy area The pastureland conserved as standing hay (Kalo) is particularly and preferentially used for draft oxen during peak cropping seasons, lactating cows, and weak animals during long rainy seasons. Excess accumulation of water on natural pasture land was one of the major challenges for livestock owners in the wetlands of the highland agro-ecological zone. Unless such excess water is drained, it affects forage availability and vegetation growth rate (Funte *et al*, 2010).

Factors Affecting Grazing Land Holding

The study area is known to supply a large volume of rain fed crop products, notably vegetables as important cash crops, such as potato, round cabbage, beet roots and onions. According to key informant interviews, over decades farmers in the study area have been allocating the major portions of their farmland for such cropping activities, usually diminishing the proportions of natural pasture land, while leaving smaller propositions of land as natural pasture/grazing areas.

CONCLUSION

The study highlighted that gradual expansion of crop cultivation is changing the agricultural landscape of the study area causing shrinkage of grazing areas and declining contribution of grassland as importance sources of feeds for livestock although the area was once a typical grassland and livestock production used to be a major means of livelihood. The area of pastureland per household is determined by the size of total land holding and the area of land allocated for crop production and tree plantation by the family. Future studies should focus on evaluation of grassland compositions, diversity and its impact on livestock production and productivity.

ACKNOWLEDGEMENT

This work was funded by International Atomic Energy Agency (IAEA) research contract 20781/RO and coordinated by School of Animal and Range Sciences, Hawassa University. We are grateful to Kofele district livestock and fishery resource office staffs and to all enumerators who helped in data collection and all the interviewed farmers for their willingness and interest to provide information.

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