academicresearchJournals

Vol. 4(6), pp. 245-254, November 2016
DOI: 10.14662/ARJASR2016.031

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

Grazing pressure and trends of livestock production: A Case of *Gudoberet* watershed, North *Shewa*, central highland of Ethiopia

Wuletaw Mekuria[1*], Workneh Negatu[2], Kindu Mekonnen[3]

[1] Centre for Rural Development, Addis Ababa University, P.O. Box 1176, Ethiopia
[2] Centre for Rural Development, Addis Ababa University, P.O. Box 1176, Ethiopia
[3] International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia

*Corresponding author, Email address: wuletaw.m@gmail.com or wuletaw.mekuria@aau.edu.et

Accepted 24 October 2016

This study was carried out in *Gudoberet* watershed, North *Shewa* Zone of *Amhara* National Regional State, Ethiopia. The objectives of this study were to diagnose trends and patterns of livestock production and to estimate grazing pressure in the study area. Heads of 211 households were interviewed to evaluate livestock production trends and feeding systems in the farming system. Results showed that 92.4% of smallholders engaged in livestock production that played a significant role for the source of income and draught power in the watershed. Although grassland has increased at the rate of 2.1% per year, livestock population has an increasing trend of 5.5% per year. The major feed resources in the watershed were crop residue and aftermath (38.7%), natural grazing (29.9%), grass species (19.0%), local residues (9.9%), agro-industrial byproducts (2.5%), and some forage shrubs. Tethering, strip foraging, free access, and rotational grazing were the main feeding systems. The estimated quantity of available feed was less than the annual requirements with grazing pressure value of 1.42. Feed shortage, low livestock productivity, and crop-livestock competition were the major constraints in the study watershed. Thus, technical support from various institutions and further research in livestock nutrition can minimize livestock production challenges.

Key words: Feed balance, Feeding strategy, Production pattern, Smallholder

Cite this article as: Mekuria W, Negatu W, Mekonnen K (2016). Grazing pressure and trends of livestock production: A Case of *Gudoberet* watershed, North *Shewa*, central highland of Ethiopia. Acad. Res. J. Agri. Sci. Res. 4(6): 245-254

INTRODUCTION

In Ethiopia, nearly 80% population depends on rain-fed agriculture (World Bank, 2013). Agriculture contributes for 80% of export earnings, 83.4% of employment opportunities (ILO, 2014), and 39% of national Growth Domestic Product, GDP (NPC, 2016). Livestock production has a large role in ensuring food security, minimize risks, means of resilience in uncertain conditions, mitigate climate change, and insurance against crop failure at the time of rainfall shortage (CSA, 2014; Iiyama et al., 2007; Kuria et al., 2014). Livestock generate more than 85% of cash income, 16% of export earnings (Yayneshet 2010), and 7.9% of national GDP (NPC, 2016). Provision of food, manure, draught power, source of energy, transport services (CSA, 2014), offsprings, and socio-cultural services are some of significant roles of livestock production. Moreover, livestock can boost crop yields by providing 25% of the nitrogen requirements through application of manure (ILRI, 2014).

Population pressure, malnutrition, tenure insecurity, excessive land fragmentation and land degradation are the main confronts in the highlands of Ethiopia (Awulachew et al., 2008; IFAD, 2013; Melkie, 2007; Nigussie et al, 2015). Moreover, soil loss, negative impact of climate change, and poverty are among the persistent challenges in the highlands (Badege, 2009; IFAD, 2013; Liniger et al., 2011; WFP, 2014; Yitebitu et al., 2010). Livestock production has constrained by unsolved bottlenecks. Low level of adoption in agricultural technologies resulted in low productivity for livestock production (IFPRI, 2011). In addition, crop-livestock competitions induced for allocation of more of land resources to crops (Amanuel, 2014; Diress et al., 2010; Herrero et al., 2012; Messay, 2011; Yodit and Fekadu, 2014).

Most studies on feed resources conducted in Ethiopia have focused on Dry Matter (DM) estimation as well as energy and crude protein determination (Belay, et al, 2012; Duncan et al., 2016; Endale et al., 2016; Mergia et al., 2014; Valbuena et al., 2014; Yisehak and Janssens, 2014) without taking into consideration changes in land-use and patterns of livestock production. On top of these, trends in temporal aspects of livestock production were less studied with regard to land use/land cover in Ethiopia in general and the study watershed in particular.

The specific objectives of this study were therefore: (1) to diagnose trends and patterns of livestock production along with land-use change, and (2) to assess feed resources and estimate grazing pressure for the existing livestock population in smallholder system of the study watershed.

METHODS

The study area: agro-ecology and socio-economy

The study was undertaken in *Basona Worana Woreda*, North *Shewa* administrative zone, *Amhara* national regional state, Ethiopia. *Gudoberet*-the study watershed is located between latitudes 9°76′ and 9°81′ North, and longitudes 39°65′ and 39°73′ East at a distance of 162 km Northeast of Addis Ababa and 32 km in the same direction of *Debre Berhan* town. The watershed covers 2425 ha of land and drains to Blue Nile. Topographically, the catchment lies between an altitude of 2828 and 3700 meter above sea level (masl) with an elevation creased form North to South. In the watershed a high proportion of land (54%) is under cultivation. About 85% of households are accessible to market at a distance not more than 3 km. Agricultural extension service, road networks, electric power line, a number of villages, and small town in *Gudoberet* are some of the key institutions and infrastructures in the watershed. There is no natural forest within the watershed. Nonetheless, eucalyptus trees are the most predominant plantation in the study site. Sheep, cattle, and donkey are the largest livestock population while barley, wheat, and pulse grains are the main crops grown in the study watershed.

Sampling procedure

The study watershed was selected purposively due to representative nature of mixed farming system and delineated based on watershed principles. The watershed has *Dega* and *Wurch* agro-ecological belts. In the upper part of *Wurch* agro-ecology five and in the *Dega* parts fourteen villages were identified. *Wurch*[1] and *Dega* areas are found between 3200 to 3700 and 2800 to 3200 masl respectively. Respondent households were identified using stratified random sampling in the sampling frame of the study population. The total sample size was determined based on the formula given by Yamane (1967) in Israel (2013): $n = N / [(1+N (e)^2]$. *N* is the study population in the watershed, *e* is an acceptance error at a given precision rate, and *n* is the required sample size. Based on census list of the study population a total sample size of 155 in *Dega* and 56 households in *Wurch* were selected from the 19 villages giving a total sample size of 211 households. These respondents were drawn through systematic simple random sampling in probability proportional to size within the study watershed. A household survey was conducted in 2016 to gather information at the household level.

DATA

The map of the watershed (Figure 1) was extracted from topographic maps, Google Earth and satellite images. Both qualitative and quantitative data types were collected from primary and secondary sources. Crop and livestock portfolio, land use/land cover types, feed resources, feeding systems, household income, bio-physical features, production potentials and constraints, and household characteristics are primary data collected mainly through household survey while conversion factors of feed sources and resources, Tropical Livestock Units (TLU), and other verification indicators are secondary data compiled from various sources.

[1] 3200 meter above sea level is used as a lower cut-point for *Wurch* agro-ecology (Addisu, 2014; Kuria *et al.*, 2014)

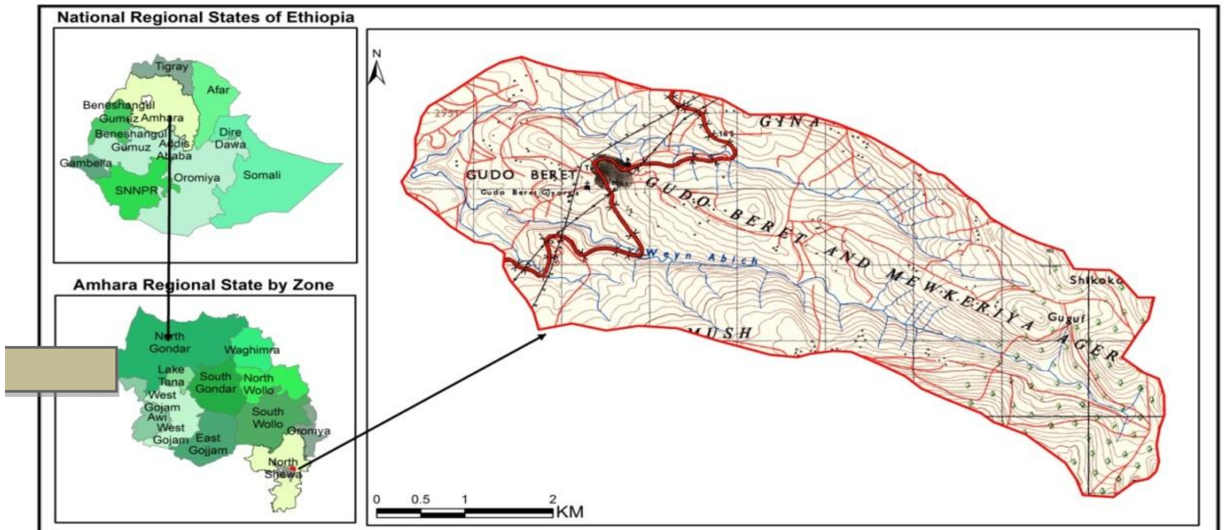

Figure 1. Location Map of the Study Watershed

Methods of data collection and analysis

Prior to respondents' interview, questions were pre-tested and interpreted to the local language (Amharic) and four data collectors and one facilitator were selected and trained. Moreover, preliminary field survey, one focused group discussion, and expert consultation were carried out. A household survey (respondents' interview) was conducted from end of May to beginning of August in 2016 at household level. On top of this, personal observation, coordinate readings, transact walk, and Geographic Information System (GIS) techniques were employed. Crop and livestock types as well as the size of cultivated land in ha and livestock population in number were collected through direct household survey. Livestock body weight was measured using girth rate for five randomly selected samples in each livestock species so as to validate the relationship between TLU and feed requirement.

Land use/land cover and changes across periods were identified using ERDAS imagine 10 which enabled to examine the trends of grazing and cultivated lands. Furthermore, data were collected on feed sources and resources though interview schedule from respondents and calculated using conversion rates. Feed balance, feeding systems, livestock production patterns, and trends of livestock population were estimated. Arc Gis 10.1 and ERDAS imagine 10 were used to generate data and image classification. Besides, Excel sheets and SPSS version 20 were employed for data analysis.

RESULTS

Basic household characteristics

Nineteen villages were identified in *Gudoberet* watershed. Five villages were found in *Wurch* agro-ecology while fourteen villages were established in *Dega* climate. *Ayzosh Amora* is a small village in which only 6 households were living while in *Gudoberet* above road number-I 42 households were settled. These two villages are found in *Dega* areas. The total size of population in *Gudoberet* watershed was about 2070 (male 51.3% and female 48.7%) and 447 households with an average family size of 4.63. The range of the family size was between 1 and 10 members with 64.3% of active labor. A total population density of the study watershed was 85.4 persons per square km. In Boserup's explanation for population density, a category of 64 to 128 persons per square km is densely populated (Boserup, 1981).

The ages of respondents were between 23 and 82 years. The ages of 40.8% youth group were between 23 and 39 years, ages of 49.8% adults were between 40 and 64 years, and 9.4% elders were above 64 years. Nearly, 29.3% of respondents were female-headed households. The housing conditions of smallholders in the watershed were thatched roofs, corrugated sheets and both thatched and corrugated sheets in the proportion of 5.7, 27.5, and 66.8% respectively. The study further indicated that 20.9% of respondents were illiterate while the rest 42.7, 31.3, 4.2 0.9% have had basic, primary, secondary

Table 1: Livestock production trends for 2012 and 2016 in the study watershed

Livestock type	Population size in 2012		Population size in 2016		Change	
	No	TLU	No	TLU	Number	%
Cow	311	248.8	319	255.0	8	2.5
Oxen	517	568.7	610	671.0	93	15.2
Heifer	70	35.0	112	56.0	42	37.5
Immature males	65	39.0	105	63.0	40	38.1
Calf	95	19.0	230	46.0	135	58.7
Horse	70	56.0	74	59.2	4	5.4
Mule	4	3.2	8	6.4	4	50.0
Donkey	411	205.5	521	260.5	110	21.1
Sheep	2529	252.9	3245	324.5	716	22.1
Goat	269	26.9	244	24.4	-25	10.2
Chicken	750	7.5	1576	15.7	826	52.4
Total	5091	1462.5	7044	1781.7	1953	27.7

Source: Survey result (2016)

and tertiary educational levels[1].

Livestock production trends in smallholder system

In the study watershed (Table 1), 92.4% of smallholders owned livestock of which 64% of holders have used livestock as a source of cash income through selling. Livestock contributed for 37.5% of a total income in the watershed. Moreover, food (milk, meat, and eggs), draught power, transport, hide and skin, and socio-cultural services are essential roles of livestock. The result (Table 1) showed that the total livestock population number was 5091 in 2012. The size has increased by 27.7% to a total number of 7044 in 2016 at a growth rate of 5.5% per year. In livestock population, calves have increased tremendously followed by chicken within five years period. This result was in-line with the remark forwarded in the study of Addisu (2014) who stated as, "chicken production has to be prioritized in highland agro-climates."

The link between land use /land cover and livestock production

In Ethiopia, the leading land use/land cover is cropland that shows an increasing trend in many watersheds of the country (Abyot, 2014; Amanuel, 2014; Amare, 2015; Eleni et al., 2013; Hadgu, 2008; Messay, 2011; Nigussie et al., 2014; Yodit and Fekadu, 2014). Despite in *Koga* and *Lenche Dima* catchments, cropland shows a declining trend (Eleni et al., 2013; Hussien, 2009). In *Gudoberet* watershed, the land allocated for cultivation was 1128.96, 1423.98, and 1310.13 in the 1980s, 2000s, and 2010s in that order. Before 2004, cropland had increased by 20.7%. Quite the reverse, between 2004 and 2016, the trend has declined by 7.9% and currently 1310.13 ha (54%) of land is allocated for cultivation purpose. Croplands in the watershed include annual crops, residential areas and homesteads, gullies and waterways, lands inherited to family members, farm lands held by smallholders who reside outside of the watershed. Barley, faba bean, field pea, wheat, potatoes, lentil, and linseed are grown in the watershed in their descending array.

From Figure 2, Cropland and grassland have contrasted dynamics over time. Grassland has declined between 1984 and 2004 from 892.62 ha to 318.69 ha (64.3%). Subsequently, it has increased by 25.3% a rate of 2.1% per year from 318.69 to 426.49 ha. Currently, 426.49 ha (17.6%) of land in the watershed is covered by grassland in free access, communal and individual holdings. Thus, the result of this study has almost similar connotations with the study of Messay (2011) and Eleni et al (2013). The overall change of grassland in those watersheds showed an escalating trend. In contrast, grasslands have declined and changed to other land use/land cover in many other watersheds of Ethiopia (Abyot, 2014; Amanuel, 2014; Amare, 2015; Diress et al., 2010). Although livestock population and grassland have increased mutually, the rate of increase for livestock surpassed the rate of increase for grassland in its proportion.

Feed resources and grazing strategies

In Table 2, feed requirement is estimated as 2.5% (6.25 kg/day/TLU) of body weight in DM equivalent as stated by Gryseels (1988). The contribution of crop residue and aftermath to the total feed supply was estimated to 1105.4 (38.7%). The conversion factors are 1.5 for barley, 1.2 for wheat and pulse crops (Faba bean, field

[1] Basic education (read and write), primary (grade 1 to 8), secondary (grade 9 o 12), and tertiary diploma and above

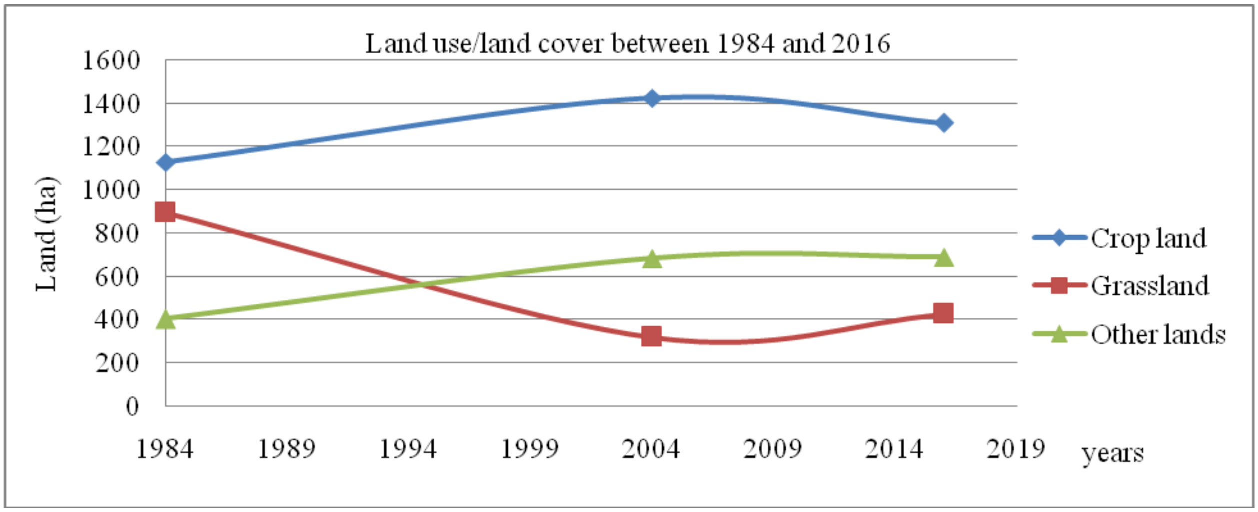

Figure 2: Crop and grassland dynamics in *Gudoberet* watershed

Table 2: Estimated feed resources of DM in the study watershed in 2016

Types of feed	Amount (ton)	Total feed supplied in %
Crop residues and aftermath grazing*	1105.4	38.7
Natural pasture	853.00	29.9
Green forage (hay, grass, oats, grass pea)	541.2	19.0
Agro-industrial byproducts (Oil cakes, concentrates, wheat bran and salt)	71.7	2.5
Improved forage trees	0.9	-
Local beer residues and leftovers	282.4	9.9
Total	2854.6	-

Source: Survey result (2016) *Aftermath was calculated as 509 ha* 0.5= 254.5 t

Table 3: Major crops grown, estimated grain yield and crop residue

Items	Major crops							
	Barley	Wheat	Bean	Pea	Lentil	Linseed	Potato	Total
Cultivated area (ha)	211.10	63.50	114.60	91.00	23.00	6.00	15.0	524.2
Share from cultivated area	40.30	12.10	21.90	17.30	4.40	1.10	2.90	
Grain yield (t/ha)	1.75	1.54	1.26	0.72	0.15	0.45	4.10	
Total grain yield (t/year)	369.40	97.80	144.40	65.50	3.50	2.70	61.5	
Conversion rate*	1.50	1.20	1.20	1.20	1.20	4.00	0.30	
Residue yield DM (t/ha)	2.62	1.85	1.51	0.86	0.18	1.80	1.23	
Residue yield DM (t/year)	553.00	117.48	173.00	78.20	4.10	10.8	18.45	955.0

Source: Survey result (2016) *Yihalem, 2012

pea, and lentil), and 4.0 for linseed straws (Yihalem, 2012).

In Table 3, in the study watershed, a total crop residue of 955.0 t was produced. According to household survey, about 89.1% of crop residue was supplied for livestock. The remaining 10.9% of crop residue was exploited for sale, soil fertility purposes and thatch roofs. Thus, about 850.9 t DM crop residue was used for animal feed. By and large, available feed was estimated as a total cultivated land per year multiplied by the amount of DM produced per ha for each crop types.

From Table 4, the total amount of DM available in natural grazing land was determined by multiplying the average grassland (communal, private and free access) with conversion factor i.e. 2 t DM/ha/years (FAO, 1987 quoted in Yisehak and Janssens, 2014). It was estimated

Table 4: Estimated feed productivity of natural grazing lands in *Gudoberet* watershed in 2016

Feed sources	Area (ha)	Conversion factor	Total DM (t/year)
Private	37.0	2.0	74.0
Communal	272.0	2.0	544.0
Open access natural grazing land	117.5	2.0	235.0
Total	426.5		853.0

Source: Survey result (2016)

Table 5: Estimated green forage feed resources produced in the watershed in 2016

Feed resources	Local units	Amount produced	Conversion rates * into kg	Total amount produced (t/year)
Green grass and weeds	*Chinet*	3334	60	200.0
Dry grass (hay)	*Chinet*	5685	40	227.4
Oats	*Shekim*	3635	30	109.1
Grass pea	*Shekim*	156	30	4.7
Total				541.2

Source: Survey result (2016)

to 853.00 t (29.9%) of available feed from the total grazing lands.

From Table 5, Forages in grass species include green and dry grass, weed, oat, and grass pea. These feed types were estimated directly from responses given by respondent households. Smallholders have used conventional unit of measurement for feed resources to move forages from their field where they have harvested to their home. One focused group discussion and samples for each feed items were carried out so as to develop conversion rates of such traditional units of quantities to convert into kilograms. The three commonly used traditional units of measurement are *Chinet*, *Shekim* and *Jerican* (local language). *Chinet* is used for both wet and dry forages loaded by pack animals while "*Shekim*" is loaded by humans. One *Chinet* of wet forage is equivalent to 60 kg while the same amount of dry grass such as hay is 40 kg. Similarly, one *Shekim* of dry forage is 20 kg while for wet forage such as grass pea and oat is 30 kg. Therefore, the total available forage was estimated to 541.2 t (19.0%).

Smallholders purchased agro-industrial byproducts for their livestock. These were concentrate feeds, oil cakes, wheat bran, and mill leftover. Respondents were interviewed how much they supplied for their livestock and it was estimated to 71.7 t (2.5%) of feed resources in this category. Nearly 13.7% of farmers have planted and used improved forage trees and shrubs such as Tree Lucerne (*Chamaecytisus proliferus*) introduced by different stakeholders. The total DM of improved forage can be measured using some formula. Nevertheless, smallholders in the watershed have supplied to their livestock using cut-and-carry system not through grazing and browsing. In this case, respondents could estimate directly using local units. Hence, it was insignificant amount of improved forages i.e. 0.9 t. Local drinks (*Tela* and *Araki*) are commonly prepared and their residues were used for livestock. In addition, cereal and pulse crop leftovers were given to livestock at the time of processing and food preparation. In this regard, about 282.4 t (9.9%) of feed was supplied by smallholders to their livestock.

The overall feed balance in terms of DM yield per year to a total TLU value of 1781.7 was in the ratio of 1.6 to 1. The ratio of forage demand to forage supply–grazing pressure was 1.42 to 1 (4064.5 t ÷2854.6 t). That means an extra amount of 1209.9 t DM per year was required. In agreement to this study, the negative feed balance is observed in many watersheds of Ethiopia (Dawit et al., 2013; Endale et al., 2016; Mergia et al., 2014). The available feed DM could supply sufficiently only for 8.5 months of the year. The grazing pressure is beyond its threshold so that animal performance reduced in terms of milk productivity. Stocking rate was also calculated as the ratio of animal units in TLU (1781.7) to land size in ha (426.49) equals to 4.2 TLU ha^{-1}. Overstocking leads to reduction in palatable species, an increase in weeds, and declines in carrying capacity (Thorne and Stevenson, 2007).

All available feed resources were estimated to calculate feed balance regardless of nutritive contents; yet the feed supply could not satisfy the feed requirement of livestock. The fundamental shortage of feed supply in the watershed could be attributed by excessive cultivation of grassland to supply crop yields for the growing population. This kind of gross estimation didn't consider losses throughout harvesting, storage and livestock trampling. There were also limitations in estimation of feed. For instance, homemade byproducts and tree leaves are not easy to quantify. Therefore, the value obtained through estimation was subject to deviation to be either under estimated or overvalued.

Patterns of feed availability in the study watershed

On the one hand, excess amount of feed was obtained from September to December. Moreover, smallholders have used individual, communal and free accessed pasturelands for their livestock. Furthermore, about 37.9% farmers supplied improved feed to their animals. Within those beneficiaries 36.2% have planted forage trees and 90.3% of them were supported by Research in Sustainable Intensification for the Next Generation in Africa (RISING) project through training and access to seedlings. On the other hand, feed shortage was observed from January to August. Livestock feed insufficiency is commonly happen between June and July in the study watershed. About 70.7% of respondents who owned livestock were reported that they face critical feed shortage in July. The probable reason for feed shortage could be low productivity of field crops in the cropping system and lack of natural pasture. According to the survey result, the productivity of cereals such as barley and wheat was 17.5 and 15.4 qt ha^{-1} respectively. The productivity of pulse crops, for instance, bean, pea and lentil was 12.6, 7.2 and 1.5 qt ha^{-1} correspondingly. The productivity of linseed was 4.5 qt ha^{-1}. It showed that the yield per ha for almost all crops in the watershed is below the national average (CSA, 2013).

In the study watershed, there was no well organized forage development strategies where and how forage could be adapted and adopted. The main feeding strategies were tethering, strip grazing, and free grazing. Almost 85.6% of smallholders who have livestock in the watershed have been utilizing cut-and-carry feeding system. In which, only 22.1% of holders were applied merely zero grazing but others have exercised various grazing strategies in combination with private, communal and free accessed fields.

Challenges and prospects of livestock production

There were encouraging prospects in livestock production in the watershed. The prevalence of disease occurrence has declined through time. Instigation of improved forage trees and livestock breeds have increased compared to the past ten years. About 41.7% smallholders in the watershed were accessible to water for livestock within 1 km distance from their residence. Smallholders have had access to sufficient feed resources from September to December. Integration between crops and livestock such as draught power, manure for crop production, and crop residue as a source of feed were significant implications in the crop-livestock system. Crop-livestock arrangements resulted in improvements for 50% of Ethiopian highlanders in terms of farm productivity and income compared to smallholders who only raise subsistence crops (Liniger et al., 2011).

Having such prospects, livestock production also went through several challenges. The average yield productivity of native and exotic breed cows was 1.3 and 2.5 liters of milk /cow /day respectively. Smallholders claimed for access to improved breeds, adequate feed, better management practices, and vaccination services. There was high competition between crop and livestock production. Some pasturelands displaced by crop and irrigation investments as a result of population growth which could reduce production potentials of livestock and exerted pressure on existing land of the study area. Feed scarcity is a major bottleneck for livestock productivity (Yisehak and Janssens, 2014). Lack of efficient utilization of feed resources was an extra impediment for livestock production. Research works were limited in due attention for animal nutrition security. For instance, common salt was not considered as an important supplementary ingredient in animal feed. A minimum of 0.2kg/day of salt is required for 1 TLU equivalent for salt limited supplements. Daily salt requirement for mature cattle is less than 0.02kg /head/day (Berger and Rasby, 2011). In the study watershed, on average 16.1 ton of salt was supplied to 1782.7 TLU. However, the total amount of salt requirement was estimated to be 130.1 t.

DISCUSSION AND CONCLUSIONS

In *Gudoberet* watershed the widespread farming system was crop-livestock production. About 92.4% of smallholders owned livestock. In which 64% of holders obtained cash income through selling of animals and their products in 2015/16. Smallholders who reside in the watershed obtained a total of 37.5% cash income from livestock. Livestock population increased from 1462.5 in 2012 to 1781.7 TLU in 2016 at an average growth rate of 5.5% (63.9 TLU per year). The total livestock population of the watershed was 61.2, 18.3, 19.6, and 0.9% of cattle, pack animals, sheep and goat, and chicken correspondingly. Moreover, there were 165 traditional, 44 transitional and 17 modern beehives with bee swarm. The proportion of livestock population had almost similar patterns with the national census (CSA, 2014).

Land use /land cover changes have direct connections with livestock production in terms of feed production. In the watershed, plantation and settlement areas have been increasing from 1984 to 2016 whereas bush land has been declining for several years. Nevertheless, cropland and grassland have had contrasted dynamics with oscillated trends in irregular patterns. Prior to 2004, grassland was decreased and crop land was increased. Subsequently, from 2004 until 2016 the trend changed inversely. In the first period (1984-2004), crop land was increased at a rate of 14.75 ha per year while grassland was declined at a rate of 28.7 ha per year. In the second period (2004-2016), the trend was reversed and grassland showed an increasing trend in average 9.47 ha per year while cropland has declined to 8.98 ha per year with asymmetrical patterns of proportions. Currently, the growth of livestock population (5.5% per year) was surpassed the expansion of grassland (2.1% per year).

The six major types of feed resources in the watershed were crop residue, natural pasture, grass, local residue, agro-industrial byproduct and improved forage trees in descending order. Crop residues obtained from barley, wheat, horse bean, field pea, lentil, linseed, and potato byproducts. A total of 524.2 ha of land were considered for feed estimation. However, 25.6 ha of vegetables, and 5.6 ha of oats were not included for feed calculation. The feed obtained from oat was computed under grass forages. Vegetables were not measured for two reasons: (i) lack of data on conversion factors, and (ii) vegetables has negligible residues which made difficulty in estimations. Natural pasture included privately owned lands, communal grazing areas and free accessed pasture lands. Grass species comprised wet and dry grass, oat, and grass pea. Home-produced alcohol byproducts such as *Atela* were included in local residues. Smallholder purchased industrial byproducts from *Debre Berhan* town such as wheat bran, oil cakes, and mill leftovers. Improved forage trees and shrubs were the least quantified available feed items. The amount of feed required and supplied was estimated. A total amount of 2854.6 t of feed was supplied while a total quantity of 4064.5 t was required. In this case, the grazing pressure was 1.42 and its stocking rate was 4.2 TLU per ha. It showed negative feed balance with a shortage of 1209.9 t per year. The high stocking rate and grazing pressure of livestock in the watershed could lead to imbalance nutrients as a result reduce livestock productivity, affects fertility, and increase costs to feed purchase.

The annual produced DM in the watershed was adequately feed only for 8.5 months. The contribution of other fed resources like bushes and plantation areas could not be ignored as those types of feed sources were not incorporated to the study. Quantification of feed resources is more challenging than quantification of crop production for a number of reasons. The pattern of feed availability in 12 months of the year is quite different. There was excess supply of feed in 4 months (September to December), adequately supplied for 3.5 Months (January to half of April), and in the remaining 4.5 months scarcity of feed was prevalent (half of April to August). These all, have depressing implication for livestock production potentials.

In conclusion, it is necessary to augment animal nutrition security studies such as urea treatment, crop residue management, silage making, forage development strategies, as well as extension service to advice smallholders how to harvest, preserve and make use of feed resources efficiently and wisely. Moreover, holistic and consistent research towards innovations for sustainable livestock in intensified farming system is important. Feed management practices at local level and further studies on nutrition should be linked with institutional support to alleviate the prevailing challenges of livestock production.

ACKNOWLEDGMENTS

We are grateful to Africa RISING project for funding the research. The first author is also grateful to Addis Ababa University and University of Gondar for providing financial assistance. Smallholders of the study area and Woreda experts are also appreciated. The authors declare that they have no competing interests. The views expressed in this paper do not necessarily reflect the views of the donor or the authors' institutions.

REFERENCES

Abyot Y, Birhanu G, Solomon A, Ferede Z (2014). Forest cover change Detection using remote sensing and GIS in Banja District, Amhara Region, Ethiopia. *International journal of environmental monitoring and analysis*. 2(6),354-360.

Addisu H (2014). Agro-ecological conditions effect on the expression of the spatial chickens' distribution. *Scholarly journal of agricultural science.* 4(9), 476-480.

Amanuel A (2014). Assessing the consequence of land use change on agricultural productivity in Nadda Asendabo watershed Gilgel Gibe sub-catchment of Ethiopia. *International journal of environmental sciences.* 3(2), 72-77.

Amare S (2015). Land use/cover change at Infraz watershed, northwestern Ethiopia. *Journal of landscape ecology*. 8(1), 70-83.

Awulachew SB, Mccartney M, Steenhuis TS, Ahmed A (2008). A Review of hydrology, sediment and water resource use in the Blue Nile basin. Colombo, Sri Lanka: Working paper 131. In: INSTITUTE, I. W. M. (ed.).

Badege B (2009). Deforestation and land degradation in the Ethiopian highlands: A strategy for physical recovery. *Ethiopian e-iournal for research and envestment forsight*. 1(1), 5-18.

Belay D, Azage T, Hegde BP (2012). Smallholder livestock production system in Dandi District, Oromia regional state, central Ethiopia. *Global veterinaria*. 8(5), 472-479.

Berger AL, Rasby RJ (2011). Limiting feed intgake with salt in beef cattle diets. Neb Guide.University of Nebraska Lincoln extension, Institute of agriculture and natural resources.

Boserup E (1981). Population and technological change:

A study of long-term trends: University of Chicago.

CSA (Central Statistics Authority) (2013). Agriculture sample survey. Volume II. Report on livestock and livestock characterstics (private peasant holdings). Addis Ababa. Statistical bulltein 570.

CSA (Central Statistics Authority) (2014). Livestock and livestock characteristics (Private peasant holdings). Agricultural sample survey 2012/13 (2005 E.C.). Central statistical agency, Addis Ababa, Ethiopia.

Dawit A, Ajebu N, Banerjee S (2013). Assessment of feed resource availability and livestock production constraints in selected Kebeles of Adami Tullu Jiddo Kombolcha District, Ethiopia. *African journal of research.* 8(29), 4067-4063.

Diress T, Moe SR, Vedeld P, Ermias A (2010). Land-use/cover dynamics in Northern Afar rangelands, Ethiopia. *Agriculture, ecosystems and environment*. 139,174-180.

Duncan AJ, Fantu B, Kindu M, Valbuena D, Rachier G, Dagnachew L, Mesfin B, Erenstein O (2016). Crop residue allocation for livestock feed, soil improvement and other uses along a productivity gradient in Eastern Africa. *Agriculture, eco-system and environment*. 228, 101-110.

Eleni Y, Wagner W, Exner-kittridge M, Dagnachew L, Blöschl G (2013). Identifying land use/cover dynamics in the Koga catchment, Ethiopia, from multi-scale data, and implications for environmental change. ISPRS International iournal of geo-information. 2, 302-323.

Endale Y. Abule E, Lemma F, Getnet A (2016). Livestock feed production and feed balance in Meta-Robi District, West Shewa Zone, Oromiya regional state, Ethiopia. *Academic research journal of agricultural science and research*. 4(2), 45-54.

Gryseels G (1988). Role of livestock on mixed smallholder farms in the Ethiopian highlands. A case study from the Baso and Worena Wereda near Debre Berhan. PhD dissertation, University of Wageningen, the Netherlands.

Hadgu, KM (2008). Temporal and spatial changes in land use patterns and biodiversity in relation to farm productivity at multiple scales in Tigray, Ethiopia. PhD dissertation, University of Wageningen, the Netherlands.

Herrero M, Thornton PK, Notenbaert A, Msangi S, Wood S, Kruska R et al (2012). Drivers of change in crop–livestock systems and their potential impacts on agro-ecosystems services and human wellbeing to 2030. A study commissioned by the CGIAR systemwide livestock programme. Addis Ababa, Ethiopia: ILRI.

Hussien AO (2009). Land use and land cover change, drivers and its impact: A comparative Study from Kuhar Michael and Lenche Dima of Blue Nile and Awash basins of Ethiopia. MSc thesis, University Cornel.

IFAD (International Food and Agriculture Development) (2013). Smallholders, sood security and the environment.

IFPRI (International Food Policy and Research Institute) (2011). Cereal production and technology adoption in Ethiopia. Development strategy and governance division: Working paper No 31.

Iiyama M, Kaitibie S, Kariuki P, Morimoto Y (2007). The status of crop-livestock systems and evolution toward integration. *Annals of arid zone.* 46 (3&4), 1-23.

ILO (International Labor Organization) (2014). Decent work country program 2014-15: Ethiopia international labour organization, ILO country office for Ethiopia and Somalia, Addis Ababa. Ethiopia.

ILRI (International Livestock Research Institute) (2014). Local solutions for a global challenge: A livestock and climate change impact narrative. ILRI research brief 27. Addis Ababa, Ethiopia: ILRI.

Israel GD (2013). Determinig sample size. PEOD 6. University of Florida, IFAS Extension.

Kuria A, Lamond G, Pagella T, Aster G, Hadgu K, Sinclair F (2014). Local knowledge of farmers on opportunities and constraints to sustainable intensification of crop-livestock-trees: Mixed systems in Basona Woreda, Amhara Region, Ethiopian highlands.

Liniger HP, Mekdaschi SR, Hauert C, Gurtner M (2011). Sustainable land management in practice: Guidelines and best practices for Sub-Saharan Africa, TerrAfrica.

Melkie E (2007). Assessment of nutritional status of preschool children of Gumbrit, Northwest Ethiopia. *Ethiop.J.Health Dev*. 21 (2),125-129.

Mergia A, Adugna T, Getnet A (2014). Feed resource assessment and utilization in Baresa watershed, Ethiopa. *International journal of science and research (IJSR)*. 3(2), 66-72.

Messay M (2011). Land-use/land-cover dynamics in Nonno district, central Ethiopia. *Journal of sustainable development in Africa.*13 (1), 123-141.

Nigussie H, Atsushi T, NyssenJ, Poesen J, Tsubo M, Dereje T (2015). Soil erosion and conservation in Ethiopia: A review. *Progress in physical geograpy.* 39(6),750-774.

Nigussie H, Samuel T, Atsushi T, Mitsuru T, Derege T, Enyew A, Asres E (2014). Dynamics of land use and land cover and ist effcets on hydrologic responses: Case study of Gilgel Tekeze catchment in the highlands of northern Ethiopia. Environ monit assess. 187, 4090.

NPC (National Planning Commission) (2016). Growth and transformation plan II (2015/16-2019/20). Volume I. Main text. Addis Ababa, Ethiopia.

Thorne M S, Stevenson MH (2007). Stocking rate: The most important tool in the toolbox. University of Hawai'i at Manoa.

Valbuena D, Tui SH, Erenstein O, Teufel N, Duncan A, Abdoulaye T, et al (2014). Identifying determinants, pressures and trade-offs of crop residue use in mixed smallholder farms in Sub-Saharan Africa and South

Asia. Agricultural systems. Article in press.

World Bank (2013). Ethiopia's productive safety net program (PSNP) integrating disaster and climate risk management.

WFP (World Food Program) (2014). Comprehensive food security and vulnerability analysis (CFSVA). Ethiopia: Ethiopian central statistical agency.

Yayneshet T (2010). Feed resources availability in Tigray region, Northern Ethiopia, for production of export quality meat and livestock.

Yihalem D (2012). Animal feed preparation and feeding system. Training manual for animal breeding practitioners. Andasa livestock research centre, Bahirdar, Ethiopia.

Yisehak K, Janssens GPJ (2014). The impacts of imbalances of feed supply and requirement on productivity of free-ranging tropical livestock units: Links of multiple factors. *African journal of basic & applied sciences*. 6(6), 187-197.

Yitebitu M, Zewdu E, Sisay N (2010). Ethiopian forest resources: Current status and future management options in view of access to carbon finances.

Yodit A, Fekadu B (2014). Examining drivers of land use change among pastoralists in eastern Ethiopia. *Journal of land use science*. 9 (4), 402-413.