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Estimation of Livestock Methane Emissions in the Extensive Crop-Livestock Farming Areas of Bale Highland, Oromia, Ethiopia

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Abstract: The study was conducted in the potential mixed farming areas of Bale highland to estimate livestock methane emissions. Using multi-stage purposive sampling, 156 households of the three wealth groups were selected based on their livelihood assets as described under methodology. Structured questionnaires, focus group discussions, key informants interview and field visits were employed during the study. Feed nutrient balance was estimated based on the demand and supply while the livestock methane emissions were estimated according to the IPCC guidelines. Descriptive statistics and one-way ANOVA tests were used to analyze the data. Cattle were the dominant (84.25%) livestock owned by the households. The estimated enteric CH_4 emission rate from mature cattle, growing cattle, sheep >1 year, sheep ≤ 1 year, horse and donkey were significantly (P<0.001) higher for the better wealth group while mature cattle (69.78%) shared the highest rate. Though, higher emission rates credited to the large number of animals in the area, cattle stay crucial to the livelihoods of the households, beside the major sources of CH_4. In conclusion, the estimated CH_4 emissions should be focus areas of interventions. Therefore, proper husbandry and quality feed supply and promotion of farm level livestock technologies should be practiced wisely to increase productivity and protect the environment from emissions of the livestock sector.

Key words: Bale Highlands · Livestock · Methane Emissions · Mixed Farming

INTRODUCTION

Ethiopia is the home to the Africa's largest livestock population standing eighth from the world [1] and is the principal exporter of live animals and meat to the Middle East [2] being endowed with the diversified species and breeds of animal. According to the recent report [3], the country is endowed with 57.8, 28.0, 28.6, 2.1, 7.9, 0.4, 1.2 and 60.5 million heads of cattle, sheep, goat, horse, donkey, mule, camel and chicken, respectively. From the total livestock population of the country, more than 75% inhabited the mixed farming areas [4]. In the country, the sector is gradually booming due to increasing global and domestic demand for their products linked to population and economic growth [5].

It has been reported that farm animals from mixed farming contribute to climate change mainly through greenhouse gas emissions and natural resource degradation [6, 34]. Because livestock and environment are closely related as livestock depends on land and water resources while livestock emits pollutant gases to environment. These let the sector recently to be blamed for significant contributions to the global climate [7, 8]. Researchers underpin those mixed farming areas livestock diets were composed of grazing, crop residues, cut and carry, concentrates and opportunistic feeds. These dietary differences were important for the disparity in methane (CH_4) emissions within the system. For example, an average figure of 32 kg CH_4 per TLU per year for African ruminants is high compared to the low production performance of the animals [7].

In Ethiopia, the livestock sector offers a potential CH_4 emission abatement, though the type of production systems and feed resources used for different production systems not mentioned separately [8]. Hence, estimation of emissions from livestock in small holder mixed farming system helps to generate baseline information that could be an input to the national emission inventory of the

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sector and subsequent mitigation strategy development. However, no attempt has been made to estimate CH_4 emissions from the livestock in the mixed farming system areas of Ethiopia in particular to Bale. Bale highland is one of the potential mixed farming areas of Ethiopia where crop-livestock farming is the predominant practice with the existing intricate problems. Provided that, livestock husbandry practices and feed resources are dynamic; livestock CH_4 emission assessment of area specific data are pertinent for the further actions [9]. In addition, the situation constrained by the factors that limit estimation of emissions from the sector due to lack of to date temporal and spatial data on livestock population trend, production type and feed resources [10]. Therefore, looking at existing livestock population of the area and CH_4 emission inter-relationships across the wealth groups is vital to explore baseline information that could be used for the national greenhouse gas inventory and future design of improved livestock production by the policy makers and livestock development intervention actors. With this consent, the study was initiated to estimate CH_4 emissions from the livestock under the prevailing production system.

MATERIAL AND METHODS

The Study Area: This study was conducted in Bale Zone of Oromia National Regional State, Southeast Ethiopia. Recent demographic report revealed that the human population of the Zone is estimated at 1,616,061 of which, 87.3% live in the rural area [11]. The study area was situated at the highland altitude with mean annual rainfall of 860.00 mm. The average minimum and maximum daily temperatures were 9.4°C and 25.2°C (NMA Bale branch unpublished data). The study area has large livestock resources, since the livelihoods base is livestock herding and cultivation. The major livestock species reared by the inhabitants include cattle, sheep, donkey, horse and chicken [3]. The three districts used for this study were among the first few potential mixed farming districts of the Zone known for the extensive cultivation and raising high livestock population [12].

Sampling Procedure: Three potential mixed farming (Cereal-cattle dominant) districts were purposively selected from the nine highland mixed farming districts based on cropland cover and livestock population potential. Nine *kebeles* were randomly selected from the fifty-five crop-livestock farming *kebeles* of the study districts. The households (HHs) were stratified into three different wealth groups on the basis of their livelihoods asset (Livestock and land) possessed and capacity of the farmers to satisfy basic needs of their family that made in consultation with development agents, district experts and community representatives [13]. The groups were better wealth (≥4.25 hectare land, >15 TLU); medium wealth (2.25-4.25 hectare land, >5 and ≥15 TLU) and low wealth (≥2.25 hectare land, ≥5 TLU). A total sample size of 156 HHs was used to represent study population [14].

Data Collection: A survey using pretested semi-structured questionnaires was carried out a face to face interview in 2015 which covered subjects like livestock holding, herd composition and major feeds available in the area. Nine enumerators who were working as development agents in the sample *kebeles* were selected and trained on the primary data collection methods under the close supervision of the researcher. A single focus group discussion comprising 9-13 people, who drawn from farmers of different wealth groups, sex, farming experience and development agents were conducted in all nine *kebeles* by the researcher.

Estimation of Livestock Nutrient Requirement: The study HHs livestock population converted to tropical livestock unit (TLU). The animal specific TLU conversion factors used for ox/bull, cow, heifer, steer, calf, sheep, horse and donkey were 1.1, 0.8, 0.5, 0.6, 0.2, 0.1, 0.8 and 0.5, respectively as recommended by Jahnke [15] and Gryseels [16]. The daily DM demand for the standard TLU of 250 kg at 2.5% of the body weight, which is equivalent to 6.25kg/day or 2280 kg/year of Jahnke [15] was used. The ME and DCP maintenance requirement for the livestock were estimated according to the daily average recommendations [17].

Estimation of Enteric Methane Emission: Enteric CH4 emission estimation requires definitions of the livestock categories: species, herd structure and existing population in the study area. Hence, cattle divided into growing and mature type based on average live body weight of 200 kg and 280 kg, respectively, sheep into (= 1 year and > 1 year) and equine into (Horse and donkey). The separation was done in line with the IPCC [7] and CDR [8] recommendations which has stated as "It is good practice to classify existing livestock population into subcategories". With respect to animal productivity, the local cattle were used for more than one purpose (Milk, meat and draught). The energy used for draught was estimated using 8 hours heavy work per day [7]. The emission factors were developed according to the dual purpose cattle of the developing countries [8].

Table 1: The formulae used to estimate different forms of net energy used by the animal

S.N.	Type of energy required	Model used to estimate the required energy
2.1	Net energy for maintenance	$NE_m = Cf_i * (weight)^{0.75}$
2.2	Net energy for activity	$NE_a = C_a * NE_m$
2.3	Net energy for growth	$NE_g = 22.02 * \left(\frac{BW}{C * MW}\right)^{0.75} * WG^{1.097}$
2.4	Net energy for work	$NE_w = 0.1 * NE_m *$ working hours
2.5	Net energy for pregnancy	$NE_p = C_{pregnancy} * NE_m$
2.6	Sheep net energy of lactation	NE_l= milk * EV (EV= 4.6MJ/kg)
2.7	REM	$REM = [1.123 – (4.092 * 10^{-3} * DE\%) + (1.126 * 10^{-5} * (DE\%))]$
2.8	REG	$REG = [1.164 – (5.160 * 10^{-3} * DE\%) + (1.308 * 10^{-5} * (DE\%))]$

REM=ratio of net energy available in a diet for maintenance to digestible energy consumed; DE%=digestible energy expressed as a percentage of gross energy; REG=ratio of net energy available for growth in a diet to digestible energy consumed; BW=the average live body weight of the animals in the population (kg); MW=the mature live body weight of an adult female in moderate body condition (kg); WG=the average daily weight gains of the animals in the population (kg day^{-1})

Source: IPCC [7]

Emission from enteric fermentation of the ruminant animals (kg CH4 per head/year) is a function of feed digestibility (i.e. the percent of GE intake that is metabolized) [18]. An enteric CH4 conversion factor: Ym (% of GE converted to CH4) was used to calculate CH4 emission factors (EF) from ruminant enteric fermentation. The enteric CH4 EFs for horse and donkey 18 and 10 (kg CH4 per head/year), respectively were adopted from Tier 1 of the developing countries. The Tier 2 approach was applied to calculate the enteric CH4 emissions due to sensitivity to the diet composition and relative importance of enteric CH4 to the total GHG emissions from cattle and sheep [7].

$$EF = \frac{GE * \left(\frac{Ym}{100}\right) * 365}{55.65} \quad (1)$$

where:

EF = Emission factor (kg CH_4 head^{-1} year^{-1}),
GE = Gross energy requirement (MJ head^{-1}day^{-1}),
Y_m = CH_4 conversion factor (% of GE in the feed converted to CH_4) and The factor 55.65 (MJ/kg CH_4) = the energy content of CH_4.

In order to calculate the emissions, first need to estimate the value the gross energy (GE) requirement using equation 2 below.

$$GE = \left[\frac{\left(\frac{NEm + NEa + NEl + NEw + NEp}{REM}\right) + \frac{NEg}{REG}}{\frac{DE\%}{100}}\right] \quad (2)$$

GE = gross energy (MJ/day),
NE_m = Net energy required by the animal for maintenance (MJ/day),
NE_a = Net energy for animal activity (MJ/day),
NE_g = Net energy needed for growth (MJ/day),
NE_l = Net energy for lactation (MJ/day),
NE_{work} = Net energy for work (MJ/day),
NE_p = Net energy required for pregnancy (MJ/day),
REM = Ratio of net energy available in a diet for maintenance to digestible energy consumed,
REG = Ratio of net energy available for growth in a diet to digestible energy consumed, DE% = digestible energy expressed as a percentage of gross energy.

After the values for GE requirement in the equation (2) calculated for each animal category, then values were substituted in the equation (1) above.

Estimation of Manure Methane Emission: `In the developed world, substantial amount of CH_4 emissions from manure management associated with confined animal management operations where manure managed in liquid-based systems. However, in the study area there was no confined manure handling practices, since the livestock production system is more of extensive grazing. Therefore, the Tier 1 default values of the livestock grazed on the roughage feeds from Tropical Africa with annual temperature range of the environment (15-25 ^{O}C) and feed digestibility of 45-55% were used to estimate CH_4 emission factors of manure from the existing livestock. The default EF values for cattle, sheep, horse and donkey were 1, 0.15, 1.64 and 0.9, respectively [7].

Therefore, based on the expressions above, the total annual CH_4 emissions from enteric fermentation and manure management of the existing livestock were estimated according to IPCC [7]:

$$CH_4 (kg^{-1} head^{-1} year^{-1}) = EF * N_t \quad (3)$$

where:

CH4 = Methane emission from defined livestock type,
EF = Emission factor for the defined livestock population, kg CH_4 $head^{-1}year^{-1}$,
Nt = The number of head of the livestock species/category under consideration and t is type of the livestock species or category.

Data Analysis: The data were analyzed using Statistical Packages for Social Sciences (SPSS) software packages version 20.0 [19]. To compare the differences between the wealth group livestock holding, nutrient requirement and methane emission rates: one-way analysis of variance (ANOVA) was used. The One-way ANOVA model used was:

$$Yij = \mu_i + W_i + e_{ij}$$

where:

Y_{ij} is the j^{th} observation in the i^{th} wealth group;
μ_i is the common effect for the whole wealth groups,
W_i is the effect of the i^{th} wealth group and e_{ij} is the random error associated with the j^{th} observation in the i^{th} wealth groups assumed to be normally and independently distributed.

The tests were done at 95% level of confidence ($\alpha = 0.05$) and Turkey's' HSD mean comparison procedure was used to test mean differences.

RESULTS AND DISCUSSION

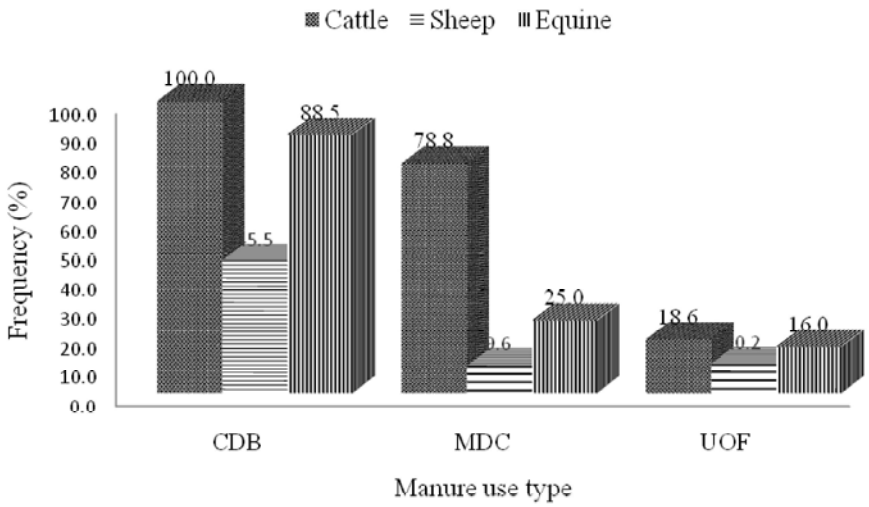
Household Livestock Holding: Table (2) depicts mean livestock species and herd categories of the HHs in TLU. The mean total cattle, cow, ox and heifer were significantly ($P<0.001$) different between the wealth groups. The mean steer and sheep TLU holding was significantly ($P<0.01$) different between better and the other groups while horse and donkey were significantly ($P<0.001$) higher for the better wealth HHs. From the total livestock owned by the wealth groups, cattle accounted for 80 to 90% at HH level while from the cattle herd structure, the oxen (48.75%) followed by cows (31.03%). The more number of TLU possessed by the better wealth HHs accounted to the difference in grazing land owned. Cattle were the dominant stock, while the number of oxen still pronounced within the herd across the wealth groups (Table 2) since cattle predominantly used for draught power in the area like the other mixed farming areas of Ethiopia [20]. In addition, sheep rose for the immediate cash need and meat while equines used for transportation of farm inputs and products, pulling cart and riding. Comparable reports confirmed the livestock raising in the mixed farming system of the country [21, 22]. The livestock herd proportions indicated that the better HHs had raised more number of diversified herd categories compared to the other wealth groups (Table 2). The observed difference between the wealth groups help to validate the diversity when planning a sustainable livestock development programs [23]. Small number of steers reported compared to other herd categories was because of early age sale to manage feed shortage.

Livestock Manure Management: Homestead manure management; collection from the place where the animal drops it (More often Kraal), family house and backyard

Table 2: Livestock herd structure (TLU per HH) in the mixed farming areas of Bale highlands

		Wealth group			Overall mean (156)	
Livestock category	Herd structure	Better (40) Mean (SE)	Medium(85) Mean (SE)	Low (31) Mean (SE)	Mean (SE)	P value
	Cow	4.78(0.1)^{a}	2.22(0.11)^{b}	0.88(0.10)^{c}	2.61(0.13)	0.000
	Ox	6.23(0.23)^{a}	3.88(0.13)^{b}	1.95(0.09)^{c}	4.10(0.15)	0.000
	Heifer	1.34(0.12)^{a}	0.69(0.05)^{b}	0.21(0.06)^{c}	0.76(0.05)	0.000
	Steer	1.38(0.16)^{a}	0.43(0.06)^{b}	0.15(0.06)^{b}	0.62(0.06)	0.007
	Calf	0.59(0.04)^{a}	0.32(0.02)^{ab}	0.14(0.02)^{b}	0.36(0.02)	0.021
	Total	13.99(0.44)^{a}	7.59(0.27)^{b}	3.48(0.19)^{c}	8.41(0.35)	0.000
Sheep		0.53(0.08)^{a}	0.28(0.04)^{ab}	0.14(0.04)^{b}	0.31(0.03)	0.010
Horse		0.98(0.06)^{a}	0.32(0.04)^{b}	0.15(0.06)^{b}	0.46(0.04)	0.046
Donkey		1.22(0.05)^{a}	0.65(0.04)^{b}	0.30(0.06)^{b}	0.73(0.04)	0.016
Cattle (%)		81.86	85.96	89.92	84.25	

abc= means within the same row with different superscripts are significantly different



CDB = collected on daily basis; MDC= made into dung cake; UOF = use as organic fertilizer

Fig. 1: Manure collection and utilization type in the mixed farming areas of Bale highlands

during night can be used either for dung cake (Fuel) and/or organic fertilizer (Figure 1) and other minor uses which are not mentioned here. Numbers depicted that cattle manure collected 100% while that of equine was 88.5%. However, there were differences in that of manure made into dung cake from cattle (78.8%) and equine (25.0%). Whereas, manure used as farm yard fertilizer from all stocks looks similar, where more attention given to the use of manure as fuel. On the other hand, manure dropped in the grazing areas during dry period collected and used as fuel while the remained dung used to maintain the ecosystem via supplying organic fertilizer to the soil [7]. Similarly, Onduru *et al.* [24] reported that in Kenya, animals graze in the fields during the day adds a potential *in situ* manure utilization of the soil fertility. In general, the present result implies that farmers are not much valued manure as organic fertilizer and biogas generation compared to the current practice (Fuel) which has environmental effect.

Estimated Livestock Methane Emissions: Table (3) presents enteric CH_4 (kg) emission factors and emission rates of different livestock categories of the wealth groups in the study area. The estimated enteric CH_4 EF from mature cattle was significantly (P<0.001) lower for the better wealth HHs compared to other groups while EF of growing cattle was significant (P<0.05) between better and other wealth groups. Whereas, EFs for sheep greater than one year, sheep to one year, horse and donkey were not significantly (P<0.05) different between the wealth groups. The enteric CH_4 emission rates from the livestock categories were significantly different (P<0.001) between the wealth groups. The overall mean estimated enteric CH_4 emission from mature cattle higher followed by growing cattle. The total enteric CH_4 emission at HH level of the wealth groups were more pronounced from the better group HHs compared to medium and the low group HHs.

This study revealed enteric CH_4 emission from mature and growing cattle were very high (91.52%) compared to sheep and equines which has credited to the more number of cattle herds at HH level was comparable to the 84% livestock emission from cattle reported by CRGE [25]. The present enteric CH_4 EFs for cattle and sheep categories were in close agreement with the IPCC values from developing countries in African, Middle East and other tropical regions livestock EFs under similar production system and animal functions [6, 7]. However, EF from mature cattle was higher than an average figure of 32 kg CH_4 per TLU per year for African ruminants [6, 35]. The emission rates from enteric CH_4 production aligned with higher EFs, large number of animals and complex herd structure possessed by the better group. Likewise [26-28, 36] reported that from the total CH_4 emission, 90% is from enteric fermentation while mixed system produces the bulk of emissions from ruminants. On the other hand, the estimated low enteric CH_4 emission from herds of the low wealth group might be due to less numbers of animal's possessed and under similar condition [29].

The other concern is that when roughage feeds intake increased beyond maintenance requirement for working animals; CH_4 escalates from the additional feed ingested to generate more energy for work. The scenario recalls for efficient use of draught power or mechanized

Table 3: Household level estimated enteric CH_4 emissions in the mixed farming areas of Bale highlands

	Wealth groups			Overall mean (156)			
	Better (40)	Medium (85)	Low (31)				
Livestock category	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	P value	Total CH4	%
Emission Factors ($kg^{-1}head^{-1}year$)							
Mature cattle**	39.40(0.0)^{b}	40.34(0.0)^{a}	40.20(0.02)^{a}	40.08(0.03)	0.000		
Growing cattle*	20.02(0.0)^{b}	20.56(0.0)^{a}	20.51(0.0)^{a}	20.42(0.02)	0.025		
Sheep > 1 year	3.48(0.0)	3.55(0.0)	3.54(0.0)	3.53(0.0)	0.070		
Sheep up to 1 year	1.74(0.0)	1.79(0.0)	1.78(0.0)	1.77(1.52)	0.202		
Horse	18.00(0.0)	18.00(0.0)	18.00(0.0)	18.00(0.0)	0.972		
Donkey	10.00(0.0)	10.00(0.0)	10.00(0.0)	10.00(0.0)	0.994		
Emission rate($kg^{-1}year$)							
Mature cattle	459.99(13.19)^{a}	252.96(8.66)^{b}	114.27(5.31)^{c}	278.48(11.22)	0.000	827.22	69.78
Growing cattle	153.61(9.63)^{a}	75.64(4.35)^{b}	28.45(3.88)^{c}	86.25(4.93)	0.000	257.70	21.74
Sheep > 1 year	8.96(1.43)^{a}	5.39(1.06)^{b}	2.63(0.85)^{c}	5.76(0.73)	0.000	16.98	1.43
Sheep up to 1 year	4.39(0.74)^{a}	2.67(0.52)^{b}	1.03(0.35)^{c}	2.79(0.36)	0.000	8.09	0.68
Horse	22.05(1.36)^{a}	7.62(0.97)^{b}	3.48(1.29)^{b}	10.50(0.88)	0.000	33.15	2.79
Donkey	23.25(0.97)^{a}	12.94(0.73)^{b}	6.13(1.19)^{c}	14.23(0.70)	0.000	42.32	3.57
Total CH_4	672.25	357.22	155.99	398.01		1185.46	
HH %	56.71	30.13	13.16				

abc= Means within the same row with different superscripts are significantly different

HH=household; **=280 kg average live weight; *=200 kg average live weight

Table 4: Household level estimated manure CH_4 emission in the mixed farming areas of Bale highlands

	Wealth groups			Overall mean (156)			
Livestock	Better (40)	Medium (85)	Low (31)				
category	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)			
	CH_4 ($kg^{-1}year$)	CH_4 ($kg^{-1}year$)	CH_4 ($kg^{-1}year$)	CH_4 ($kg^{-1}year$)	P value	Total CH_4 ($kg^{-1}year$)	Total emission (%)
Cattle	19.33(0.65)^{a}	9.95(0.38)^{b}	4.23(0.28)^{c}	11.22(0.49)	0.000	33.51	80.28
Sheep	0.77(0.12)^{a}	0.45(0.09)^{ab}	0.19(0.06)^{b}	0.48(0.06)	0.033	1.41	3.38
Horse	2.01(0.12)^{a}	0.69(0.09)^{b}	0.32(0.12)^{b}	0.96(0.08)	0.016	3.02	7.24
Donkey	2.09(0.09)^{a}	1.16(0.06)^{b}	0.55(0.11)^{c}	1.28(0.06)	0.012	3.80	9.10
HH total	24.20	12.25	5.29	13.94		41.74	
HH share (%)	57.98	29.35	12.67				

abc= Means within the same row with different superscripts are significantly different; HH=household

cultivation to curb CH_4 emission from extra GEI which is also accompanied by lose of energy whenever feed energy converted to CH_4. Enteric CH_4 from working males (53.6%) is more than female (46.4%) in India [29], while animals with a higher feed intake had more CH_4 emission [30]. Hence, herding animals of better productivity performance with the low enteric emission rate per product or services rendered is a likely solution to lessen livestock CH_4 emissions. On the other hand, increasing roughage feeds digestibility was an expedient way to reduce enteric CH_4 emissions with accompanied minimized animal number and increased product [36, 37]. Therefore, the present report of enteric CH_4 production of the existing livestock herd categories of the prevailing feeding regime presents ample scopes to abate CH_4 emission through appropriate feeding interventions.

Manure Methane Emission: The estimated CH_4 emission from manure handling practices in the study area wealth groups' livestock is presented in Table (4). There were a significant (P<0.001) difference between the three wealth groups manure CH_4 emissions from cattle. But, emission from donkey was significantly (P<0.05) higher for better groups. Similarly, CH_4 emission from sheep was different (P<0.01) between better and low groups. In the mixed farming areas of Ethiopia; manure has been used for fuel and sometimes as organic fertilizer on farm lands which is a similar practice to the study area. In the study area, manure was collected mainly from Kraal and made into dung cake in open environment (Figure 1). When manure handled in such a way, the potential CH_4 emission was less significant due to aerobic condition of the open environment. Likewise, when manure utilized in a dry form

Table 5: Livestock emitted CH_4 global warming potential in the mixed farming areas of Bale highlands

		Farm level total emission		Study districts total emission		
Livestock species		CH_4 (kg^{-1}year))	*CO_2-e GWP (MT)	Livestock (head)	CH_4 (kg/year) ('000)	CO_2-e GWP (MT)
1	Cattle	375.95	$1.28x10^{-6}$	388334.0	145994.2	4.96
2	Sheep	9.03	$3.07x10^{-7}$	49815.0	449.8	0.015
3	Horse	11.46	$3.91x10^{-7}$	23080.0	264.5	0.089
4	Donkey	15.51	$1.55x10^{-7}$	23368.0	362.4	0.012
Total	411.95	$1.40x10^{-5}$		147070.9	5.01	

* = IPCC (2014); CO_2-e=carbon dioxide equivalent; GWP=global warming potential; MT=mega ton

such as in stacks or dry lots for fertilizer on fields, it tends to decompose under aerobic conditions and insignificant amounts of CH_4 produced [26, 31]. The manure from kraal was collected and made into dung cake on the dry ground/soil under the sun and used as fuel. Though small amount of CH_4 produced from manure under the existing traditional husbandry practice, it is not a sound problem of CH_4 effect compared to the enteric emissions observed from the existing livestock. However, the increase in the herd size might lead to the increased manure CH_4 emission particularly when manure stored for long period of time under anaerobic condition at farm level.

Farm level livestock emitted CH_4 ($kg^{-1}head^{-1}year$) and its equivalent global warming potential in the study districts is indicated in Table (5). The large enteric CH_4 emission from cattle in the study area wealth group HHs and total livestock emission of the districts had a higher GWP compared to the other animals raised by the farmers. Similarly, farm level CH_4 emission in the study area was very small amount compared to the total emission from the total study districts livestock of the mixed farming system. While livestock contributions to the socio-cultural and sustainable livelihoods are substantial, their influence on climate change cannot be overlooked. The relevant studies reported that the likely increase of CH_4 emissions in the coming decades because of the ever increasing demand for livestock products [7, 32]. Therefore, livestock sector become an attractive target of GHG reduction campaigns. From this sector, a small change per animal emission could result in large changes in total GHG emissions due to large livestock population broadly in Ethiopia and in the study area in particular

The overall, estimated CH_4 emission has prominent effect on climate change due to its high global warming potential (34 times that of CO_2) when the concentration increased in the atmosphere [33]. In general, the cumulative effect of CH_4 emission was a sound problem of the highland mixed farming areas compared to the farm level relative small amount of emission in the study area due to its higher GWP (Table 5). Therefore, a key starting point to assess mitigation of the livestock emissions were to understand baseline level of CH_4 emission associated with different livestock categories, major GHGs emitted, the main sources and the farming community wealth differences under the prevailing livestock production system.

CONCLUSSION

From this study, it can be concluded that livestock production is a hub sector that plays crucial role to the smallholder's livelihood in the study area. Livestock farming contribute to climate attributes variation in different ways in course of production due to perceived traditional husbandry practices, species raised (Large number of ruminants) and poor resource allocation that increase livestock contribution to climate change through hampering animal productivity and enhancing CH_4 emissions. In the area, mature and growing cattle emitted 69.78% and 21.74 % enteric CH4, respectively at farm level. Though sheep and equine emitted low enteric CH_4, compared to cattle, they lack some products and services provided by cattle to the households. Hence, emission from study area livestock could be linked to species type, population size and low productivity which cause extra emission without obtaining valuable product. This tends to increase CH_4 emissions from the sector that has a global warming potential of 34 times that of CO_2 in the atmosphere and the total CH_4 emission from the study area total livestock population has an implication to global warming at lower extent compared to tropical African's livestock CH_4 emission rates.

Abbreviations:

BoFED……Bureau of Finance and Economic Development
CDR……Community Development Research
CRGE……..Climate Resilient Green Economy
CSA…….Central Statistical Authority
EF……Emission Factor

GHG……Greenhouse Gas
HH……...Household
IGAD……..Intergovernmental Authority on Development
IPCC……Intergovernmental Panel on Climate Change
TLU…….Tropical Livestock Unit

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