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Methane Emissions from the Cattle Population in Uganda

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Abstract: We used the Livestock Analysis Model (LAM) to estimate the current and projected amount of methane, a greenhouse gas, produced by the cattle population in Uganda in the period from 2000 to 2030. The LAM is a data-intensive computer model developed by the United States Environment Protection Agency. The data required for the model were derived from official documents of the Government of Uganda. Secondary data on human and cattle population and production target of beef and milk were subjected to stepwise regression analysis and the outputs were used in the LAM. Primary data for the LAM were also generated through a national livestock survey. According to the LAM, the total methane emissions from cattle in Uganda in the year 2000 were estimated at 337,796 tons. This amount is projected to nearly triple by the year 2030 unless appropriate mitigation measures are put in place in the country. Among indigenous cattle breeds, the Zebu and Nganda had the highest methane emissions per unit of product, generating approximately 1 kilogram of methane per kilogram of milk produced, while the Ankole cattle emitted approximately 0.566 kg of methane per kilogram of milk produced. On the other hand, the improved breeds emitted only 0.123 kg of methane per kilogram of milk produced. The results of this study show that the cattle sector in Uganda has a potential for international investments for reduction of methane emissions in line with the Clean Development Mechanism under the Kyoto Protocol.

Key words: Methane emissions, cattle, Uganda, population, regression, analysis

INTRODUCTION

Increased atmospheric concentration of greenhouses gases is the primary cause of the enhanced greenhouse effect, commonly referred to as global warming. This is now a major environmental concern world-wide. The major greenhouse gases include carbon dioxide (55%), methane (17%), tropospheric ozone (14%) and nitrous oxides (5%) (IPCC, 1996). Although methane is second to carbon dioxide as a greenhouse gas, it is twenty times more effective in trapping heat in the atmosphere as compared to carbon dioxide. In addition to a direct radiative effect, methane contributes to global warming by influencing the amount of ozone in the troposphere and stratosphere, the amount of hydroxyl in the troposphere and the amount of water vapor in the stratosphere.

Methane levels in the atmosphere have doubled over the last two hundred years (Johnson *et al.*, 1996). The major sources of methane in the environment include ruminant animals, fossil fuel production, rice cultivation, biomass burning and landfills. Globally, ruminant animals produce approximately 80 million tons of methane annually and are the largest source of anthropogenic methane emissions. Approximately 30% of the global anthropogenic methane from ruminants comes from developing countries. In ruminant animals, methane is produced as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream. The amount of methane emitted depends on the type, age and weight of the animal, the quality of the feed and the energy expenditure of the animal.

In Uganda, the livestock sector contributes approximately 17% of the national Gross Domestic Product (MAAIF, 2003). The national cattle herd consists of indigenous, exotic and crossbreeds between the indigenous and exotic cattle. The indigenous breeds account for over 80% of the national herd and they include the Ankole, Zebu and Nganda breeds. Hitherto, the amount of methane produced by the Uganda's national cattle herd was largely unknown and hence its contribution of the global methane emissions and was unknown. The objectives of this study were, firstly, to

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estimate the current and future amount of methane produced by cattle population in Uganda and secondly to elucidate methane emission characteristics of the Ugandan indigenous breeds of cattle. The study provides baseline data for auditing framework for potential investments for mitigation of methane emission from cattle populations in Uganda in line with the provisions of the United Nations Framework Convention on Climate Change and the Kyoto Prototocol, to which Uganda is signatory.

MATERIALS AND METHODS

Methane emissions estimation and projection: We used the Livestock Analysis Model (LAM) for estimating the current and projected amount of methane emissions produced by Uganda's cattle population from the year 2000 to the year 2030. The LAM is a personal computer based model and was developed by United States Environment Protection Agency (US-EPA). According to the US-EPA, LAM is currently the best and most accurate methodology available for calculating methane emission from cattle populations (EPA, 1994). The Intergovernmental Panel on Climate Change also recommends use of the LAM for estimating current and future cattle methane emissions in a given country (IPCC, 1996).

The LAM is a data-intensive model, requiring data inputs on current dairy, meat and draft power demands, current herd sizes, production targets and characteristics of feed and care for the livestock. In order to gather data required in the LAM, we undertook an extensive data collection from published studies and official reports of the Government of Uganda. We also carried out a national livestock survey in order to generate data that was missing from secondary sources and also to verify the accuracy of the secondary data collected.

Secondary data sourcing and analysis: Demographic data and production targets for milk and meat were sourced from official reports Ministry of Agriculture, Animal Industry and Fisheries, majorly from the Meat Master Plan (MAAIF, 1997). Permission to collate these data was obtained from the relevant desk officers in the respective ministries. Data on human and cattle populations and demands for milk and meat were subjected to trend analysis and the models derived were used to make yearly projections up to the target year of 2030. The data collected were evaluated for its robustness and accuracy for use in the LAM.

Production targets took into consideration the projected human population growth and projected human meat and milk consumption. Regression analysis was used to project national human population growth and milk and meat consumption estimates up to year 2015. Subsequently, the equations obtained were used to estimate the projections up to year 2030. The following equations were derived:

$$Y_1 = \text{E-15e}^{0.02579x} \ (R^2 = 0.9999)$$
$$Y_2 = 789.41x^2\text{-3e+06x} + 09 \ (R^2 = 0.9591)$$
$$Y_3 = 187.02x^2\text{-743608x} + 7e + 08 \ (R^2 = 0.4823)$$

Where:
Y_1 = Human population estimates
Y_2 = National milk targets (liters)
Y_3 = National beef targets (kilograms)

From these equations, the milk and meat consumption per capita rates as:

$$Z_1 = Y_2/Y_1$$
$$Z_2 = Y_3/Y_1$$

A comparative analysis of these milk and meat per capita consumption figures presented the best goodness of fit, whereby the assumption was made that over the next thirty years the economic and social development of the country will continue to increase.

The national cattle population projections were broken down by animal numbers and regression analysis used to estimate the total national herd. The following regression equation was derived:

$$CA = \text{9E-21e}^{0.309x} \ (R^2 = 0.9920)$$

Where:
CA = Projected number of Cattle per Annum

National livestock survey: The survey was conducted in 14 districts of Uganda, namely, Bushenyi, Iganga, Katakwi, Lira, Luwero, Masaka, Masaka, Mbale, Mpigi, Naksongola, Pallisa, Rakai, Soroti and Tororo. These districts were purposely selected and they represented the major agro-ecological zones in Uganda where cattle keeping is predominant.

A standardized questionnaire was developed, pre-tested and administered to a representative number of cattle keepers in these districts. In each of these districts, one county was selected for the study and at least 30% the households keeping cattle was targeted for administration of the questionnaires. The selection of the households was guided by the respective area veterinary officers. The questionnaires were administered by a team of enumerators who had been trained on the use of the study instrument.

The questionnaire captured data on the background of households keeping cattle: Age, gender and highest level of education, experience and motives for keeping cattle. These factors were considered to contribute significantly in management of cattle and indirectly to the ability of the cattle resource in meeting the production targets. The questionnaire also sourced data on the cattle resource base of each household in terms of breed composition and herd structure to verify already collected data. A third aspect of the survey capture data pertaining to herd dynamics, including reproductive parameters and factors associated with mortality rates, culling rates and longevity of adult females and male cattle in the herd. Additionally, to conform and verify the robustness of researched and published data, farmers' estimates of milk production, length of lactation and proportion of milk used for human consumption were recorded.

Data analysis: Data obtained from the different districts were entered in a spreadsheet, cleaned for outliers and was analyzed using the Statistical Analytical Systems computer package. Descriptive statistics using frequency distributions, standard deviations, percentages and means were computed. These statistics were those considered for entry into the LAM. In the case of production targets, the data obtained from the Ministry of Agriculture, Animal Industry and Fisheries were subjected to stepwise regression analysis in order to determine the most appropriate model for projections.

RESULTS AND DISCUSSION

The results of the national livestock presented here are those that were directly used in the LAM. Other results of the survey that were not directly used in the LAM have been reported elsewhere (GLG, 2002). Table 1 shows the national means of the parameters derived from the livestock survey. The parameters are disaggregated by breed. In general, the estimates given by cattle keepers were lower than those reported in government reports (MAAIF, 1996). Wide inter-district variations in the estimates were recorded. For this reason, the figures reported here and used in the LAM are weighted averages.

Table 2 shows the LAM projected results for methane production from cattle population in Uganda for the period 2000 to 2030. The total annual methane emission in the year 2000 was estimated at 337,796 tons. The results from the LAM show that annual methane emissions out put from cattle in Uganda is likely to triple over the next three decades unless there are some improved feeding, breeding and herd management practices implemented. The total cattle population is projected to increase from approximately 6.9 million heads of cattle in the 2000 to 18.5 million heads in year 2030. This population will be enough to ensure that the projected milk and meat demands of the population are met. Additionally, it is estimated that the current carrying capacity of the agricultural land in Uganda can support between 15 and 20 million heads of cattle. With the assumed advancement in rangeland care and improved feeds there should be adequate carrying capacity these cattle in Uganda. The current projection is that the national cattle herd of Uganda has sufficient room for expansion to allow it to meet the milk and meat needs of the population.

Among indigenous cattle breeds, the Zebu and Nganda had the highest methane emission per unit of product, generating approximately over 1 kg of methane per kilogram of milk produced. The Ankole cattle emitted approximately half the amount of methane per kilogram of milk produced (0.566 kg) as compared to the

Table 1: National mean estimates of selected parameters used in the LAM

	Breed				
Parameter	Ankole	Nganda	Zebu	Crossbred	Exotics
Milk yield per lactation (l)	326	210	133	421	759
Lactation length (months)	6	5	6	7	8
Calving interval (months)	19	16	14	14	12
Percent national herd composition	46	13	26	11	4
Percent cows bred	100	100	100	100	100
Percent milk used for human consumption	85	63	78	85	79
Mortality rate (adults males)	4.2	12.5	6.1	5.9	5.7
Mortality rate (adult females)	4.2	8.2	5.7	6.5	7.5
Mortality rate (replacement males)	5.8	19.4	16.6	8.4	9.2
Mortality rate (replacement females)	5.3	12.9	7.5	7.3	6.9
Mortality rate (male calves)	4.4	9.6	11.5	5.9	11.4
Mortality rate (female calves)	5.7	13.3	13.3	8.3	9.5
Annual culling rate (adult males)	12.9	14.2	17.1	8.2	9.3
Annual culling rate (adult females)	19.9	10.1	7.0	11.1	3.7
Productive herd life of female (years)	9.6	8	7.3	5.1	7.5
Productive herd life of males (years)	8	6	6	3	3.7

Table 2: Methane emissions in Uganda over the period from 2000 to 2031

Year	Estimated population (000,000s) Human	Cattle	Total consumption (000s tons) Milk	Beef	Annual emissions of methane (tons)
2000	21.0	6.9	661.7	101.9	337.796
2001	21.6	7.3	697.7	10.7.4	354.553
2002	22.1	7.6	727.6	112.4	368.843
2003	22.7	7.8	759.1	117.8	379.703
2004	23.3	8.1	792.2	123.6	391.744
2005	23.9	8.4	826.8	129.7	408.235
2006	24.5	8.8	863.1	136.6	425.769
2007	25.2	9.1	900.9	143.1	443.844
2008	25.8	9.4	940.2	150.4	457.476
2009	26.5	9.8	981.2	158.1	477.189
2010	27.2	10.1	1,023.7	166.1	490.229
2011	27.9	10.5	1,067.9	174.5	511.097
2012	28.6	11.0	1,113.6	183.2	532.533
2013	29.4	11.3	1,160.8	192.4	545.752
2014	30.1	11.6	1,209.7	201.9	562.373
2015	30.9	11.9	1,260.1	211.7	578.095
2016	31.7	12.3	1,312.1	222.0	598.718
2017	32.5	12.8	1,365.7	232.6	622.568
2018	33.4	13.1	1,420.9	243.6	635.960
2019	34.3	13.9	1,477.6	255.0	657.430
2020	35.2	13.9	1,536.0	266.8	670.572
2021	36.1	14.4	1,595.9	278.9	695.919
2022	37.0	14.7	1,657.4	291.4	709.791
2023	38.0	15.0	1,720.4	304.3	722.118
2024	39.0	15.3	1,785.1	317.5	729.788
2025	40.0	15.6	1,851.3	331.2	752.073
2026	40.0	16.1	1,919.1	345.2	777.980
2027	42.1	16.7	1,988.5	359.5	810.248
2028	43.2	17.2	2,059.4	374.4	840.017
2029	44.3	17.8	2,132.0	389.4	873.037
2030	45.5	18.5	2,206.1	404.9	907.601
2031	46.7	19.1	2,281.8	420.8	939.541

Table 3: Percent methane emissions by sector in 2000 and 2030

	Percent methane emission in	
Livestock sector	2000	2030
Cows	58	38
Female slaughters	2	10
Young females	2	2
Female replacements	25	12
Bulls	1	1
Male slaughters	10	34
Young males	1	3
Male replacement	1	0

Zebu and Nganda. The improved breeds emitted 0.65 kg of methane per kilogram of milk produced.

Table 3 shows percent methane emissions in the years 2000 and 2030 projections disaggregated by the national herd structure. In the year 2000, the majority of methane emissions was coming from cows (58%), followed by female replacements (25%). Male slaughter cattle contributed only constitute 10% of the methane emission source in 2000, but in 2030 that percentage increases to 34%. During this time the female replacements contribution to the national methane emission is projected to drop substantially from 25 and 12%.

Considering developments over the next thirty years, the LAM results showed that the proportion of methane coming from improved verses native cattle gaps widens with regards to efficiency and impact on Uganda's national herd. As the native herd drops in percentage of the national herd by approximately 20%, the percentage of methane emissions coming from the native herd only drops by 15%. Conversely, the improved cattle population herd grows as a percent of the national herd by about 20%, but methane emissions increase by 15%.

This study is the first report on the emissions of methane from cattle population in Uganda. Generally, very limited studies have been conducted on emissions of methane from cattle in developing countries. Although cattle in Uganda emit large quantities of methane, they also represent opportunities for emission reductions through improvement in productivity and efficiency. The high amounts of methane emitted by the cattle population in Uganda per unit of product may largely be attributed to the poor quality feedstuffs. The feed digestibility has an important impact on methane emissions in cattle. The greater the digestibility of the feed, the more easily the feed is broken down and used by the animal for production. A lower percent digestibility means that the feed will be harder to utilize by the animal and more energy will be converted to methane. The majority of cattle in Uganda are grazed on natural pastures whose digestibility ranges from 50 to 60%.

A highly productive cow emits approximately 0.017 kg of methane per kilogram of milk produced (EPA, 1994). From the present findings, a Zebu or Nganda cow in Uganda emits approximately 59 times this amount. It is interesting to note that the Ankole cattle emit lower amounts of methane per kilogram of milk than Zebu and Nganda cattle. This could be due to genetic differences. Compared with the the Zebu and Nganda breeds, the Ankole cattle are generally bigger animals, with males attaining adult weight of up to 500 kg, while the adult females can attain an adult body of weight of 400 kg (Epstein, 1971).

In Zimbabwe, Mupeta *et al.* (2006) reported that methane emissions in cows decrease with increased level of sunflower cake supplementation (Mupta *et al.*, 2006). In that study, supplementation of cows with sunflower cake resulted in a 45% reduction of methane emissions per unit of milk produced. In Uganda, the indigenous cattle breeds are raised mainly on unimproved natural pastures. Little or no feed supplementation is provided to them.

CONCLUSION

We conclude that among the indigenous cattle breeds in Uganda, the Ankole cattle emit less methane per unit of milk produced than do the Zebu and Nganda cattle. There is a potential for reducing methane emissions from cattle in Uganda in order to gain carbon credits for reduction of greenhouse gas emissions in line with the UNFCC.

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