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Harnessing methane generated from livestock manure in Ghana, Nigeria, Mali and Burkina Faso

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ABSTRACT

Methane emission from livestock manure is increasingly contributing to the global green house gas emissions. In this paper the methane emission from cattle, pig, sheep, goat and chicken manure in four West African countries; Nigeria, Ghana, Burkina Faso and Mali were estimated. A systematic estimation of the methane emission was done based on the livestock production projections by FAO from 1998 to 2008 and guidelines provided by the Intergovernmental Panel on Climate Change (IPCC). During this period, cattle were found to have emitted more methane followed by pigs, goats, sheep and chicken in that order. A total of about 845 Gg of methane was emitted by the livestock during the period of which cattle contributed about 40%, whereas pigs, goats, sheep and chicken contributed 21.2%, 18.7%, 13.1% and 6.6% respectively. The methane emission from manure management in these countries increased from 64.1 Gg in 1998 to 90.5 Gg in 2008, with an annual growth rate of 3.4% y^{-1}. The methane estimated from livestock manure over the period was shown to be consistent with the linear group model which predicts that in 2018, 2.4 Mt CO_2-eq will be emitted increasing to 3.0 Mt CO_2-eq in 2028 if the mechanism of manure management remains unchanged. This paper reveals that generating methane from the manure produced by the livestock under controlled conditions could supplement the energy needs, increase Gross Domestic Product (GDP) and consequently reduce the direct impact of methane on climate change.

1. Introduction

Currently, climate change has become the most discussed subject globally. It has however, been induced by the effect of increasing green house gases which causes great environmental concern. Chiefly among this gases are carbon dioxide and methane. Methane is mostly produced biologically by methanogenic archaea in anaerobic environments [1]. Each year some 590 Tg to 880 Tg of methane are released worldwide into the atmosphere through microbial activities [2]. A major cause of this rising concentration of methane is the increasing emission, particularly from agricultural activities involving cattle, and other domestic animals such as cattle, buffalo, sheep, goats and camel, bacteria break down food in the rumen and generate methane as a by-product [3]. The methane is produced together with carbon dioxide in a form of biogas. Apart from methane and carbon dioxide, there are traces of other gases as shown in Table 1. The amount of methane produced depends on the type of animal, the amount, the kind of feed it consumes and the type of animal waste management [2].

United Nations Framework Convention on Climate Change (UNFCCC) has encouraged nations to communicate emission

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Table 1 – Average composition of biogas from different organic residues [4].

Gases	Volume fraction (%)
Methane (CH_4)	40–75
Carbon Dioxide (CO_2)	25–40
Nitrogen (N)	0.5–2.5
Oxygen (O)	0.1–1
Hydrogen sulphide (H_2S)	0.1–0.5
Ammonia (NH_3)	0.1–0.5
Carbon monoxide (CO)	0–0.1
Dihydrogen (H_2)	1–3

Table 3 – Manure management emission factors [7].

Livestock type	Emission factor (kg head^{-1} y^{-1})[a]
Cattle[b]	1
Pig	2
Sheep	0.21
Goat	0.22
Chicken	0.023

a Almost all livestock manure is managed as a solid on pastures and ranges.
b The emission factor for non-dairy cattle was used in the calculation.

inventories of green house gases (GHG) such as methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) from various sectors like energy and industry, agriculture, land use-land use change and forestry and municipal waste [5].

The use of animal manure and other organic-based waste products as bioenergy feedstocks for waste-to-bioenergy conversion processes would allow farmers to take advantage of new markets for traditional waste products. The results of implementing such programmes help these farmers to improve upon their productivity. In effect, livestock waste-to-bioenergy treatments have the potential to convert the treatment of livestock waste from a liability or cost component into a profit center that can: (1) generate annual revenues; (2) moderate the impacts of commodity prices; and (3) diversify farm income [6]. Factors that affect methane and emission from manure include temperature, oxygen level (aeration), moisture and sources of nutrients [3]. In the estimation of the methane emission for livestock, Intergovernmental Panel on Climate Change (IPCC) has published useful methods using a simplified approach that relies on default emission factors for Tier 1 where necessary population data be readily obtainable within the country or from the Food and Agricultural Organization (FAO), or the Tier 2 which requires additional data on manure characteristics and manure management practices, for which country-specific data should be used [7]. In this study, livestock production data for four West African countries namely; Ghana, Nigeria, Burkina Faso and Mali were considered.

Most of Nigeria has a tropical climate with warm temperatures throughout the year with the Northern part of the country appear to be generally hotter and drier than the Southern part. The average annual temperature in the northern part is about 29 °C, (daily temperatures may rise above 38 °C) and the average annual temperature in the South part is about 27 °C [8]. The average annual temperature for these countries influences the selection of methane emission factors for live manure management. Basic energy indicators

Table 2 – Selected livestock production data for Nigeria, Mali, Burkina Faso and Ghana (head) [22].

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Nigeria											
Cattle	15088100	15103200	15118300	15133400	15148600	15163700	15700000	15875266	16065770	16152700	16293200
Pig	4666817	4853487	5047624	5249540	6111824	5677900	5910000	6141220	6390000	6642340	6908030
Goat	37500000	40000000	42500000	45260400	46400000	47551700	48700000	49959000	51223600	52488200	53800400
Sheep	21500000	24000000	26000000	28692600	29400000	30086400	30800000	31547900	32314200	33080400	33874300
Chicken	126000000	126000000	113200000	124620000	131125000	137680000	143500000	150700000	158400000	166127000	175000000
Mali											
Cattle	5634512	5774818	5934736	6116077	6320953	6551799	6811473	7103306	7431226	7843400	8278400
Pig	55233	56430	58375	61287	65463	71308	84601	90380	105349	71100	75000
Goat	6741722	6897183	7087081	7314994	7585208	7902845	8273953	8705721	9206601	9667000	10150350
Sheep	5409891	5628809	5876708	6157390	6475328	6835781	7244924	7710057	8239797	8870700	9500000
Chicken	24500000	25000000	25000000	23364000	28000000	29000000	30000000	31000000	32000000	33000000	33000000
Burkina Faso											
Cattle	5820092	6091801	6673865	6673865	6985432	7311544	7652883	8010158	8378600	8764100	9167300
Pig	1170856	1288102	1417089	1558992	1715105	1886851	2075795	2283658	2512000	2763200	3039500
Goat	8531873	8813429	9104277	9404723	9715084	10035687	10366875	10708992	11062400	11427500	11805000
Sheep	5993171	6128787	6267471	6409294	6554326	6702640	6854307	7009407	7163600	7321200	7482300
Chicken	21301000	21885000	22484000	23100000	23734000	24384000	25052000	25739000	26440000	27150000	27900000
Ghana											
Cattle	1272900	1288000	1302000	1315000	1330000	1344000	1365000	1385000	1406000	1427100	1427100
Pig	351800	332000	324000	312000	310000	303000	300000	305000	229000	239000	239000
Goat	2739380	2931000	3077000	3199000	3230000	3560000	3595600	3631600	3668000	3704700	3704700
Sheep	2516455	2658000	2743000	2771000	2922000	3015000	3111500	3211100	3314000	3420000	3420000
Chicken	17302000	18810000	20472000	22032000	24251000	26395000	29500000	30000000	30500000	31000000	31000000