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Review Article

A Concise Review of Livestock as a Key Anthropogenic Climate Change Forcer

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ABSTRACT

This study reviewed the main issues relating livestock as a significant anthropogenic climate change forcer. It obtained knowledge mainly from vital related literatures on livestock as an anthropogenic cause of climate change. The study revealed the sources of greenhouse gases (GHGs) from livestock as well as its contributions to anthropogenic GHGs emissions. It affirms that livestock is a key causal factor of climate change through the emission of methane, carbon dioxide and nitrous oxide. This paper built on these indications to provide appropriate mitigation strategies. It recommended that an empirical study based on an in-depth conversation with livestock keepers and sellers over their perception of the roles played by livestock to induce climate change should be carried out.

1. INTRODUCTION

Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persist for an extended period (IPCC, 2007). It is a consequence of anthropogenic greenhouse gases (GHGs) emissions related to resource production, exploration and consumption processes. Human activities are said to be responsible for the growing rate of climate change and its adverse effects (Odjugo, 2010). The human factors that produce large amounts of GHGs include industrialization, burning of fossil fuel, gas flaring, urbanization and agriculture. These activities have been proven to be responsible for the ongoing unequivocal global warming and climate change (IPCC, 2007). The emitted GHGs are carbon dioxide (CO_2), chlorofluorocarbons (CFCs), methane (CH_4), nitrous oxide (N_2O) among others. Spore Special Issue (2008) opined that the phenomenon of climate change arises because the concentration of GHGs produced by human activity has significantly increased. However, Goodland and Anhang (2009) noted that whenever the causes of climate change are discussed, fossil fuels top the list. Crude oil, natural gas and coal are the major sources of human-caused emissions of CO_2. In addition, Odjugo and Edokpa (2009) reported that industrialization; urbanization, water pollution, deforestation and transportation are among the highest contributors to climate change.

The role of livestock as an anthropogenic causal factor in GHGs emissions has been grossly downplayed. Goodland and Anhang (2009) affirmed that livestock has been enormously underestimated as a source of GHGs, and in fact account for at least half of all man-induced GHGs. Globally, livestock and livestock systems are a major cause of global warming. In addition, climate change will have major impacts on poor livestock keepers and on the ecosystem goods and services on which they depend (Herrero and Thornton, 2009). The weight of evidence is currently so strong that livestock roles in climate change can no longer be ignored (Gerard and Lefkothea, 2011). There is limited literature especially in the tropics regarding livestock as a major source of GHGs. The aim of this paper is to review the role of livestock as a key contributory factor of climate change. Such scholarly research is significant to initiate policies and implement climate change mitigation strategies as related to livestock.

2. METHODOLOGY

The method adopted was basically on content study of secondary data. Reports and presentations from International Fund for Agricultural Development (IFAD), World Bank, Food and Agriculture Organization (FAO) of the United Nations and World Initiative for Sustainable Pastoralism (WISP) were acknowledged for review through an all-inclusive search and revision. Associated published literatures and documents were also searched in an orderly manner, adopting an array of key words connecting livestock to climate change.

3. LIVESTOCK AND CLIMATE CHANGE

Livestock production systems, from feeding, importing and marketing animals and animal products, directly and indirectly produce 18 % of world GHGs emissions as evaluated in CO_2 equivalents (Steinfeld et al., 2006). Livestock production is increasing globally, driven by growth of human population, living standards and urbanization. Livestock production accounts for about 30 % of the gross value of agricultural production, with 92 % of that coming from the production of beef cattle, dairy cattle, goats, sheep and chickens (IFAD, 2009). World Initiative for Sustainable Pastoralism reported that Africa covers a total land area of approximately 30 million km^2 and livestock production takes place on about 54 % or 16 million km^2 where nearly 80 % of the population lives with Sudan, South Africa, Ethiopia and Nigeria together containing about a quarter of Africa's livestock-producing land (WISP, 2010). Total human population in Africa continues to grow at about 2.5 % per year while the total livestock population in Africa is about 250 million Tropical Livestock Unit (TLU) equivalents (World Bank, 2013). The sector is widely constrained by a lack of regulation which leads to negative externalities such as land degradation, water pollution and loss of biodiversity and emission of GHGs (WISP, 2010). Livestock production according to FAO (2007) is responsible for a greater proportion of anthropogenic GHGs emissions than the entire global transportation sector (which emits 4000 - 5200 Tg CO_2 eq/yr).

4. CONTRIBUTIONS OF ANTHROPOGENIC GHGs EMISSIONS FROM LIVESTOCK

Livestock's Long Shadow estimate puts the global contribution of anthropogenic GHGs emissions from the livestock sector at 7100 Tg CO_2 eq/yr, which is about 18 % of global anthropogenic GHGs emissions (FAO, 2006). WISP (2010) revealed that Africa contributes to approximately 4 % of the world's GHGs. Furthermore, they reported that African agriculture contributes 12 % of that and African livestock production generates a plausible third of agriculture GHGs production. Hence, African livestock would be responsible for 0.16 % of the world's GHG emission in CO_2 equivalent. Onyenechere (2010) noted that in Nigeria, current estimates indicated that emissions from combined livestock population of over 44 million led to the emissions of over 1115 Gg of methane. According to Maurice et al. (2009), the prime categories of anthropogenic GHG emissions are: enteric fermentation and respiration (1800 Tg CO_2 eq/yr), animal manure (2160 Tg CO_2 eq/yr), livestock related land-use changes (2400 Tg CO_2 eq/yr), desertification linked to livestock (100 Tg CO_2 eq/yr), livestock related release from cultivated soils (230 Tg CO_2 eq/yr), feed production (240 Tg CO_2 eq/yr), on-farm fossil fuel use (90 Tg CO_2 eq/yr) and postharvest emissions (10 - 50 Tg CO_2 eq/yr) They opined that from the first seven of these eight categories, livestock account for 9, 35 to 40 and 65 % of the total global anthropogenic emitted CO_2, CH_4, and N_2O, respectively.

5. LIVESTOCK AND GREENHOUSE GASES EMISSION

The greenhouse gases emission profile of livestock production is fundamentally different from that of other sectors. The emissions result from inherently variable biological processes which are extremely numerous and complex. According to WSPA (2012), animal farming contributes to GHG emissions through several routes. The most significant GHG emissions are carbon dioxide from land use and its changes (32 %), nitrous oxide from manure and slurry (31 %) and methane from animal digestion (25 %). There are three direct sources of GHG emissions in the livestock production system: the enteric fermentation of animals, manure (waste products) and production of feed and forage (Dourmad et al., 2008). The indirect sources of GHGs from livestock are mainly attributable to changes in land use and deforestation to create pasture land. In the Amazon rainforest, 70 % of deforestation has taken place to create grazing land for livestock (IFAD, 2007).

6. IMPORTANT GREENHOUSE GASES

6.1. Methane

Methane is produced from the microbial digestive processes of ruminant livestock species such as cattle, sheep, and goat. However, cattle are the largest contributing species to enteric fermentation while swine are the second greatest source of CH_4 emissions from manure management. Enteric fermentation during rumination relates to the initial microbial breakdown which occurs in the rumen where microbial fermentation converts fibrous feed into products digested and utilized by the animal (Sun et al., 2008). Monteny et al. (2001) noted that rumination enhances digestion of cellulose and hemicelluloses with the support of microbes and protozoa through the hydrolysis of polysaccharides, which is followed by microbial fermentation generating H_2 and CO_2. Methane is thus the by-product of enteric fermentation and carbohydrate digestion and is expelled through the mouth of the livestock via eructation (Monteny et al., 2001). In ruminant livestock, enteric fermentation is strongly affected by quantity and quality of their diet (Johnson and Johnson, 1995). Enteric methane emissions per unit of production are highest when feed quality and level of production are low (Crutzen et al., 1986).

Methane primarily produced by enteric fermentation and manure storing has an impact on global warming 28 times higher than CO_2 (Grossi et al., 2019). Goodland and Anhang (2009) reported that although methane warms the atmosphere much more strongly than CO_2, its half-life in the atmosphere is only about 8 years, versus at least 100 years for CO_2. Livestock production is the single greatest anthropogenic source of methane hence, Goodland and Anhang (2009) noted that 37 % of human-induced CH_4 comes from livestock. Odjugo (2010) affirmed that a gram of CH_4 is about 23 times higher than the effects of the same volume of CO_2. Solomon et al. (2007) reported that over a 20 year time frame CH_4 has a warming impact 72 times that of CO_2. These studies revealed that the impact of CH_4 as a GHG cannot be underestimated. As a result, mitigation strategies in livestock rearing worldwide would reduce GHGs quickly compared with measures involving renewable energy and energy efficiency. Methane production from enteric fermentation is considered as the primary source of global anthropogenic CH_4 emissions accounting for approximately 73 % of the 80 Tg of CH_4 produced globally per year (Johnson and Johnson, 1995). Goodland and Anhang (2009) reported that FAO estimated 103 million tons of CH_4 emissions through enteric fermentation and manure management which is equivalent to 2,369 million tons of CO_2.

6.2. Carbon Dioxide

Livestock accounts for 51 % of all anthropogenic GHG emissions and carbon dioxide from livestock respiration makes up more than a quarter of livestock emissions (Goodland and Anhang, 2009). FAO (2006) reported that CO_2 from respiration of livestock amounts to ~3000 Tg CO_2 eq/yr. De Gryze et al. (2008) affirmed that under aerobic conditions, CO_2 is preferentially produced. The conversion of forests to rangelands is also a contributing factor to CO_2 emission as emissions from deforestation are equivalent to a quarter of GHG emissions from fossil fuel combustion and cement production (Houghton, 2009). This is known as land-use change from livestock perspective. Land-use changes would include any land adapted for livestock rearing (Houghton et al., 1999). When forest ecosystems undergo relatively abrupt land-use

changes, such as; deforestation, forest regrowth, biomass burning, wildfires, agriculture abandonment, wetland drainage, plowing and accelerated soil erosion, a significant loss of soil organic carbon (SOC) and increase in GHGs emissions occur. Forests cover approximately 4.1 109 ha of the Earth's land area and are estimated to contain 80% of all above ground carbon and 40 % of all below ground terrestrial carbon (Dixon et al., 1994). Forest helps in reducing levels of carbon dioxide and other GHG in the atmosphere. They reduce atmospheric CO_2 through sequestration and reducing GHG emissions by conserving energy used for space heating and cooling. Forest trees are long-lived plants that develop a large biomass, thereby capturing large amounts of carbon over a growth cycle of many decades. Thus, a forest ecosystem can capture and retain large volumes of carbon over long periods. When deforestation takes place, a significant amount of CO_2 is released into the atmosphere.

Growth in market for livestock products is greatest in developing countries, where rainforest normally stores at least 200 tons of carbon per hectare (Goodland and Anhang, 2009). Furthermore, Goodland and Anhang (2009) opined that where forest is replaced by moderately degraded grassland, the tonnage of carbon stored per hectare is reduced to 8. Hopkins and Del Prado (2007) noted that when natural vegetation is converted to agricultural land through deforestation, a large proportion of the soil carbon can be released. Such land conversion contributes approximately one third of the total CO_2 emissions globally. CO_2 is also released by burning crop residues, using fuels for agricultural production and from livestock processing. In most developing countries, during processing, most livestock especially cattle, goat and sheep have their fur burnt using kerosene and fire. This process emits black carbon into the atmosphere and the black particles cause warming in the atmosphere by absorbing sunlight and re-radiating heat (Gerard and Lefkothea, 2011). Fires for pasture maintenance and deforestation are the single greatest source of black carbon which according to Baron et al., 2009), such emissions are responsible for as much as 40 % of the net global warming.

6.3. Nitrous Oxide

Agriculture is considered the largest source of anthropogenic nitrous oxide and livestock are the second greatest source of N_2O emissions from manure management (De Gryze et al., 2008). The management of animal manure can produce anthropogenic N_2O via nitrification and denitrification of organic nitrogen in animal manure and urine (Bouwman, 1996). Indirect N_2O emissions are produced from nitrogen lost as runoff, and leaching of nitrogen during treatment, storage, and transportation of livestock products (Mosier et al., 1998). Quantitatively, the rate of N_2O emissions from soil is highly dependent on several variables including rate of synthetic nitrogen-fertilizer application, organic manure application, presence/absence of crop residues, mineralization of soil matter, presence of N-fixing crops, irrigation, and tillage practices (Del Grosso et al., 2006). N_2O from soil is the primary agricultural source of GHGs and these N_2O emissions are primarily due to fertilizer and livestock manure applied to agricultural soils (De Gryze et al., 2008). De Gryze et al. (2008) noted that 65 % of global anthropogenic N_2O emissions are derived from agricultural soils, use of synthetic and manure fertilizers, manure deposition and biomass burning.

7. MITIGATION STRATEGIES

Mitigation according to IPCC (2007) refers to activities designed to reduce the sources and enhance the sinks of GHGs in order to limit the negative effects of climate change and to decrease the level of emission of GHGs. Strategies for mitigating climate change induced from livestock, which are subject to local context according to WISP (2010) should include the following:

- Eliminating unproductive animals and increasing the overall efficiency of livestock production.
- Selection of more productive livestock breeds where conditions allow.
- Establishing and improving existing rangelands through improved pasture management.
- Enabling of transhumance and effective communal pasture management.
- Reforestation and tree protection in pasture lands.
- Improved feeding quality of livestock.

8. CONCLUSION AND RECOMMENDATIONS

It is evident that livestock is a major emitter of greenhouse gases, hence a key anthropogenic cause of climate change. Globally, as a result of the trending devastating effects of climate change, there is an urgent need to reduce greenhouse gas emissions. Thus, it is compelling and desirable to adopt mitigation strategies. It is also suggested that an empirical research based on a detailed conversation with livestock keepers and sellers over their perception of climate change and the roles played by livestock should be carried out. This will provide the basis for the enhancement of the workability of the mitigation strategies against climate change induced by livestock.

9. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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