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Review Article

Impact of Livestock Enteric Emission on Climate and its Mitigation

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ABSTRACT

The increase in production of greenhouse gases is a major cause of global warming for which livestock holds a big share in total greenhouse gas emission annually. The greenhouse gases produced by livestock include carbon dioxide, methane, nitrous oxide etc. Cattle and buffalo are the major contributors responsible for 90% emission of GHG followed by sheep and goat. Increase in carbon dioxide emission by livestock, decaying of dung in absence of oxygen, enteric fermentations are the major sources of greenhouse gas production by livestock species. Owing to greenhouse effect, the elevated greenhouse gases cause global warming resulting in the increase of surface temperature of earth, decreased precipitation, and huge damage to environment and affect the flora and fauna turning the conditions on earth unfavorable for survival of living forms. The major impacts are loss of biodiversity, loss of habitat for animals and plants, uncertainty in climate, increase in livestock diseases, damage to feed sources (plants), decrease in productivity of livestock species and many more. Mitigation measures needed to be focused on decreasing the global meat consumption, implementing carbon tax, feeding dietary oils/nitrates, manure management and its biodigestion, genetic manipulations besides strengthening of global livestock environmental assessment models.

Keywords: *Green House Gases, Carbon dioxide, Enteric fermentation, Carbon Tax, Cattle.*

INTRODUCTION

The requirement of livestock products is increasing day by day and is expected to increase significantly in future. Since the developing nations still have unexplored potential, there will be additional increase in demand from them. But to meet the world demands the nations either has to increase the quantity of their livestock, or the quality, viz, production potential.

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However choosing either option is not an easy task for these nations because of the adverse effects livestock has on the climate, which is an alarming global issue and needs to be addressed immediately.

About one-third of the ice free terrestrial surface area of the planet is occupied by livestock, which uses almost 15% of the global agricultural water (World Bank, 2009). As per one estimate livestock are accountable for 20% of rangeland degradation and out of biodiversity of 825 worldwide ecoregions, livestock poses a threat to biodiversity of 306 ecoregions (Le Gall, 2013). The most detrimental impact of livestock on the climate change is through the production of enormous amounts of Green House Gases (GHGs). The agricultural sector, through its green house gas emissions contributes 22% to the total world emissions, out of this the contribution from livestock (including transport of livestock and feed) accounts for 80% of the emissions. (McMichael et al., 2007). The livestock sector has a contribution of 14.5% of all the global anthropogenic green house gas emissions (Henderson et al., 2016). The global warming potential of CH_4 and N_2O are 25 and 310 times more, respectively when compared with CO2 (Opio et al., 2013). Carbon dioxide from the respiration of livestock, though, is not considered as a net source of GHG emissions (Kyoto Protocol, 1997) but according to studies conducted by British Physicist, Alan Calverd in 2005, CO2 from the respiration of livestock accounts for 21% of anthropogenic GHGs (Calverd, 2005). The figure however was changed to 13.7% after considering some important facts which Calverd has not paid heed to in his studies (Goodland & Ahnang, 2009). As per a study enteric methane contributes 4% to the world methane production (Forster et al, 2007; & Klieve & Ouwerkerk, 2007) The sources of GHGs from livestock rearing are enteric fermentation (90% contributor) and excreta. In one study FAO has predicted that the GHG emissions may get doubled in the coming 35-40 years.

1. GREENHOUSE GAS PRODUCTION BY VARIOUS LIVESTOCK SPECIES:

The intergovernmental panel on climate change of United Nations in a report submitted that the probability of global warming is huge and that the humans are mostly responsible for it (IPCC, 2007). Carbon dioxide, methane, nitrous oxide, hydro fluorocarbons, per fluorocarbons and Sulphur hexafluoride: are the greenhouse gases included by IPCC as the major causes of global warming. Among these methane is produced considerably in huge amounts by livestock and is an important greenhouse gas the levels of which are elevated in atmosphere (Bhatta et al., 2005, 2006a). The greenhouse gases cause warming of earth due to trapping of energy by the GHG particles (IPCC, 2001). The carbon footprint of livestock is greater in developing than in developed countries (Cole et al., 2016). There are four ways by which livestock cause the emission of gases into the atmosphere which include Enteric fermentation, Decaying of dung in absence of oxygen, Increased carbon dioxide (due to various processes involved in livestock production and marketing) and clearing of trees (Leng, 1991). Nitrous oxide and methane are important sources of GHG emitted from livestock through livestock products while in monogastrics, only nitrous oxide is the main GHG emitted. CO2 is not important as far as livestock products are concerned (Vries & Boer, 2009). The major contributor of the GHG emission is Asia pacific (32.74%) followed by Latin America, Europe, Africa and North America. (Key & Tallard, 2012). The total GHG emission in world by livestock species and humans in 1983 is summarized in **Table (1)**. So far as enteric methane emission from different livestock species in India is concerned, Cattle and buffalo together contribute more than 90% and sheep and goat contribute over 7.5%. A detailed account of the emissions by livestock in India is presented in **Table (2).**

Cattle: Cattle has a major share in GHG emission by livestock which is more than 50%. The milch animals have a lower emission rate as compared to beef cattle because of their preference towards milk production and thus diluting emissions with respect to maintenance requirement. Also cattle reared in grazing system have more emission intensity than those reared in mixed farming system. The contribution of cattle include 2.9 gigatonnes from beef production and 1.4 gigatonnes from milk production. Other Goods and services related like manure contribute about 0.3 gigatonnes.

Buffalo: Buffalo contribute less as compared to cattle prior to their less population although per head emission in case of buffalo is more than cattle. This is because of lower digestibility of feed in buffalo. They contribute over 390 million tonnes from milk production and 180 million tonnes from meat production and 48 million tonnes from other related goods and services.

Small Ruminants (Sheep and Goats): About 475 million tones CO_2-eq is released by sheep and goat, 299 million tonnes from meat production and 130 million tonnes from milk production. Compared to Cattle and buffalo, the emission rate is less in small ruminants even though additional emission from fiber production is seen in small animals.

Pig: Pig contributes 668 million tones of livestock emission from meat production. Other main emission sources with respect to pig include feed and manure.

Chicken: Chicken emits 606 CO_2-eq million tones, 217 million tonnes from egg production and 389 million tonnes from meat production. The other emission sources include feed production and manure. (FAO, 2013)

The latest information regarding the greenhouse gases emitted due to activities pertaining to livestock species during the period 1995-2005 is given in **Table (3).**

2. Impact of Livestock on Climate and it's Repercussions on Biodiversity:

Climate is the average weather. It is the mean of temperature, precipitation, and wind over prolonged period of time. Climate has changed over several years attributing to various phenomena like rising concentration of greenhouse gases which cause global warming owing to the greenhouse effect. The surface temperature of earth has elevated by 1.4°F over last 100 years (Le Treut et al., 2007). The amount of GHG in present era is more than that estimated over last 650 thousand years (U. Siegenthaler et al., 2005). There has been an increase of 80% in greenhouse gases emission since 1970, leading to change of 2838 Mw/m^2 equivalent to atmospheric concentration of 473 ppm CO_2e (Butler & Montzka, 2011; & NRC, 2010). A significant portion of these greenhouse gases is contributed by livestock leading to severe consequences, which are harmful to the biodiversity and the climate of earth. The impacts of increased greenhouse gases causing increase in the surface temperature of earth, owing to global warming are as hereunder.

3. a. Impact on habitat and environment:

3. a.i. Desertification: Global warming owing to increase in greenhouse gases along with decreased precipitation will most probably lead to desertification especially in dry lands (Dr. Tim Lane, 2014). The arid area of earth is expanding (Thompson, 2010). This would lead to decreased vegetation, erosion by wind and also water logging (Dregne & Cou, 1992) and would result in food scarcity especially in grazing animals.

3. a.ii. Increased melting of snow and ice: Melting of glaciers and ice caps over last 30-35 years due to continuous global warming is a huge matter of concern (Thompson, 2010). The species of animals which would be severely affected include Polar bears, Seals, Walrus etc, as they would lose their habitat. Melting glaciers are a big threat to wild species because of loss of favorable environmental conditions (Stracansky, 2010).

3. a.iii. Sea level rise: This is the considerable effect of the global warming. The sea level is predicted to be increased to faster rate which would cause submerging of low lying coastal area. From 1880 -2009, there was 21cm increase in sea level. (Church & White, 2011). This would account for huge losses of marine biodiversity.

3. a.iv. Stronger storms and extreme events: Global warming would cause increased disaster probability and intensity. Drought and storms due to continuously increasing global temperature is a probable certainty. (The impact of climate change on natural disasters.Drought causes the maximum damage to the livestock while storms such as hurricanes affect fisheries heavily (FAO, 2015).

3. a.v. Ocean acidification: Increased carbon dioxide leads to acidification of ocean, causing much damage to biodiversity .Oceans absorb much of CO2 emission which form carbonic acid on reacting with sea water (Logan, 2010).

3. a.vi. Smog and Ozone pollution: The amount of Ozone has doubled in concentration from last century due to increase in methane and nitrogen oxide. (West J et al., 2006). Ozone is harmful for livestock, plants and the human beings. It has shown to decrease life expectancy and the yields of key staple crops like maize, wheat etc. (Anenberg et al., 2010; & Avnery et al., 2013).

3. b. Impact on feeds: Feed crops are affected by climate increased greenhouse gases in several ways: The increased temperature and changes in the CO_2 levels have brought great changed in the herbage growth, the proportion of grasses to legumes has changed thereby changing the pasture composition owing to the change in climate, increased precipitation in certain areas has led to increase in N leaching in the soil. (Hopkins & Del Prado, 2007). Due to drastic changes in climate, the plants adjust their optimal growth ranges and this leads to change in pasture composition as the species alter their competition dynamics. However in mixed systems, the influence is not that noteworthy as they don’t count of availability of pastures always (Thornton, 2009). Decreased rainfall and increased temperatures can lead to less accessible feedstuff for animals.

3. c. Impact on livestock diseases: There has been a tremendous change in the epidemiology of the infectious diseases prior to climate change. These impacts are both indirect and direct. Direct effects concern mainly with the host immune response, increased pathogenicity of disease causing pathogens or vectors and the reemergence of diseases due to these. Conversely, indirect effects are the different living patterns of present society including sociological, cultural, economic changes which have somehow disturbed the host-pathogen interaction or vector-pathogen development, be in the increased contact of host-pathogen due to migration or reemergence of diseases owing to different livestock practices or the changing biodiversity. Due to increase in the extreme events like floods, drought, cyclones, desertification etc, the risk of serious outbreaks of certain diseases has increased like more flooding can result in more outbreaks of leptospirosis and foot rot (Bett et al., 2016). The major effects on livestock diseases owing to climate change are:

3. c.i. Impact on host immune system: Owing to increased greenhouse gases the increase in temperature more than the optimal range (10-30°C) for domestic animals severely affects their normal physiology, reproduction, feed and water intake, milk production, and immunity (Das et al., 2016). The endocrine functions are also affected due to change in temperature resulting in altered secretion of the hormones. The increased secretion of cortisol from adrenal gland due to change in temperature suppresses immune response in animals thus making it more prone to infectious diseases (Dittmar et al., 2014). Reduced feed intake in animals also causes decrease in immunity. Temperature above 30°C has been seen to decrease feed intake in domestic animals like sheep, goat. (National Research Council [NRC], 1981).

3. c.ii. Impact on vectors and pathogens: The changing climate affects the vector activity, survival, development rates and resistance against different medications. The temperature change mostly affects those pathogens which have a major part of their life cycle in open environment. The effects include higher rate of replication inside vector (Bett et al., 2016).

3. d. Impact on productivity: The climate change may affect livestock productivity and their reproductive performance (Nienaber et al., 1999) by affecting their growth, reproduction, adaptation. milk production (Sejian et al., 2016). Heat stress in animals causes decrease in milk, meat and egg production (Nardone et al., 2010).

3. Mitigation Measures

As per the FAO, the world human and livestock population is expected to double from 2006 to 2050. That implies livestock related GHG emissions will also increase substantially and at the same time it is predicted that the industrial GHGs will drop thus making the livestock related GHGs emissions even more objectionable than their current hazardous levels. (Robert & Jeff, 2009).

4. a Managing the demand for livestock products: The technologies available nowadays to deal with these emissions from livestock sector claim to decrease the non CO_2 emissions by less than 20%. So a new strategy to tackle this menace is to reduce the consumption of livestock products. Assuming a 40% hike in global population by 2050 and no advance in livestock related green house gas emissions, in order to stabilize the emissions from this sector there should be a need of decreasing the global meat consumption to an average 90 g/person. This would require reduction of meat consumption especially from the methane producing ruminant animals. (McMichael et al., 2007).

4. b Implementing Carbon taxes: Carbon Tax is a fee implemented on the fossil fuel users for paying the damage their fossil fuel imposes on the climate by releasing carbon dioxide into the atmosphere. Carbon tax in Norway, implemented in 1991 contributed to a decline in onshore emissions of 1.5% and total emissions of 2.3%. (Annegrete & Bodil, 2002). This tax has been instated on the energy sector, but since the emissions from livestock are huge, as a measure to curb the emissions, this can be extended to the livestock sector as well, say, if the livestock producers were priced per head of cattle, relative to the amount of carbon each animal produced, a tax could be applied accordingly. This would automatically lead to the control of animal numbers; i.e., holding a fewer animals with high potential in place of large number of non producing animals.

4. c Livestock Production and Management Systems:

The ruminant production systems contribute 90% to the global GHG emissions (Henderson et al., 2016). There's a need of introduction of abatement practices that would target enteric CH_4 emissions and increase soil CO_2 sequestration. Following practices could be followed to serve the purpose.

4. c.i Alteration in feeding practices: Methane production per unit of animal can be decreased significantly by taking measures that would improve the quality of feed offered to the Ruminants (Monteny et al., 2006).

4. c.ii. Feeding of dietary oils: Feeding of dietary oils to ruminants has lead to decrease in the GHG emissions (Henderson et al., 2016). This has been proved by a study in which a mixture of feed additives containing lauric acid, myristic acid, linseed oil, and calcium fumarate was fed to lactating dairy cows. These ingredients were added @ 0.4%, 1.2%, 1.5% and 0.7% of dietary dry matter, respectively. The methane emission (g/d) by the animals show a 10% decline (Ziderveld et al., 2011).

4. c.iii. Feeding of Nitrates: Joblin (1999) suggested three ways of decreasing the enteric methane production: viz; removal of methanogens from rumen, reduction in H2 production and provide a H2 sink. Since Nitrate is an electron sink, it is known to reduce the methane production in Sheep (Takahashi & Young, 1991; & Sar et al., 2005). This was proven by a study in which 22g Nitrate/kg DM in the diet reduced methane emission by 32% in Nellore beef steers fed sugarcane based diets (Hulshof et al., 2012).

4. c.iv. Reducing GHGs from manure management: Managing the nutrition of the animal (Aarnick et al., 2007) and taking measures for better handling and storage of manure (Oenema et al., 2007) can aid in bringing down the GHGs emission from manure. We can decrease the production of CH_4 production by following a suitable management system, since the CH4 emission is under anaerobic conditions, storage of the dung in pits or lagoons leads to more CH_4 emission from the excreta. However in India (and most of the developing countries) the dung is packed in heaps hence the emission is less since it is only from deeper inner layer only.

4. c.v. Biodigestion of manure: At the time of biodigestion the biogas from the digestion chamber is collected and only a little amount of degradable organic matter remains that could be converted to methane. This leads to decrease in GHG emissions as well. Reduction in the use of mineral fertilizer by 15% leads to decrease in the emission of direct Nitrous oxide by 5%.

4. c.vi Increasing the Milk production: It has also been shown that by implementing strategies that lead to increase in milk production, the GHG emissions (methane and nitrous oxide) could be decreased. One of the strategies is increasing the concentrate intake to 235 kg/year in a cow weighing 500 kg/year (CVB, 2002).

4. d Genetic Manipulations: Various strategies have been adopted to alter the genetic makeup of animals so that there is decrease in the emissions of GHG. A study concluded that the methane emission and production (g/day) are a heritable and repeatable trait (Pickering et al., 2015). Calculation of the genomic breeding values to facilitate the genetic selection has been proposed as a way to reduce GHG emission. Some strategies also aim at altering the genetic makeup of plants taken by Ruminants so as to decrease the GHG emissions. RFI (Residual Feed Intake) is another field which can be worked upon. This is an indirect approach for reducing enteric methane emission in beef and dairy cattle. RFI is moderately heritable (0.26 to 0.43), moderately repeatable across diets (0.33 to 0.67) and is independent of body size and production besides independent of body fatness in growing animals (Basarab et al., 2013).

As per a research conducted by the Indian scientists, the dwarf breed of Cattle, Vechur has shown to emit far less methane than other dairy cows. Though the milk produced by the animal is quite less when compared to other dairy breeds, but the methane gas emitted by Vechur is one-tenth the level of methane emitted by a normal sized cow. Encouraging the breeding of Vechur breed, the levels of methane emitted could be brought down by a significant amount.

4. e Future scope: Work is being done on a vaccine in New Zealand by a policy analyst Kara Lok which could act as methane inhibitor and would reduce the methane gas emissions by 30% and is expected to be ready in 5-7 years (Yvonne O'Hara, 2017).

About the Global Livestock Environmental Assessment Model (GLEAM)

This model is being developed by FAO since 2009 to address the need of comprehensive tool to access the interactions between the livestock and the environment. GLEAM aims at quantifying the production and the use of natural resources which are being used in the livestock sector. Additionally, the aim of GLEAM is to identify the impacts of the livestock on the environment so as to devise strategies for the assessment, adaptation and mitigation to move towards a sustainable livestock sector (FAO, 2010).

Table 1: The total GHG emission in world by livestock species and humans in the year 1983 Total estimate for emission from domestic animals has uncertainty factor of ±15% (Crutzen et al., 1986)

Species	Methane production (teragrams annually)
Bos taurus	54.3
Bubalus bubalis	6.2
Ovis aries	6.9
Capra hircus	2.4
Camelus	1.0
Equus caballus	1.2
Equus asinus	0.5
Sus scrofa	0.9
Homo sapiens	0.3
Total	**73.7**

Table 2: Emissions by livestock in India (Kamra, 2014)

Livestock species	Methane emissions Kg /head /year
Cattle –crossbred	46
Cattle – Indigenous	25
Buffalo	55
Yak	55
Mithun	55
Sheep	05
Goat	05
Horse/Pony	18
Mule	10
Donkey	10
Camel	46
Pig	01

Table 3: Information regarding the greenhouse gases emitted due to activities pertaining to livestock species during the period 1995-2005 (Mario Herrero et al., 2016)

Livestock species	Emission (gigatonnnes CO2 e)
Cattle –crossbred	1.3-2.0 ¿ 0.92 0.23 0.03
Cattle – Indigenous	0.43
Buffalo	1.6-2.7
Yak	0.2-0.4 02-0.5
Mithun	0.11
Sheep	0.02
Goat	0.023
Horse/Pony	2.0-3.6
Mule	5.6-7.5

*Livestock emissions according to IPCC emissions guidelines.
LCA (life cycle assessment) as implemented by FAO15.
¿ Includes N2O emissions from manures applied to pastures, and from fertilizers to croplands for both feed and pasture. Emissions from manure applied to pastures ranges from 0.42–0.95 Gigatonne CO2 equivalent
. (LUC-land-use change.)

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