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Global Climate Change: Role of Livestock

S.M.K. Naqvi and V. Sejian
Division of Physiology and Biochemistry, Central Sheep and Wool Research Institute,
Avikanagar (Via-Jaipur), Rajasthan-304 501, India

Abstract: Climate change is seen as a major threat to the survival of many species, ecosystems and the sustainability of livestock production systems in many parts of the world. Green house gases (GHG) are released in the atmosphere both by natural sources and anthropogenic (human related) activities. An attempt has been made in this article to understand the contribution of ruminant livestock to climate change and to identify the mitigation strategies to reduce enteric methane emission in livestock. The GHG emissions from the agriculture sector account for about 25.5% of total global radiative forcing and over 60% of anthropogenic sources. Animal husbandry accounts for 18% of GHG emissions that cause global warming. Reducing the increase of GHG emissions from agriculture, especially livestock production should therefore be a top priority, because it could curb warming fairly rapidly. Among the GHGs, CH_4 is considered to be the largest potential contributor to the global warming phenomenon. Ruminant livestock such as cattle, buffalo, sheep and goats contributes the major proportion of total agricultural emission of methane. Indian livestock system is a large contributor to GHGs and therefore also to the global warming phenomenon. Methane emission from enteric fermentation from Indian livestock ranged from 7.26 to 10.4 MT/year. In India more than 90% of the total methane emission from enteric fermentation is being contributed by the large ruminants (cattle and buffalo) and rest from small ruminants and others. Generally CH_4 reduction strategies can be grouped under two broad categories such as management and nutritional strategies. Although the reduction in GHG emissions from livestock industries are seen as high priorities, strategies for reducing emissions should not reduce the economic viability of enterprises if they are to find industry acceptability.

Key words: GHGs, Global warming, methane, mitigation, ruminants

INTRODUCTION

The livestock sector accounts for 40% of the world's agriculture Gross Domestic Product (GDP). It employs 1.3 billion people, and creates livelihoods for one billion of the world's population living in poverty (FAO, 2006). Climate change is seen as a major threat to the survival of many species, ecosystems and the sustainability of livestock production systems in many parts of the world (Moss *et al.*, 2000). Global demand for livestock products is expected to double during the first half of this century, as a result of the growing human population, and its growing affluence. Over the same period, we expect big changes in the climate globally. The dramatic expansion of crop production for biofuels is already impacting on the resources available globally for food production, and hence on food supply and cost. Food security remains one of the highest priority issues in developing countries, and livestock production has a key role in many of these countries. However, food security is re-emerging as an important issue in many developed countries that had previously regarded it as 'solved'. These interconnected issues are creating immense pressure on the planet's resources. We need high quality animal science to help meet rising demand for livestock products in an environmentally and socially responsible way.

Global climate change is one of the most significant environmental threats to the earth planet. The Inter-governmental Panel on Climate Change (IPCC) has dictated that global warming/climate change could lead to many environmental problems i.e., Drought, floods, crop and animal farming, food production, and health hazards etc. Green House Gases (GHG) are released in the atmosphere both by natural sources and anthropogenic (human related) activities. During last few decades, there is a considerable increase in the amount of GHG released into atmosphere through human resources. Assessment of potential factors responsible for global climate change has been a long, tedious, and complicated process. Over 2500 scientists around the world discussed together in 1985 under IPCC and agreed that anthropogenic emission of GHG playing major role in climate change.

Corresponding Author: Dr. Veerasamy Sejian, Scientist, Adaptation Physiology Laboratory, Division of Physiology and Biochemistry, Central Sheep and Wool Research Institute, Avikanagar, Via-Jaipur, Rajasthan, India. Tel.: +91-9828624721; Fax: +91-01437-220163

The impact of climate change on animal production has been categorized by Rotter and Van de Geijn (1999) on (a) availability of feed grain, (b) pasture and forage crop production and quality, (c) health growth and reproduction and (d) disease and their spread. The climate change may result in decrease or increase in population of a livestock species in a region (Moss *et al.*, 2000; IPCC, 2007). Animals which are more hardy and adapted to reference climate condition may thrive well while others may either shift to more suitable region or suffer stressful environment. Livestock adapted to hot environment will be preferred in hot semi-arid/arid region of the country over high producing and less thermal tolerant sheep. Thermal stress is known to influence more severely to non-adapted and high producing sheep. The production performance and survivability of Bharat Merino sheep i.e., Crossbred (75% exotic inheritance), was unsatisfactory at Avikanagar (semi-arid tropical area) but their shifting to Mannavanur (sub-temperate location) resulted in marked increase in production and health performance (growth, reproduction and survivability). Mitigation of climatic stresses becomes necessary if a high producing and less tolerant livestock are to be reared in harsh environmental conditions. More than 70% of total livestock in India thrive in arid and semi arid regions of the country. There has been frequent drought and decrease in annual rainfall over last few decades. The pasture quality is deteriorating and total availability of feed and fodder resources are constantly diminishing. In some areas C_3 grasses of high nutritive value are being replaced by lower quality C_4 tropical grasses (Barbehenn *et al.*, 2004). An attempt has been made in this article to understand the contribution of ruminant livestock to climate change and to identify the mitigation strategies to reduce enteric methane emission in livestock. Special emphasis was given to contribution of Indian livestock to GHGs.

Essentiality of GHG for ecosystem: Total GHG contribute a very small portion (<1%) of the gases in the earth's atmosphere. But these gases play very important role in maintaining the atmospheric temperature suitable for human, plant and other species of ecosystems. Without GHGs, plants and animals life could have not been supported and maintained on this planet.

Climate change: Global Warming defined as the increase of the average temperature of earth as the earth is getting hotter with disasters like frequent hurricanes, droughts and floods. Over the last 100 years, the average temperature of the air near the Earth surface has risen a little less than 1º Celsius, which is insignificant whereas it is responsible for visible increase in storms, floods and raging forest fires observed in the last 10 years (FAO, 2006). The meteorological data indicate that an increase of one degree Celsius makes the earth warmer now than it has been for at least a thousand years. Out of the 20 warmest years on record, 19 have occurred since 1980 whereas the three hottest years ever observed have all occurred in the last eight years. However, it is not only about how much the earth is warming, it is also about how fast it is warming. There have always been natural climate changes with Ice Age and the warm intermediate times between them, evolved over periods of 50,000 to 100,000 years whereas, the fast temperature rise recorded over the last 30 years has never happened before. According to natural effects like solar cycles and volcano activity, the Earth should now be in a cool-down-period and not in a heating-up phase. All these facts lead scientists to infer that the global warming we are now experiencing is not a natural occurrence and that man is responsible the observed drastic changes.

Table 1: Global warming potential (GWP) of the GHGs

GHG	Chemical formula	Lifetime (years)	Radiative efficiency (W/m^2ppb)	GWP
Carbon dioxide	CO_2	Up to 100 years	1.4×10^{-5}	1
Methane	CH_4	12	3.7×10^{-4}	21
Nitrous Oxide	N_2O	114	3.03×10^{-3}	310

Increasing concentrations of GHGs in the atmosphere have contributed to an increase in the earth's atmospheric temperature, an occurrence known as global warming (FAO, 2006). Indeed, average global temperatures have risen considerably, and the IPCC (2007) predicts increases of 1.8-3.9ºC (3.2-7.1ºF) by 2100. With business as usual, Earth's temperature may rise by 1.4 to 5.8ºC by the end of this century. With rare unanimity, the scientific community warns of more abrupt and greater climatic change in the future (Gleik *et al.*, 2010).

The GHG emissions from the agriculture sector account for about 25.5% of total global radiative forcing and over 60% of anthropogenic sources (FAO, 2009). Animal husbandry accounts for 18% of GHG emissions that cause global warming. Emission of CH_4 is responsible for nearly as much radiative forcing as all other non-CO_2 GHG gases combined (Beauchemin and McGinn, 2005). While atmospheric concentrations of GHGs have risen by about 39% since pre-industrial era, CH_4 concentration has more than doubled during this period (WHO, 2009). Reducing the increase of GHG emissions from agriculture, especially livestock production should therefore be a top priority, because it could curb warming fairly rapidly (Sejian *et al.*, 2010).The major GWP of livestock production worldwide comes from the natural life processes of the animals. The global warming potential of major GHGs was depicted in Table 1. Infact, CH_4 is considered to be the largest potential contributor to the global warming phenomenon (Steinfeld *et al.*, 2006). It is

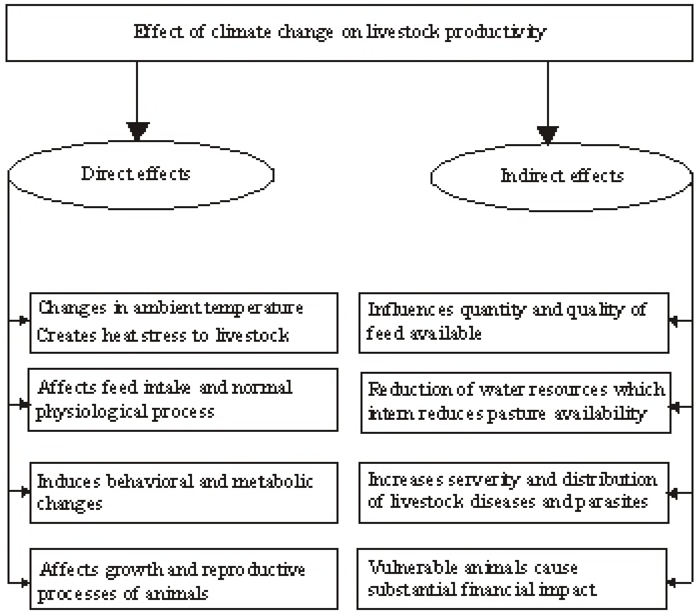

Fig. 1: Effects of climatic change on livestock productivity

an important component of GHG in the atmosphere, and is associated with animal husbandry (Sejian *et al*., 2010). Much of the global GHG emissions currently arise from enteric fermentation and manure from grazing animals and traditional small-scale mixed farming in developing countries. Further the consequences of climate change may lead to warming of earth, sea level may rise. Many coastal wetland and entire nations may be covered by sea. Forest may disappear or potential species either vanish or alter their characteristics. There may be outbreak/spread of many infectious diseases, increase in the incidences of heat stroke and diseases due to air pollution to livestock. Figure 1 describes the effect of climatic change on livestock productivity.

Role of methane to GHG inventory and climate change: Methane is one of the primary components of the green house gases and second to CO_2 in its contribution towards green house effect. This gas is having a great heat trapping capacity in atmosphere. The trapping capacity is about 21 times than its for CO_2 on kg/kg basis. Methane has relatively shorter atmospheric life compared to other GHG and therefore means/factors reducing this gas in atmosphere will provide rapid benefits. Currently low cost technologies are available to control mostly human related anthropogenic methane production. Methane concentration is constantly rising in the atmosphere and has been double over last two centuries. Methane is released in the atmosphere either by natural or anthropogenic sources. Natural sources include wetlands, termites, ocean fresh water; gas hydrates and contributes about 30% of total global methane emission. Rest 70% of

Table 2: Description of some important facts about methane

S.No.	Facts about Methane
1	Methane is one of the primary Green House Gases and second to only CO_2 in generating green house effect.
2	Methane is 21 times more effective in trapping heat than CO_2 on Kg/Kg basis
3	Methane has short atmospheric life (10-12 years compared to other GHG i.e., 120 years for CO_2). Reduction of methane leads to rapid benefit.
4	Cost effective technologies are available to control most anthropogenic methane emission
5	Methane is constantly increasing in the atmosphere and has doubled in last 2 centuries
6	Methane emission by natural sources is 30% and by anthropogenic activities is 70%
7	Methane emission contributes about 19% of overall warming

methane emission is contributed by anthropogenic activities like livestock including ruminants and non-ruminants, rice/paddy cultivation, natural gas and petroleum processing and use, coal mining, land fills, livestock manure, waste water treatment etc.

Methane from agricultural sources: More than 50% (about $2/3^{rd}$) of world's anthropogenic methane emission are produced through agricultural practices. The major sources of agricultural emission of methane are ruminants, rice cultivation, handling and processing of livestock manure and biomass burning (Fearon, 2002). Table 2 describes some important facts about methane while Table 3 describes the list of various sources and sinks of global methane emission.

Contribution of ruminants to GHGs through enteric methane emission: Ruminant livestock such as cattle,

Table 3: List of various sources and sinks of global methane emission

Natural sourc 30%	Anthropogenic activities 70%
Wet lands	Livestock
Termites	Rice cultivation
Ocean/fresh	Natural gas and Petroleum use
Gas Hydrate	Coal mining
	Biomass burning
	Land fills
	Livestock manure
	Waste water treatment

Table 4: Ruminant population in India (Millions)

Species	India	World	World (%)	Rank in World
Cattle	185.5	1334.50	13.90	
Buffalo	97.7	172.70	56.57	First
Goat	120.0	780.10	15.38	Second
Sheep	62.5	1038.76	6.02	Third
Total	465.7	3326.06	14.00	

Source: FAO, 2006

Table 5: Methane emission from Indian Livestock

Species of ruminants	Methane emission (MT/animal/year)	Total (%)
Cattle	5.35	53.1
Buffalo	3.93	39.0
Goat	0.47	4.7
Sheep	0.18	1.8
Others*	0.14	1.4
	10.08	100.0

*: Camel, horses, ponies, donkeys, and pig; Source: Singhal *et al.* (2005)

buffalo, sheep and goats contributes the major proportion of total agricultural emission of methane (Leng, 1993; Lassey 2007; Chhabra *et al.*, 2009). Ruminants are categorized by the presence of rumen, a special digestive organ, in the body. Besides having unique ability to digest fibrous and low grade roughages/plant material, it is also a major producer of methane, a potent green house gas. The enteric fermentation in rumen is highly useful for humankind because it converts coarse and fibrous plants into food and fiber for humankind. However, enteric fermentation in rumen also produces methane through bacterial breakdown of feeds called as methanogenesis. The animals release methane into atmosphere through exhaling or ruminating through mouth or nostrils. Methane production and release accounts for release of digestible energy to atmosphere and therefore inefficient utilization of feed energy. Enteric fermentation also produces volatile fatty acids. Among the volatile fatty acids, acetate and butyrate promotes methane production. Global emission of methane from digestion process of ruminants is about 80 Million tones per year (Gibbs and Johnson, 1994) and considered to be single largest source of anthropogenic methane emission (IPCC, 2001). Methane emission from ruminants provides enough scope of easy and practical management for reduction in methane emission (McMichael *et al.*, 2007).

Role of Indian livestock in methane production: Indian livestock system is a large contributor to green house gases and therefore also to the global warming phenomenon. There is a huge population of ruminants in India. Table 4 describes the ruminant livestock population in India. A large proportion (about 14%) of total ruminant (cattle, buffalo, goat and sheep) population inhabitate/thrive in India and contributing Rs.15, 000 crores to Indian economy. The global methane emission from all sources has been estimated as 500-600 Million tones/year (IPCC, 2001). About 50% of the total global emission of methane is through anthropogenic activities of which significant or major contributor is found to be livestock sector. Estimated values of methane emission from domesticated animals varied widely in different reports from 70-220 Million tones/year (Ehhalt, 1974; Baker-Blocker *et al.*, 1977; Sheppard *et al.*, 1982; Blake, 1984). The large variation in values attributed to the methodology adopted and assumption made in estimating the per animal emission rate.

Livestock production systems play a significant role in Indian economy by contributing a large amount of food (milk, meat etc.); fibre (wool, costume); skin and manure. It also generates employment to 5% of total working population of the country. Table 5 describes the contribution Indian livestock to methane emission. Methane emission from enteric fermentation from Indian livestock ranged from 7.26 to 10.4 million tonne (MT) /year (Garg and Shukla, 2002; US-EPA, 1994). These estimates were made without considering the amount and quality of feed available to animals. Methane emission for Indian livestock has been reported to be 9.02 MT/year (Singh, 1998) on the basis of experimental digestibility trials and available feed resources in different region of the country. Singhal *et al.* (2005) reported total emission of methane from Indian livestock as 10.08 MT considering different categories of ruminants and type of feed resources available in different zone of the country.

In India more than 90% of the total methane emission from enteric fermentation is being contributed by the large ruminants (cattle and buffalo) and rest from small ruminants and others (Swamy and Bhattacharya, 2006). Amount of feed consumed and its digestibility are two important factors, which determine the total methane production. Per animal methane production in the country is relatively much lower than the values reported for the animals in developed countries. This is attributed to the poor quality roughages/feed available to the animals. On average Indian cattle produces about 35 kg/annum methane as compared to 95 kg/annum for dairy cows in Germany (Crutzen *et al.*, 1986; Sirohi and Michaelowa, 2007). The lowest annual methane production for dairy (180 kg/herd) and non-dairy cattle was reported in Indian subcontinent (Sharma *et al.*, 2006) while comparing with other regions of the world (North America, Western Europe, Eastern Europe, Oceania and Africa and Middle east) (IPCC, 1996 Guideline for National Green House Gas Inventories reference manual).

Table 6: Strategies to reduce methane emission from livestock

S.No.	Different strategies to reduce methane emission from farm animals
1	Improved genetic selection to produce low methane producing animals
2	Efforts must be taken to reduce livestock population
3	Improved nutrition by providing high quality feed and strategic supplementation of essential nutrients
4	Improving grassland management
5	Ensuring proper health and care through upgraded veterinary practices
6	Increasing the proportion of concentrate feeding
7	Diet modification through ammonia and molasses feeding to reduce methane
8	Oil and ionophore supplementation eg., monensin and tannin
9	Defaunation and rumen microbial intervention
10	Reducing the manufacture of livestock products
11	Employing advance technology like immunization and recombinant technology for reducing methane production

Source: Sejian *et al.* (2010)

Global climate changes are today's major concern of scientist's world over and possess a great threat and tremendous challenges to mankind. This has been due to increasing concentration of Green House Gases (GHG's) in the atmosphere over the last century due to human related activities (Wood and Knipmeyer, 1998). Methane one of the potent GHS's in trapping the warmth, is mainly contributed by anthropogenic activities including rearing of livestock and manure management. Strategies and research efforts are required to be directed towards mitigating the methane emission from entering fermentation of feed in ruminants and manure management to reduce the rate of methane emission in the atmosphere.

Methane emission mitigation strategies: The technologies that can reduce the amount of methane production in rumen or total release of methane into atmosphere are useful for efficient use of feed and making the environment more favorable. Several options have been considered for mitigating methane production and emitting in atmosphere by the livestock (Joblin, 2001). All approaches points towards either reduction of methane production per animals or reduction per unit of animal product (Johnson *et al.*, 2002). Gworgwor *et al.* (2006) in their review described the factors to be considered for selection of best options for methane emission reduction: these include climate, economic, technical and material resources, existing manure management practices, regulatory requirements etc. Generally the methane mitigation strategies can be grouped under three broader headings viz., managemental (Ulyatt and Lassey, 2001; DeRamus *et al.*, 2003), nutritional (Yan *et al.*, 2000; Lovett *et al.*, 2005) and advanced biotechnological strategies (Sejian *et al.*, 2010).

Methane has relatively short life (10-12 years) in the atmosphere as compared to other GHGs, for example CO_2 has 120 years and therefore strategies to reduce the methane in atmosphere offer effective and practical means to slow global warming (Turnbull and Charme, 2001). Decreased emission rate of only 10% will stabilize methane concentration in atmosphere at present level (Lelieveld *et al.*, 1993). Table 6 describes the mitigation strategies for reducing enteric methane production from ruminant livestock.

CONCLUSION

Given that the livestock production system is sensitive to climate change and at the same time itself a contributor to the phenomenon, climate change has the potential to be an increasingly formidable challenge to the development of the livestock sector. Responding to the challenge of climate change requires formulation of appropriate adaptation and mitigation options for the sector. The projected trend of population growth indicates that livestock population will increase tremendously over the next few years and hence creating a database for GHG inventory are important indicators for studying the future impacts of livestock to climate change. There are urgent needs to understand the various factors affecting variability in enteric CH_4 production to decrease the uncertainty in GHG emission inventories and to identify viable GHG reduction strategies. Although the reduction in GHG emissions from livestock industries are seen as high priorities, strategies for reducing emissions should not reduce the economic viability of enterprises if they are to find industry acceptability.

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