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Impact of Climate Change on Livestock Production: A Review

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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. In Indian subcontinent, heat stress is the most important climatic stress. Heat stress adversely affecting productive and reproductive performance of livestock, and hence reducing the total area where high yielding dairy cattle may be economically reared. The livestock sector which will be a sufferer of climate change is itself a large source of methane emissions contributing about 18% of total enteric methane budget. Ruminant livestock such as cattle, buffalo, sheep and goats contributes the major proportion of total agricultural emission of methane .In India, although the emission rate per animal is much lower than the developed countries, due to vast livestock population the total annual methane emissions 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.

Keywords: Climate change, methane, mitigation, ruminants, livestock production

The crop livestock system is one of the most important characteristics of Indian agrarian economy and livestock sector is the integral part of India's agriculture sector. Indian livestock sector provides sustainability and stability to the national economy by contributing to farm energy and food security. Livestock sector not only provides essential protein and nutrition to human diet through milk, eggs, meat and by products such as hides and skin, blood, bone and fat etc., but also plays an important role in utilization of non-edible agricultural by-products. During the last decade, the annual growth rate of livestock production has maintained a steady growth of 4.8 to 6.6% with a compounded growth rate of more than 5.0%. In contrast, the crop production remained either stagnant or increased marginally. Therefore, the livestock sector has emerged as one of the key components of agricultural growth in India.

However, in future the situation is likely to change due to global warming with anticipated rise in temperature between 1.8-4.0^{0} C (IPCC) over the entire country together with increased precipitation resulting from climate change. Atmospheric concentrations of GHGs have risen by about 39% since pre-industrial era, CH_4 concentration has more than double during this period (WHO, 2009).

Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report (IPCC, 2007) indicated that many of the developing countries tend to be especially vulnerable to extreme climatic events as they largely depend on climate sensitive sectors like agriculture and forestry. It is likely to aggravate the heat stress in dairy animals, adversely affecting their productive and reproductive performance and adversely affect livestock production by aggravating the feed and fodder shortages. The consequences of climate change phenomena are now visible everywhere including in animal farm industry (Lal, 2002) and considered as the serious long term threat to agriculture (ACIAR, 2007). On the other hand, the livestock sector which will be a sufferer of climate change is itself a large source of methane emissions, an important greenhouse gas. 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).

Contribution of livestock to climate change

The GHG emissions from the agriculture sector account for about 25.5% of total global radioactive forcing and over 60% of anthropogenic sources (FAO, 2009). Animal agriculture is responsible for 18% of greenhouse gas (GHG) emissions (9% CO_2, 37% methane and 65% N_2O) (FAO report, "Livestock long shadow: environmental issues and options", 2006). Ruminants (cattle, sheep and goats) account for a large share of total livestock emissions, because they are less efficient in converting forage into useful products than monogastrics (pigs and poultry). GHG emissions includes methane (CH_4) emission from enteric fermentation and manure management, nitrous oxide (N_2O) emission from animal manure and carbon-di-oxide (CO_2) emission from land-use change caused by demand for feed grains, grazing land and agricultural energy and as much as 37% of anthropogenic methane emission from the agriculture sector (FAO, 2006). Emission of CH_4

is responsible for nearly as much radiative forcing as all other non-CO_2 GHGs combined (Beauchemin and McGinn, 2005).

Recent estimation of livestock methane production using IPCC methodology indicates that the total methane emitted due to enteric fermentation and manure of 485 million heads of livestock was 9.37 Tg/ annum for the year 2003. The other livestock with minor population consisting only 2% (0.15 Tg) of total emission from livestock sector. The ruminants, both small and large, were the main contributors (98%) to the enteric methane emission in India. 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). The major contributors to methane emission were indigenous, crossbred cattle, buffalo and sheep & goat accounting 40, 8, 40 and 10% respectively. Amount of feed consumed and its digestibility are two important factors, which determine the total methane production. The livestock characteristics (age, weight and species), health and living conditions influence the energy requirement. Higher methane production results from higher energy requirement and feed intake. 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) due lower energy requirement. 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 (NorthAmerica, Western Europe, Eastern Europe, Oceania andAfrica and Middle east) (IPCC, 1996 Guideline for National Green House Gas Inventories reference manual).

Lactating animals comprising of buffaloes and cattle contributed 3.42 Tg with a major share of 2.04 Tg from lactating buffaloes (Upadhyay *et al.,* 2009). The contribution of milch buffaloes was 59.6%, crossbred cows 11.4% and Indigenous cows 28.9% to the total emissions from dairy animals (Upadhyay *et al.,* 2009). 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 zones of the country. Although goats are the dominant livestock with a population share of 33.1%, their contribution to the CH_4 emission is only 0.14 Tg/ year or 4.5%.

GHG emissions from livestock manure management

Livestock manure is primarily composed of organic material and water. Under anaerobic conditions, the organic material in the livestock manure is decomposed by anaerobic and facultative bacteria resulting into formation of CH_4, CO_2 and stabilized organic material. Livestock manure management is also a significant source of CH_4 emission (Swamy and Bhattacharya, 2006). The total global CH_4

emissions from livestock manure management have been estimated as 9.3 Tg/year (Scheehle, 2006), of which the developed countries contribute about 52%. The different manure management practices in India, as compared to the western countries, lead to much lower methane emissions from manure. Cattle and buffalo manure is extensively used in the country as fuel and is largely managed in dry systems. The emissions for India are estimated to be 1.27 Tg in the year 1994 (Singhal and Madhu Mohini 2002). India's contribution to nitrous oxide emissions from manure management in 1990 is estimated to be 0.017 Tg/year, which is projected to increase to 0.022 Tg by 2020 (Scheehle, 2002).

Impact of climate change on animal production

Climate change, particularly global warming, may strongly affect production performance of farm animals worldwide. Among the environmental variables affecting animals, heat stress seems to be one of the intriguing factors making animal production challenging in many geographical locations in the world (Koubkova *et al.,* 2002). However, new knowledge about animal responses to the environment continues to be developed, managing animals to reduce impact of climate remains a challenge (Hahn *et al.,* 2003).

Animal stress level due to temperature rise has been worked out using Temperature Humidity Index (THI) in India (Upadhyay *et al.,* 2008). All animals have a range of ambient environmental temperatures termed the thermo neutral zone and temperature below or above this thermo neutral range of the animal create stress conditions in animals. Climate change scenario constructed for India revealed that temperature rise of about or more than 4˚C is likely to increase uncomfortable days (THI>80) from existing 40 days (10.9%) to 104 days (28.5%). This change in THI has a negative impact on the livestock production both directly and indirectly. Dhakal *et al.* (2013) observed climate change had negative impact on milk production and lactation length and infertility in Nepal.

Impact on Milk Production

One of the direct impacts of climate change on livestock is on the milk yield. Increase in number of stressful days (THI more than 80) and their frequency will impact yield and production of cattle and buffaloes (Upadhyay *et al.,* 2007). A thermal environment is a major factor that can negatively affect milk production in dairy cows, especially in animals of high genetic merit. At all India level an estimated annual loss due to direct thermal stress on livestock is about 1.8 million tonnes of milk (₹ 2661.62 crores), that is, nearly 2% of the total milk production in the country. Ravagnolo and Misztal (2000) reported milk yield decline by 0.2 kg per unit increase in THI when THI exceeded 72. Maust *et al.* (1972) reported the variation in milk yield (9%), milk fat (13%), feed intake (5%) and rectal temperature due to THI were attributable to weather condition. The extent of milk yield decline observed in heat-stressed cows is dependent on several factors that interact with high air temperature. The milk yield losses seem positively related with milk yield of cows (Gauly *et al.,* 2013). The increase in milk yield increases sensitivity of cattle to thermal stress and reduces the threshold temperature at which milk losses occur (Berman, 2005). According to the studies by Berman, A. (2005) and Nardone *et al.,* (2010) when high milk producing cattle were kept in hot climatic zones, metabolic heat production was intensified that resulted in an increase respiratory rate, consequently, decrease in the milk production. Molee *et al.,* (2011) found that Holstein crossed with local breeds in the tropics and subtropics perform better than the pure bred Holstein and were also resistant to heat stress. Purwanto *et al.*(1990) reported that when non-lactating cows, lower milk yielding (18.5 kg/d) or high yielding (31.6 kg/d) were compared, low and high yielding cows produced 27 and 48% more heat than non-lactating cows despite of having lower BW (752, 624, and 597 kg for non-lactating, low, and high producers, respectively).

The stage of lactation is also an important factor affecting dairy cows' responses to heat. Johnson *et al.* (1998) observed that the mid-lactating dairy cows were the most heat sensitive compared to their early and late lactating counterparts. In fact, mid-lactating dairy cows showed a higher decline in milk production (−38%) when the animals were exposed to heat. Upadhyay *et al.* (2007) observed the extent of decline in milk yield were less at mid lactation stage than either late or early stage and decline in yield varied from 10 -30% in first lactation and 5-20% in second or third lactation in Murrah buffaloes

The minor importance of small ruminant for milk production in the world, lower selection for high productivity in these species and their supposed higher adaptability to hot environments, explain the fact that less attention has been given to the effects of heat stress in these species. Milk production traits in ewes seem to have a higher negative correlation with the direct values of temperature or relative humidity than THI. The values of THI, above which ewes start to suffer from heat stress, seem to be quite different among breeds of sheep. Solar radiation seems to have a lesser effect on milk yield, but a greater effect on yield of casein, fat and clot firmness in the milk of Comisana ewes (Sevi *et al.,* 2001). High air temperatures even affect goats, reducing milk yield and the content of milk components. In particular, if lactating goats are deprived of water during the hot season, they activate an efficient mechanism for reducing water loss in urine, milk and by evaporation, to maintain milk production for a longer time (Olsson and Dahlborn, 1989).

Impact on Animal Reproduction

Animals can adapt to the hot climate, nevertheless the response mechanisms are helpful for survival but are detrimental to productive and reproductive performance. Reproduction is basically a 'luxurious phenomenon' and appropriate when the animal is in just right homeostasis. Heat stress due to high ambient temperature accompanied with excess humidity during summer months causes infertility in most of the farm species and have adverse effect on reproductive performance of farm animals. During hot dry (March- June) and hot humid (July- September) seasons, the THI values exceeds 80 in most parts of India. The pattern of estrus varies among cattle and buffaloes. Most of the buffaloes exhibit sexual activity during cooler parts of the year (October- Feb), when the THI generally remains < 72 (Upadhyay *et al.,* 2009). A temperature rise of more than 2°C in unabated buffaloes may cause negative impacts due to low or desynchronized endocrine activities particularly pineal-hypothalamo-hypophyseal-gonadal axis altering respective hormone functions (Upadhyay *et al.,* 2009), whereas in case of cattle, the effects of heat stress on fertility appear to carry into the autumn (October and November) even though the cows are no longer exposed to heat stress (Drew B. 1999). Gwazdauskas *et al.* (1973) reported that an increase in uterine temperature of 0.5° C above average is associated with a decline in conception rate of 12.8%. Low temperature and THI during nights in summer (April and May) provide an opportunity to buffaloes to dissipate heat during night hours compared to day hours. This may be the reason that buffaloes experienced less stress during hot dry season compared with hot humid season (Upadhyay *et al.,* 2009). Diurnal pattern of estrus behaviour has been observed in majority of Murrah buffaloes. During heat stress, motor activity and other manifestations of estrus are reduced (Nebel *et al.,* 1997) and the incidence of anestrus and silent ovulation is increased (Singh *et al.,* 2011).

Reproductive processes in male animal are very sensitive to disruption by hyperthermia with the most pronounced consequences being reduced quantity and quality of sperm production and decreased fertility. There were no significant effects of ambient temperature or humidity on sperm production and semen quality, (Everett and Bean, 1982). However, Taylor *et al.* (1985) demonstrated that extreme temperatures (−24 to −19°C and 27–32°C) had only small effects on sperm production. Sperm production (ejaculate volume, sperm concentration and total sperm number) and percentage of normal sperm cells decreased during the hot season in *B. indicus* bulls in Africa. Collier *et al.* (1982) reported that dairy cows experiencing heat stress during late gestation had calves with lower birth weights and produced less milk than cows not exposed to heat stress. Scrotal circumference, testicular consistency, tone, size and weight are decrease in hot summer in the sub tropics than those of the same breeds of buffalo reared under temperate environmental conditions (Yarney *et al.,* 1990).

Impact on Feed and Fodder Availability

India has one of the largest livestock populations in the world, and one of its notable characteristics is that almost its entire feed requirement is met from crop residues and by-products; grasses, weeds and tree leaves; and grazing on common lands and harvested fields (Dikshit and Birthal, 2010). Climate change affects livestock production by altering the quantity and quality of feed available for animals. Climate change is expected to change the species composition (and hence biodiversity and genetic resources) of grasslands as well as affect the digestibility and nutritional quality of forage (Thornton *et al.* 2009). Droughts and extreme rainfall variability can trigger periods of severe feed scarcity, especially in dry land areas, with devastating effects on livestock populations. Reductions in the quantity and quality of feed (leading to less feed intake and higher mortality) could make the impacts of climate change on livestock systems severe in certain places.

Impact on livestock health

Animal Diseases

The effects of climate change on the health of farm animals have not been studied in depth. However, it can be assumed that as in the case of humans, climate change, in particular global warming, is likely to greatly affect the health of farm animals. Global climate change alters ecological construction which causes both the geographical and phonological shifts (Slenning, 2010). These shifts affect the efficiency and transmission pattern of the pathogen and increase their spectrum in the hosts (Brooks and Hoberg, 2007). The increased spectrum of pathogens increases the disease susceptibility of the animal and thus, supports the pathogenicity of the causative agent. The livestock systems are susceptible to changes in severity and distribution of livestock diseases and parasites as potential consequences. Incidence of external parasite (43.3%) was first ranked as the problem in the warm temperate (Dhakal *et al*., 2013).

Effect on vectors

The epidemiology of many diseases are based on transmission through vectors such as ticks, lice, mites, mosquitoes and flies, the developmental stages of which are often heavily dependent on temperature and humidity. Changes in rainfall and temperature regimes may affect both the distribution and the abundance of disease causing vectors, as can changes in the frequency of extreme events (Thornton *et al.* 2009). Research studies from India have found that meteorological parameters like temperature, humidity and rainfall explain 52 and 84% variations in the seasonality of Foot and Mouth (FMD) disease in cattle in hyper-endemic division of Andhra Pradesh and meso-endemic region of Maharashtra states, respectively

(Ramarao 1988). The hot– humid weather conditions were found to aggravate the infestation of cattle ticks like, *Boophilus microplus, Haemaphysalis bispinosa* and *Hyalomma anatolicum* (Basu and Bandhyopadhyay 2004; Kumar *et al.* 2004).

Effect on Pathogens

Higher temperatures resulting from climate change may increase the rate of development of certain pathogens or parasites that have one or more life cycle stages outside their animal host. This may shorten generation times and, possibly, increase the total number of generations per year, leading to higher pathogen/ parasite population sizes (Harvell *et al.,* 2002). Conversely, some pathogens are sensitive to high temperatures and their survival may decrease with climate warming. Pathogens and parasites that are sensitive to moist or dry conditions may be affected by changes to precipitation, soil moisture and the frequency of floods. Changes to winds could affect the spread of certain pathogens and vectors. Some pathogens/parasites and many vectors experience significant mortality during cold winter conditions; warmer winters may increase the likelihood of successful overwintering (Harvell *et al.,* 2002).

Effects on hosts

Climate change may bring about substantial shifts in disease distribution, and outbreaks of severe disease could occur in previously unexposed animal populations (possibly with the breakdown of endemic stability) (Thornton *et al.* 2009). E*ndemic stability* occurs when the disease is less severe in younger than older individuals, when the infection is common or endemic and when there is lifelong immunity after infection. Certain tick-borne diseases of livestock in Africa, such as anaplasmosis, babesiosis and cowdriosis, show a degree of endemic stability (Eisler *et al.* 2003).

Impact on biodiversity

Climate will continue to change rapidly (Watson 2002); cheap energy and other resources, including fresh water, will diminish and disappear at an accelerating rate; agricultural and farm communities will deteriorate further while we lose more genetic diversity among crops and farm animals ; biodiversity will decline faster as terrestrial and aquatic ecosystems are damaged; harmful exotic species will become ever more numerous. Out Of the 3831 breeds of ass, water buffalo, cattle, goat, horse, pig, and sheep recorded in the twentieth century, at least 618 had become extinct by the century's end, and 475 of the remainder were rare. The FAO (2007) report on animal genetic resources indicates that 20% of reported breeds are now classified as at risk, and that almost one breed per month is becoming extinct. For developing regions, the proportion of mammalian species at risk is lower (7–10%), but 60–70% of mammals are classified as being of unknown risk status.

Mitigation Strategies

Agriculture was responsible for 10–12% of total global non-CO_2 greenhouse gas (GHG) emissions in 2005, but emissions of CH_4 and N_2O increased globally by nearly 17% from 1990 to 2005, with both gases contributing equally to the increase (Smith *et al.*, 2007). Enteric CH_4 fermentation accounted for about 32% of total non-CO_2 emissions from agriculture in 2005 (Smith *et al.,* 2007). If CH_4 emissions grow in direct proportion to projected increases in livestock numbers, then global CH_4 emissions from livestock production are expected to increase 60% by 2030 (FAO, 2003). Given the contribution of CH_4 to global GHG production, there have been several recent reviews of mitigation strategies to reduce enteric CH4 emissions from livestock (Eckard *et al.,* 2010). 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)

Several options have been considered for mitigating methane production and emitting in atmosphere by the livestock. All approaches points towards either reduction of methane production per animal or reduction per unit of animal product (Johnson *et al.,* 2002). Generally the methane mitigation strategies can be grouped under three broader headings viz., managemental (De Ramus *et al.,*2003), nutritional (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). Several mitigation options are available for methane emissions from livestock:

Reduction in Livestock Population

Global analyses have clearly shown that non-CO_2 greenhouse gas (GHG) emissions [(i.e., enteric methane (CH_4) and nitrous oxide (N_2O)] are inversely related to animal productivity (Gerber *et al.,* 2011). Increase in animal productivity can be achieved through improvements in animal genetics, feeding, reproduction, health, and overall management of the animal operation. In many parts of the world, reduction in animal numbers was the single most influential mitigation strategy that significantly reduced the C footprint (Capper *et al.,* 2009). Similarly, In the Netherlands, with increase in milk production per cow from 6,270 kg in base year 1990 to 8.350 kg in 2008, with a decrease in CH_4 production from 17.6 to 15.4g/kg FPCM, respectively (Bannink *et al.,* 2011).

Blümmel *et al.* (2009) estimated that increasing milk yield per animal in India from the national average of 3.6 liter per day to up to 9.0 liter per day was possible using currently available feed resources, and this would potentially reduce CH_4 production in the country from 2.29 to 1.38 Tg/yr. Sheep population has been reduced from 57.9 million in 1990 to 45.2 million in 2000, while dairy cattle and beef cattle population have increased slightly. The net outcome was a decline in ruminant CH_4 emission from 1.45 to 1.31 Tg/year from 1990 to 2000 (Sejian *et al.* 2011).

Animal Nutrition

There are a number of nutritional technologies for improvement in rumen efficiency like, diet manipulation, direct inhibitors, feed additives, propionate enhancers, methane oxidisers, probiotics, defaunation and hormones (Moss, 1994). Dietary manipulation through increased green fodder decreased methane production by 5.7% (Singhal and Madhu Mohini 2002). Ruminant production systems based on concentrate feeds are reportedly more efficient from the animal perspective and emit less GHG per unit of product (Pelletier *et al.,* 2010).Increasing the concentrate in the diet of animals reduced methane by 15–32% depending on the ratio of concentrate in diet (Singhal and Madhu Mohini 1999). The methane mitigation from molasses urea supplementation was 8.7% (Srivastava and Garg 2002) and 21% from use of feed additive monensin (De and Singh 2001). Bell *et al.* (2011) demonstrated that improvements in feed efficiency and milk production can significantly reduce GHG emissions and land use of the dairy herd. However, selection for high milk production and decreased productive life, increased death rate, and decline in fertility need to be avoided (Norman *et al.*, 2009). Organic dairy production systems have generally higher GHG emission than conventional dairy systems (Heller and Keoleian, 2011; Kristensen *et al.,* 2011). Field experiments in India showed that dietary manipulation through increased green fodder decreased methane production by 5.7% (Singhal and Madhu Mohini 2002).

Improved Feeding Management

Composition of diet has the effect on the rumen microbial ecosystem so any manipulation in the diet by means of forage, concentrate and their components results in change in the microbial community and may decrease or inhibit activity of methanogenic bacteria. There are several strategies which can be used to reduce methane production from livestock.

1. Methane Inhibitors tested in vivo were bromo-chloromethane (BCM), 2-bromo-ethenesulfonate (BES), chloroform and cyclodextrin reduced methane production by up to 50% in cattle and small ruminants (Knight *et al.,*2011)

2. Ionophore antibiotics such as monensin are known to decrease methane production (typically used to improve animal efficiency for production) (Beauchemin *et al.,*2008).
3. Nitrate: - Hulshof *et al.,* 2012 has shown hopeful results of feeding with nitrate in decreasing enteric methane production by up to 50%.

Grazing management

Implementing proper grazing management practices to improve the quality of pastures will increase animal productivity and lower CH_4 per unit of product. Measurements of CH_4 production from grazing beef cows indicated a 25% reduction in CH_4 losses with alfalfa-grass pastures (7.1% of GEI) compared to grass-only pastures (9.5% of GEI) (McCaughey *et al.* 1999). Early grazing of alfalfa-grass pastures, reduced CH_4 production (% GEI) by 29–45% in steers compared to grazing at mid and late seasons (Boadi *et al.* 2004).

Manure Management

In India, the possibility of capturing or preventing emissions from animal manure storage is limited as it is extensively used as fuel in the form of dry dung cakes or spread in field. Animal wastes including manure account for more than 25 million tonnes methane emission globally per year. Improving management of animal waste products through different mechanisms such as covered storage facilities can reduce the methane emission. Separation of manure solids and anaerobic degradation pre-treatment can mitigate CH_4 emission from subsurface- applied manure, which may otherwise be greater than that from surface applied manure. The GHG emission from manure (CH_4, N_2O, and CH_4 from liquid manure) is dependent on the temperature, timing of application and duration of the storage.

Lowering Livestock Product Consumption

Lowering consumption of meat and milk in areas having high standards of living will support short term response to the GHG mitigation. Europe, North America, and the non-European Union former Soviet Union countries produced 46.3% of ruminant meat and milk energy and only 25.5% of the enteric CH_4 emissions in 2005 (O'Mara, 2011). In contrast, Asia, Africa, and Latin America produced a similar amount (47.1%) of ruminant meat and milk energy but a large proportion (almost 69%) of enteric CH_4 emissions. Therefore, the Intergovernmental Panel on Climate Change (IPCC, 2007) estimated that about 70% of the global GHG mitigation potential from agriculture lies in developing countries (Smith *et al.,* 2007).

All these strategies call for formulation of long-term policies at government level and significant investment in the livestock production and processing industry; which may help in improvement and boost of livestock production.

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 long term adaptation strategies and mitigation options for the livestock sector. Factors affecting variability in enteric CH_4 production requires urgent attention and efforts to decrease the uncertainty in GHG emission inventories. It is very essential to identify viable GHG reduction strategies. First, much more clarity is needed concerning the benefits of livestock, the negative impacts they can have on greenhouse-gas emissions and the environment, and the effects of climate change on livestock system. 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.

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