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The Contribution of Livestock Production to Greenhouse Gases Emissions and the Possible Mitigation Strategies: A Review

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Abstract

This review was attempted to collect information on the contribution of livestock production to greenhouse gases (GHGs) emission and the possible mitigation options. Animal husbandry accounts for 18% of GHGs emission which has a bigger share than that of transport sectors that account for 13% of GHGs emission. Livestock sector account for an estimated 9% of CO_2, 35-40% of CH_4 and 65% of N_2O global emissions. Livestock production also generates 64% of human related ammonia. The major sources of agricultural CH_4 emission are ruminants, rice cultivation, poor quality feed, handling and processing of livestock manure, and biomass burning. In livestock production systems, grazing, livestock-crop and intensive system contribute for 30.5%, 67.29% and 5.51% of CH_4 and 24.32%, 68.11% and 7.57% of N_2O emissions, respectively. As mitigation options, organic farming, pigs and poultry production, intensive livestock production system, livestock management, nutritional and advanced biotechnological strategies are the main GHGs emission mitigation strategies. In conclusion, addressing livestock issues to GHGs emission requires multifaceted approaches including choosing of the types of meat we eat and replacing omnivorous diet with a vegan diet.

Keywords: Climate change, Emissions, Greenhouse gases, Mitigation options, Livestock production

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Abbreviations

EPA= Environmental Protection Agency; FAO= Food and Agriculture Organization of the United Nations; GHGs=greenhouse gases; IFOAM= International Federation of Organic Agriculture Movements; WURC= Wageningen University and Research Centre

Introduction

Livestock account for about 20 percent of the total terrestrial animal biomass and they use nearly one-third of the earth's entire landmass, even more land is used to produce their feed in the future (FAO, 2006b; Seinfeld *et al.,* 2006). The sector accounts for 40% of the world's agriculture GDP, employment of 1.3 billion people and creates livelihoods for one billion populations living in poverty (FAO, 2006b). However, food security remains one of the highest priority issues in developing countries. Livestock production has a key role for food security (Naqvi and Sejian, 2011). Livestock sector is undergoing a complex process of technical and geographical change. Production is shifting from the countryside to urban and peri-urban areas, and towards sources of animal feed. There is also a shift in species, with accelerating growth in production like pigs and poultry that slowdown cattle, sheep and goats production, which are often raised extensively (FAO, 2006b). Moreover, with increased prosperity, people are consuming more meat and dairy products every year. Due to this global meat production is projected to more than double from 229 million tons in 1999/2001 to 465 million tons in 2050, while milk output is set to climb from 580 to 1043 million tons (FAO, 2006b). Regarding livestock species, broiler and pork production and consumption will be increasing worldwide in alarming trends as compared to beef (Bauman and Capper, 2011).

The role of livestock for food security is re-emerging as an important issue in many developed countries (Naqvi and Sejian, 2011). However, for long decades the sector has assumed as unrecognized role in global warming (FAO, 2006b). According to FAO (2006a), the contribution of livestock to global warming will likely increase in coming years as global meat production is projected. Livestock production also contributes much to global warming come from deforestation, as the growing demand for meat results in trees cutting to make space for pasture or to grow animal feed. Since the sector is potential contribution to global warming to solve environmental problems major improvements could be achieved at reasonable cost and urgent actions are required for remedy situations. Therefore, this review was attempted to collect information on the contribution of livestock production to GHG emissions and the possible mitigation options.

Sources of GHGs Emission

Greenhouse gases are released into the atmosphere both by natural sources and anthropogenic activities (Naqvi and Sejian, 2011). The 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 (FAO, 2006b; Steinfeld *et al.*, 2006; Naqvi and Sejian, 2011) which has a bigger share than that of transport sectors; the entire world's cars, trains, planes and boats account for a combined 13% of greenhouse gas emissions (FAO, 2006b). In detail, livestock account for an estimated of 9%, 35-40% and 65% of global CO_2, CH_4 and N_2O emissions (the 3rd major greenhouse gas emission mainly due to manure), respectively (FAO, 2006b; Steinfeld *et al.,* 2006). Livestock also generates 64% of human related ammonia, which contributes to acid rain and the acidification of ecosystems (Steinfeld *et al.*, 2006; Hudak, 2007). In the US alone, livestock can produce 130 times GHG more excrement than the entire global human population in a single day (Beauchemin and McGinn, 2005).

Methane (CH_4) Sources

Methane is one of the primary components of the GHGs and second to CO_2 in its contribution towards greenhouse effect and its concentration is constantly rising in the atmosphere and has been double over last two centuries (Naqvi and Sejian, 2011). The same authors reported that, CH_4 is released in the atmosphere either by natural or anthropogenic sources and it has a great heat trapping capacity in atmosphere. Enteric fermentation and anaerobic decomposition of manure are the main source of CH_4 where enteric fermentation generates approximately 86 million metric tons of CH_4 emissions worldwide annually (Steinfeld *et al.,* 2006). The amount of CH_4 produced and excreted by the animal depends on the animal's digestive system as well as the type of feed they consumed. In anaerobic decomposition of manure CH_4 emissions are dependent on the storage condition of the manure, feed type and the animals' digestive system, ambient temperature and moisture that facilitate the growth of CH_4 producing bacteria. Feed that is easier to digest produce lower manure CH_4 emissions (www.virtualcentre.org).

About 2/3 of world's anthropogenic CH_4 emission are produced through agricultural practices where, the major sources of agricultural emission are ruminants, rice cultivation, handling and processing of livestock manure, and biomass burning (Fearon, 2002). The enteric fermentation in rumen is highly useful for humankind because it converts coarse and fibrous plants into food for humankind. However, enteric fermentation produces CH_4 through bacterial breakdown of feeds through a process called methanogenesis (Naqvi and Sejian, 2011). Animals release the produced CH_4 to atmosphere via exhaling or ruminating through mouth or nostrils which is potent GHG (Fearon, 2002). The released CH_4 accounts for release of digestible energy to the atmosphere that causes inefficient utilization of feed energy. Enteric fermentation also produces volatile fatty acids. Among the volatile fatty acids, acetate and butyrate promotes CH_4 production. In general, enteric fermentation and CH_4 emissions are affected by a number of factors, including the animal's age, body weight, feed quality, digestive efficiency, and exercise (Paustian *et al*., 2006; Steinfeld *et al.,* 2006).

Impacts of livestock diets on CH_4 emission

Individual animals produce relatively small amounts of CH_4 (EPA, 2007b), however, greater than 1 billion ruminants annually have significant influence the amount CH_4 emission (FAO, 2008). Feed quality and quantity effect the amount of CH_4 emitted. Poor quality feed increases methane emissions, whereas, good quantity of feed decreases CH_4 emissions. According to Kirchgessner *et al.* (1995) fiber content of the diet was the major determinant of CH_4 production. Miller (1995) reported that anaerobic fermentation in the lower gut of other species does not produce large amounts of CH_4. In non-methanogenic fermentations, H_2 is used to reduce CO_2 to acetate. Studies had revealed that concentrations of acetogens in the rumen were similar to those of methanogens (Greening and Leedle, 1989), but there is no evidence of significant acetate formation from CO_2 when rumen contents are incubated in an atmosphere of CO_2 and H_2 (Miller, 1995).

Nitrous oxide (N_2O) sources

Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste. At the farm stage, the dominant GHG gases are N_2O from soil and livestock processes (Garnett, 2010). Nitrous oxide is the second most important emission from nitrogen turnover in feed production and manure management (FAO, 2006a). About 70% of anthropogenic emissions of N_2O result from crop and animal agriculture, where farm animal production including growing feed crops, accounts for 65% of global N_2O emissions (Steinfeld *et al*., 2006). The emissions from manure management are more important in warmer climates, since the processes generating GHG emissions are stimulated by higher temperatures (FAO, 2006a).

Carbon Dioxide (CO_2) Sources

Carbon dioxide enters the atmosphere through the burning of fossil fuels, solid waste, trees and wood products, and also as a result of other chemical reactions. Approximately 0.8 million metric tons of CO_2 are emitted annually from the transportation of feed and animal products to the places where they will be consumed (Steinfeld *et al*., 2006). Carbon dioxide has the most significant direct impact on global warming because of the sheer volume of its emissions. Of all the natural and human induced influences on climate over the past 250 years, the largest CO_2 concentrations attributed to burning fossil fuels and deforestation (Bierbaum *et al.,* 2007). Animal agriculture accounts for CO_2 emissions primarily as a result of fertilizer production for feed crops, on farm energy expenditures, feed transport, animal product processing and transport, and land use changes. Additional 90 million metric tons of CO_2 may be emitted per year by fossil fuels expended for intensive livestock confinement operations (Steinfeld *et al.,* 2006). Although a large portion of the energy used for intensive confinement operations goes toward heating, cooling, and ventilation systems, more than half is expended by feed crop production, specifically to produce seed, herbicides, and pesticides. The amount of fossil fuels burned varies depending on the species and type of animal product. For example, processing 1kg of beef requires 4.37 mega joules (MJ), or 1.21 kilowatt hours (Steinfeld *et al*., 2006), and may result in GHG emissions equivalent to 36.4 kg of CO_2, with almost all the energy consumed attributed to the production and transport of feed (Ogino *et al.,* 2007). Processing 1 dozen eggs requires greater than 6 MJ, or 1.66 kilowatt hours (Steinfeld *et al*., 2006).

Deforestation, land degradation, soil cultivation, and desertification are responsible for CO_2 emissions from the livestock sector land use, because farm animal production facilities uses more than 2/3 of all available agricultural land including the land used to grow feed crops (Haan *et al.,* 1997). Animal agriculture is a significant catalyst for the conversion of wooded areas to grazing land or cropland for feed production, which may emit 2.4 billion metric tons of CO_2 annually as a result of deforestation. Farm animal production also results in releases of up to 28 million metric tons of CO_2 per year from cultivated soils. Like forests, soil act as carbon sinks and store more than twice the carbon found in vegetation or in the atmosphere. However, human activities have significantly depleted the amount of carbon sequestered in the soil, contributing to GHG emissions (Steinfeld *et al.,* 2006).

Extent of global GHGs are emitted due to livestock production

Ruminants have highest GHG emissions compared to monogastrics (EPA, 2007a; Zervas and Tsiplakou, 2012) with small ruminants share being 12.25% of the total GHG emissions, producing 9.45 kg CO_2 equivalent per kg body weight with the respective values for cattle, pigs and poultry being 5.45kg, 3.97kg and 3.25kg, respectively. Globally, ruminant livestock digestion process produces about 80 million metric tons of CH_4 annually (Gibbs and Johnson, 1994). Similarly, clearing of tropical forests and rain forests to get more grazing land and farm land is responsible for an extra 2.8 billion metric tons of CO_2 emission per year (DeRamus, *et al*., 2003).

The impacts of livestock population and species on GHGs emission

According to FAO (2008), approximately 56 billion land animals are globally slaughtered for human consumption annually. Livestock inventories are expected to double by 2050, with most increases occurring in the developing world (Steinfeld *et al.,* 2006). Since 1940s, farm animal populations are escalating in large and confined operations (Paustian *et al.*, 2006). As the numbers of farm animals reared for meat, egg, and dairy production rise, so do their GHG emissions. According to USDA (2004) report GHG emissions from livestock are inherently tied to livestock population sizes. Similarly, livestock production systems significantly affect the GHG emissions, grazing, livestock crop complex, and intensive ones account for 30.5%, 67.29% and 5.51% for total CH_4 emissions and 24.32%, 68.11% and 7.57% for N_2O emission, respectively (Zervas and Tsiplakou, 2012).

Beef production

Although there are many exceptions animal products production such as meat and dairy, have on average higher GHG emissions per kilogram (Table 1) than vegetable products production (Sonesson *et al.,* 2009). Beef production contributes more than half percent of the total global warming potential from agriculture. In intensive beef production, a large share of the feed is concentrate, their provisions increases the emissions of both N_2O and CO_2, but lower CH_4 emissions. Since emissions from biological processes in the rumen are important, it is vital that the growth rate of cattle should be higher in order to have low emissions per kg of meat. If animals grow very slow, a lot of CH_4 will be produced from the digestion of feed needed to maintain the animals' life, without producing any meat (Sonesson *et al.,* 2009).

Table 1: GHG emissions due to beef production reported in different studies

Study	CO_2-equiv./kg bone free meat				MJ/kg bone free meat
	Total	CH_4	N_2O	CO_2	
Ogino *et al.,* (2007) ,Japan	32	23	2	7	
Casey & Holden (2006a,b), Sucker, Ireland	28-32				
Williams *et al.,* (2006), "Average UK beef"	16				28
Williams *et al.,* (2006),"100% sucker UK"	25				41
Verge *et al.,* (2008), "Average Canadian beef"	30	15	11	4	
Cederberg *et al.,* (2009a), "Average Brazil beef"	40	31	9	0	5
Cederberg *et al.,* (2009b), "Average Swedish beef 2005"	28	17.5	7	3.5	
Cederberg & Darelius (2000), "Swedish beef from combined systems dairy-beef"	17-19	9-10	5-6	3	44

Source: Sonesson *et al.* (2009)

Dairy production

The GHG emissions from dairy production are similar to that of beef production. Enteric fermentation and manure decomposition dominates with contribution of 50-60% CH_4 emission and N_2O emission from feed and manure management contributes around 30% (Sevenster and de Jong, 2009). However, there are differences in dairy farming between developing and develop world. In developed countries are generally more intense with a larger use of concentrate feeds, as a consequence feed provision is slightly more important. In dairy production, milk yield per cow is a determining factor (Sonesson *et al.,* 2009), the large share of total feed intake (and methane emissions) is used for producing milk as opposed to used for body maintenance. Milk has higher water content (about 88%); normalizing it to 70% water means the emissions of GHG between 3.1 and 3.8 kg CO_2equiv/kg (Sevenster and de Jong, 2009).

Pork production

Since pigs are mono-gastric animals, they cannot utilize cellulose and hemi cellulose in the feeds. They need to be fed on grains and that can be used directly as food for humans. As a result they produce very small amount of CH_4 in digesting their feed (Sonesson *et al.,* 2009). Emissions of GHGs from pork is dominated by N_2O (Cederberg and Darelius, 2001; Eriksson *et al.,* 2005). Besides the differences in feed digestion, pork production produce lower GHG emissions than beef production (Table 2) due to a higher feed conversion, also a sow can produce up to 25 piglets yearly (Sonesson *et al.,* 2009).

Table 2: GHG emissions due to pork production reported in different studies

Study	CO_2-equiv./kg bone free meat				MJ/kg bone free meat
	Total	CH_4	N_2O	CO_2	
Williams *et al.,* (2006)	5.6-6.4				14-17
Basset Mens and Vander Welf, (2003)[a]	5.3-8.0				37-42
Cederberg and Flysjö, (2004)	4.1-3.6	1.1	1.6-2.1	0.9-1.2	15-18
Strid Eriksson *et al.* (2005)[b]	3.2-3.5				13-16
Cederberg m.fl. (2009b)[c]	5.2	1.3	2.6	1.3	

Source: Sonesson *et al.* (2009)

Poultry production

Chickens are the absolutely dominating type of poultry globally. As pigs, they are mono-gastric animals and have high feed conversion efficiency. At the same time chicken have high demands on feed composition *e.g.* high demand on protein, both quality and quantity, which in turn puts high, demands on feed production. Poultry only contributes 1% of the total global warming potential from agriculture. Their high feed conversion efficiency results relatively low GHGs emissions (Table 3). In temperate and cold climates, barns have to be heated, and depending on what energy source is being used the emissions vary. In warmer climates cooling of barns can be an important contributor, but no studies including this have been found (Sonesson *et al.,* 2009).

Table 3: GHG emissions due to chicken production as reported in different studies

Study	CO_2-equiv./kg bone free meat			
	Total	CH_4	N_2O	CO_2
Tynelius, (2008)[a]	1.5			
Pelletier, (2008)[b]	2.6			
Cederberg *et al*., (2009b)[c]	2.5	0.1	1.2	1.2
Williams *et al.,* (2006), conventional [c]	6.1			
Williams *et al.,* (2006), free-range [c]	7.3			

Source: Sonesson *et al.* (2009)

Fisheries production

Fisheries production has impact on climate dominated by CO_2 emissions from diesel combustion, which is directly related to the amount of fuel used. The second major factor is the leakage of refrigerants from cooling equipment. Analyzing the entire production chain from fisheries to fish consumption, is the fishing phase that accounts for the greatest share of total energy utilization and fuel combustion during fishing in modern and industrialized fisheries (Thrane, 2006). Numbers of factors affect the climate impact per kilo of landed fish; perhaps the most significant are fishing gear and species biology (Ziegler *et al*., 2003; Tyedmers, 2004; Thrane, 2006). The stock situation is another key factor that affects fuel efficiency. Low fish stocks means more time is required to accumulate the same catch compared with the same fish stock at a higher density, using the same gear. In addition to the fishing method, the stock situation is a key factor in determining the energy efficiency of fisheries (Schau *et al.,* 2009).

Possible Mitigation Options Selecting livestock farming system and species

Since livestock utilize around 80% of the world's agricultural land (FAO, 2009), they generate the bulk of GHG emissions. Several options have been considered for mitigating CH_4 production by livestock (Joblin, 2001). Organic farming has the potential to reduce GHG emissions and sequester of carbon (IFOAM, 2004). All mitigation approaches point towards either reduction of CH_4 production per animals or per unit of animal products (Johnson *et al*., 2002). According Gworgwor *et al*. (2006) selection of best mitigation options for reduction of CH_4 emission include climatic, economic, technical and material resources, existing manure management practices, regulatory requirements. Generally, the CH_4 mitigation strategies can be grouped under three broader headings namely managemental (Ulyatt and Lassey, 2001; DeRamus *et al*., 2003), nutritional (Lovett *et al*., 2005) and advanced biotechnological strategies (Sejian *et al*., 2010).

Methane has relatively short life time (10-12 years) in the atmosphere as compared to other GHGs, for example CO_2 has 120 years life time in the atmosphere and therefore strategies to reduce the CH_4 in atmosphere offer effective and practical means to slow global warming (Turnbull and Charme, 2001). Another key issue is decreasing climate impact of agricultural nitrogen turnover. Producing nitrogen as mineral fertilizer soil turnover of nitrogen and manure management as well cause GHG emissions. So, if less nitrogen is wasted, less N_2O will be produced and fewer emissions will occur from nitrogen. Nitrogen use can be optimized in arable farming by more accurate application, in animal husbandry by reduced emissions from manure storage and spreading but also through optimized feeding (Sonesson *et al.,* 2009).

Improved livestock management mitigate CO_2 emission, using land management that increases the content of organic content in soil will increase carbon sink (Sonesson *et al.,* 2009). Improved livestock management can also reduce atmospheric concentrations of CO_2 through the mechanism of soil carbon sequestration on grazing lands. Even though a large portion of the plant material is harvested through grazing, good management residues accumulate and increase the amount of organic matter in the soil. Some of this organic matter will remain in the soil or plant root system for long periods of time instead of being released back into the atmosphere as CO_2 (EPA, 2007a).

Intensive livestock production system uses less land than extensively reared animals. Since feed crops are more nutrient dense than grass, less area is needed to give quantity nutrition, fewer GHGs emission (in particular CH_4). In contrast, extensively reared animals produce less edible output per unit of GHGs emitted, and have been largely held responsible for the bulk of livestock induced agricultural deforestation (FAO, 2006a). Since their feed conversion efficiency is better, pigs and poultry require less land and produce fewer emissions than ruminants. Moreover, their growth and reproductive rates are fast, good genetic traits can be more rapidly introduced. Hence mono-gastric appear more 'efficient' to reproduce than ruminants and are more pro table. In addition, in recent years a rapid growth in production and consumption of pig and poultry products have been seen; this trend is anticipated to continue and considered positive from of reducing GHG emissions perspective (Defra, 2010).

Selecting livestock feeding strategies

Livestock feeding strategy is the most selected GHGs mitigation and prevention strategy undertaken by the animal agriculture focused on technical solutions via investigating the reformulation of ruminant diets to reduce enteric fermentation and CH_4 emissions (Connolly, 2007). One of such remedy is a plant based bolus, formulated to reduce excessive fermentation and regulate the metabolic activity of rumen bacteria to reduce CH_4 emissions from both the animals and their manure. Some large scale intensive livestock confinement facilities, capture CH_4 from manure to use as a source of energy (Storck, 2007), but not economically viable for small-scale farms (Silverstein, 2007).

Feeding system and manure management are the main factors affecting GHG emissions (Zervas and Tsiplakou, 2012). Raising cattle for beef organically on grass, in contrast to fattening confined cattle on concentrated feed, may emit 40% less GHGs and consume 85% less energy than conventionally produced beef (Cederberg and Stadig, 2003; Fanelli, 2007; Ogino *et al.,* 2007). Adding fish oil to the diets of cows and other ruminants may significantly reduce the amount of CH_4 that the animals can emit (Gutierrez, 2009), because the fish oil affects the CH_4 producing bacteria in the rumen, leading to reduced emissions. Understanding which microbial species are particularly influenced by changes in diet and relating them to CH_4 production could bring about a more targeted approach to reducing CH_4 emissions in animals. Adding 2% fish oil by weight to the regular feed of cows can significantly reduce the number of CH_4 producing bacteria and reduce CH_4 emissions by 21% (Gutierrez, 2009). Ionophores are widely used in ruminant diets to improve the efficiency of food utilization, also shown to reduce CH_4 production substantially for the first few days of treatment but again the effects are not sustained (Gibbs and Johnson, 1994). However, increasing feed efficiency stemming from the use of ionophores results in a decrease in CH_4 production proportionate to the reduction in food intake (Kirchgessner *et al.,* 1995). In the developing world, measures to improve livestock productivity include the use of improved fodder varieties in the place of low quality grasses approach to increase productivity and reduce GHG emissions. Another approach is animal breeding developments together with strategies to optimize the balance between the carbohydrate and protein content of the feeds, so as to maximize growth or yields while minimizing CH_4 and nitrogen losses. In the developed world this means diets which include high levels of concentrates (Naylor *et al.,* 2005; FAO, 2009). Moreover, the combinations of breeding and feeding strategies have led to substantial reductions in emissions per kg of edible products (Garnett, 2010).

Using manure managements

A similar microbial process to enteric fermentation leads to CH_4 production from stored manure. Anytime the manure sits for more than a couple days in an anaerobic environment, CH_4 will be likely produced. Methane can be generated in the animal housing, manure storage, and during manure application. A small amount of CH_4 is also produced from manure deposited on grazing lands. Nitrous oxide is produced from manure storage surfaces, during land application, and from manure in bedded packs and lots (Crystal and Powers, 2012). Livestock productivity efficiency improvements can reduce N_2O emissions (EPA, 2007a).

Generally, addressing livestock issues requires a multi-faceted approach including re-formulating animal diets, introducing soil conservation methods together with controlled livestock exclusion from sensitive areas and setting up biogas plant to recycle manure (FAO, 2006a). Many different management practices can improve a livestock operation's production efficiency and reduce GHGs emissions. Some of the most effective practices are indicated in Table 4, however, the particular practices a livestock producer utilizes to improve production will depend on the circumstances of operations, including the goals to be achieved, financial and labor resources (EPA, 2007a).

Table 4: Strategies reported by different studies to reduce methane emission from livestock

Strategies
Selection of genetic improved breeds that produce low methane (Sejian *et al*., 2010) Improving genetics and reproductive efficiency of animals (EPA, 2007a) Reduce livestock population (Sejian *et al*., 2010) Improve livestock nutrition by providing high quality feed and strategic supplementation of essential nutrients (EPA, 2007a; Sejian *et al*. 2010) Soil testing, followed by the addition of proper amendments and fertilizers (EPA, 2007a) Improving grassland management (EPA, 2007a; Sejian *et al*. 2010) Ensuring proper healthcare veterinary practices (EPA, 2007a; Sejian *et al*. 2010) Increasing the proportion of concentrate feeding (Sejian *et al*., 2010) Diet modification through ammonia and molasses feeding (Sejian *et al*., 2010) Oil and ionophore supplementation (Sejian *et al*., 2010) Defaunation and rumen microbial intervention (Sejian *et al*., 2010) Reducing the manufacture of livestock products(Sejian *et al*., 2010) Employing advanced technology like immunization and recombinant technology (Sejian *et al*., 2010)

Reducing meat consumption

Our meat consumption receives much less attention than other climate change issues, but meat consumption is in fact amongst the top three contributors to GHG emissions (Table 5). If we replaced the beef in our diet with chicken, every individual could save 8kg of CO_2 greenhouse pollution every week (Williams *et al.*, 2006). By replacing omnivorous diet with a vegan diet, the average person can prevent the emission of about 1.5 tones of CO_2 into the atmosphere annually that's 50% more CO_2 saved (New Scientist, 2005).

Table 5: CO_2 emissions due to the four most common types of meat consumed

1 kg of meat from	Produced kg CO_2 equv.
Beef	34.6
Lamb	17.4
Pork	6.35
Chicken	4.57

Source: Defra (2006)

Insects could contribute to more sustainable protein production; therefore, insect meat could form an alternative to more conventional types of meat (Science Daily, 2011). Insects produce much smaller quantities of GHGs per kilogram of meat than cattle and pigs (Science Daily, 2011). Wageningen University and Research Center quantified the production of GHGs of several edible insect species. The research team quantified the GHGs produced per kilogram of insect product for the first time. The results demonstrated that insects produce much smaller quantities of GHGs than conventional livestock. For example, a pig produces between ten and a hundred times as much GHGs per kilogram compared with mealworms. However, further research is required to ascertain whether the production of a kilogram of insect protein is also more environmentally friendly than conventional animal protein when the entire production chain is taken into account (WURC, 2011).

Conclusion

As the numbers of farm animals raised for their products increase, so do GHGs emission from their production. Mitigating and preventing the environmental harms caused by livestock sector require immediate and substantial changes in livestock production system, feed quality, manure management and type of meat consumption need top priority. Organic farming, pigs and poultry farming, intensive livestock production systems, manure management, nutritional quality and advanced biotechnological strategies are the main GHGs emission mitigation strategies. Generally, addressing livestock issues requires a multi-faceted approach including re-formulating animal diets, introducing soil conservation methods together with controlling livestock from sensitive areas and setting up biogas plant to recycle manure. Chicken, pork and insect consumption reduce of CO_2 production and replacing omnivorous diet with a vegan diet reduces more GHGs emission.

Conflict of Interest

The author declared that there is no conflict of interst regading to this paper.

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