



Livestock and greenhouse gas emissions: The importance of getting the numbers right

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ABSTRACT

Estimates of global greenhouse gases (GHG) emissions attributable to livestock range from 8 to 51%. This variability creates confusion among policy makers and the public as it suggests that there is a lack of consensus among scientists with regard to the contribution of livestock to global GHG emissions. In reality, estimates of international scientific organizations such as the International Governmental Panel on Climate Change (IPCC) and the Food and Agriculture Organization (FAO) are in close agreement, with variation mainly arising on how GHG emissions are allocated to land use and land use change. Other estimates involve major deviations from international protocols, such as estimated global warming potential of CH₄ or including respired CO₂ in GHG emissions. These approaches also fail to differentiate short-term CO₂ arising from oxidation of plant C by ruminants from CO₂ released from fixed fossil C through combustion. These deviances from internationally accepted protocols create confusion and direct attention from anthropomorphic practices which have the most important contribution to global GHG emissions. Global estimates of livestock GHG emissions are most reliable when they are generated by internationally recognized scientific panels with expertise across a range of disciplines, and with no preconceived bias to particular outcomes.

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Abbreviations: FAO, Food and Agriculture Organization; GHG, greenhouse gases; GWP, global warming potential; IPCC, Intergovernmental Panel on Climate Change.

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1. Introduction

Livestock farming plays a critical role in global food production, and has formed part of local landscapes and ecosystems for millennia. The importance of livestock in providing human societies with food, incomes, employment, nutrients and risk insurance is widely recognized (Perry and Sones, 2007; Herrero et al., 2009).

At the same time there is a growing awareness within the research and policy communities that rapid growth in global production and consumption of livestock products is contributing to a range of serious environmental problems, the most notable being the sector's substantial contribution to climate changing emissions.

In 2006, using well documented and rigorous life cycle analyses, it was estimated that livestock contributed 18% of global greenhouse gas (GHG) emissions (FAO, 2006). According to this study, the main sources of GHG from livestock systems arise from land use change (CO_2), enteric fermentation from ruminants (CH_4) and manure management (N_2O). A recent non-peer reviewed report published by the Worldwatch Institute (Goodland and Anhang, 2009) contested these figures and argued that GHG emissions from livestock are closer to 51% of global GHG emissions. In our view, this report has oversimplified the issue with respect to livestock production while emphasizing negative impacts of livestock on the environment and ignoring positives. In so doing it used a flawed methodological approach to estimate GHG emissions from livestock. Even though Goodland and Anhang (2009) do not present detailed methodologies or clear scientific evidence to back their results, differences between their approach and internationally accredited approaches arise in the following areas.

2. Exclusion of carbon dioxide emissions from livestock respiration

According to Goodland and Anhang (2009), CO_2 from livestock respiration was an overlooked source of GHG from the FAO study (2006). Under Intergovernmental panel on climate change inventory guidelines (IPCC, 2006), and under the Kyoto protocol, CO_2 from livestock is not considered a net source of CO_2 because this CO_2 is considered to be part of a rapid biological system where plant material consumed by the animals is created by photosynthesis, sequestering CO_2 in the process. The amount of C in feed consumed, and CO_2 emitted by livestock, are considered to be broadly equivalent and part of the short term C cycle resulting in no net increase in the concentration of atmospheric CO_2 within relevant time horizons. In addition, while it is true that in some livestock production systems the balance between C consumed and CO_2 emitted is not perfectly equal, these differences are small when overall global rangeland and forage productivity are considered as a C sink. There is also a substantive body of evidence, which suggests that grasslands and their growth more than offset CO_2 emissions from livestock (Fisher et al., 1994; IPCC, 2006). Regardless, if respiration is accounted for, then CO_2 absorption related to plant growth must also be considered in the overall C cycle analysis.

3. Emissions from land use and land use change

Goodland and Anhang (2009) claim that emissions from land use and land use change induced by the livestock sector have been grossly underestimated. While estimates from FAO (2006) may be conservative in many aspects, the argument and analysis presented by the authors raises some questions.

Firstly, in estimating the 'unaccounted for emissions' from land use and land use change, the authors utilize a different approach from the FAO report (2006). The authors use a *consequential approach* that applies a 'what-if scenario' in estimation of emissions from land use, and then assess the potential emission reductions arising from use of land for alternative practices. In other words, it quantifies the amount of C that would be sequestered if existing grazing lands were allowed to revert to forest, and then attributes the 'lost' opportunity for C sequestration to livestock production. The FAO assessment (2006), in contrast, bases its analysis on actual land use trends, thereby allocating C losses resulting from *current* changes in land use to livestock production. While in a land constrained world it is important to consider different future possible uses for land so as to ensure food security, C storage and biological diversity, the approach adopted by Goodland and Anhang (2006) is methodologically inconsistent. The authors do not quantify the lost opportunity for C sequestration that results from other forms of land use, such as arable crop production for human consumption, or urban development. If they were to do this, then overall anthropogenic GHG emissions would be higher, and livestock related impacts would need to be seen as a proportion of this higher figure.

More importantly, Goodland and Anhang (2006) advocate that livestock products be replaced with alternative food sources, a strategy which would require a portion of the grazing land used for forage production to be converted to land for annual crop production for use as food or as a substrate for biofuel production. This practice would contribute to habitat destruction of native grasslands, an ecosystem which harbors a number of at risk species. Furthermore, the authors fail to provide detailed analysis on which alternative protein sources would replace animal protein and what would be the likely implications in terms of land use, land use intensity, food security, human nutrition and livelihoods.

Goodland and Anhang's (2006) proposal to convert grazing land to cultivated land for biofuel production is also misleading from a land use change perspective. In a hypothetical world without livestock, there could be many potential uses for land currently utilized for livestock. Land use would depend on alternative opportunity costs, labour and transport, as well as other factors, none of which have been considered systematically by Goodland and Anhang (2006). At the same time, in most cases livestock occupy large areas of the world where other forms of agriculture are impractical, whether for producing plant based human foods, biofuels or for other uses. In addition, Goodland and Anhang (2006) erroneously assume that biofuel

production is GHG neutral (Searchinger et al., 2008). This limits their scenario of growing biofuels in all areas occupied by livestock. Production of alternative biofuels may be limited to areas which are close to markets and that possess adequate infrastructure, but even these areas would have competing land uses and substantial opportunity costs.

Removal of domesticated ruminants would also have implications with regard to populations of wild ungulates, as wild ungulate species could prevail in vacated niches. In some instances GHG emissions from wild ruminants may be even higher than from domesticated ruminants that have been selected over generations for efficiency. These facts point to the reality that estimating emissions from livestock systems is very complex and needs to be assessed with solid conceptual models of global environmental, social and economic change.

Goodland and Anhang (2006) also omit to acknowledge that many key drivers of land use and land use change, such as deforestation, are outside of productive land uses and are driven by motivations and policies such as infrastructure development, land speculation, urbanization and development of renewable energy. Many of these policies are driven by a lack of economic incentive to conserve or maintain natural resources.

4. Global warming potential of methane

Goodland and Anhang (2006) suggest use of a 20 yr global warming potential (GWP) for CH₄ of 72. The debate on how much warming that CH₄ causes is an ongoing one (Shindell et al., 2009). Scientific advancements have led to corrections in CH₄ GWP values over the past decade. Indeed the IPCC, in its 4th Assessment Report, effectively revised the global warming potential from 23 to 25 as indirect effects of CH₄ on ozone and stratospheric water vapor were included. It should be noted that, at the time of the writing of the 2006 FAO report, the GWP of 23 over a 100 yr time horizon was considered valid and acceptable. As CH₄ has an atmospheric lifetime of 12 yr, in the short term it contributes more to current global warming than the factor 25 suggests, but this effect decays almost completely after a period of 20–30 yrs. Consequently, CH₄ is a very important gas to target for short term reduction in radiative forcing. However, the GWP is a measure to prioritize mitigation practices, for which the scale of a century is currently considered appropriate, although still under debate (Shindell et al., 2009). The IPCC has acknowledged the value of alternative metrics (e.g., Global Temperature Potential) and indicated that further research is required (Plattner et al., 2009). Selection of a time horizon is a scientific relevant issue, but also a political one based on the relative weight given to short versus long lived GHG.

5. Attribution of greenhouse gases to livestock

Goodland and Anhang (2006) identify a number of GHG sources currently excluded from GHG assessments from livestock. Of particular importance are issues related to the complexity of attributing certain emissions to the livestock sector. For example cooking in open fires, waste management, use of toxic chemicals, packaging and temperature controlled supply chains, and the occurrence of chronic degenerative diseases, are aspects that do not only relate to production and consumption of livestock products. Methodologies for estimating and adequately attributing these kinds of emissions to specific sectors are still under development and have not been vetted by the international scientific community.

Goodland and Anhang (2006) point out that the FAO 18% estimate lacks relevance and is outdated. The authors erroneously assume that a 12% increase in global tonnage of livestock products translates into a proportionate increase in GHG emissions. This ignores the reality that production systems can become more efficient at higher production levels. For example in Europe (EU-12), livestock production increased slightly between 1990 and 2002, while emissions of CH₄ and N₂O decreased 8–9% (EA, 2009). Some European countries have seen even more dramatic improvements in efficiencies. Denmark reduced its emissions of CH₄ and N₂O by 23% from 1990 to 2002, while maintaining dairy production output and increasing pig production by 27% (Danish Environmental Protection Agency, 2005). Increased production per animal led to a reduction in livestock populations, and more efficient use of manures and N fertilizers.

Goodland and Anhang (2006) cite use of unrealistically low population estimates of livestock in estimation of GHG, and failure to use a correction factor to account for growing livestock populations, as one of the shortfalls of the 2006 FAO report. Specific reference is made to production of 33 million poultry worldwide. This, however, stems from a misinterpretation on the part of the authors who confuse 'poultry biomass' with production of poultry meat and, despite some shortcomings of FAO statistics, it remains the only globally recognized source of GHG data on agriculture. Goodland and Anhang (2006) correctly point out that the FAO assessment (2006) omit emissions related to preparation of animal products, and that estimates for land use change, transport and processing are deliberately conservative. These methodological decisions were constrained by availability of data from a global perspective in 2006.

6. Conclusions

Livestock production needs to be considered as the global community seeks to address the challenge of climate change. The magnitude of the discrepancy between the Goodland and Anhang paper (2006) and widely recognized estimates of GHG from livestock illustrates the need to provide the climate change community and policy makers with accurate emissions estimates and information about the link between agriculture and climate. Improving the quality of the global estimates of GHG attributed to livestock systems is of paramount importance, not only because we need to define the magnitude of the impact of livestock on climate change, but also because we need to understand their contribution relative to other

sources. Such information will enable effective mitigation strategies to be designed to reduce GHG emissions and improve sustainability of the livestock sector while continuing to provide livelihoods and food for humans. We need to understand where livestock can help and where they hinder the goals of resilient global ecosystems and livelihoods to ensure that they contribute to a sustainable future.

We believe these efforts need to be part of an ongoing process, but one which is conducted through transparent well established methodologies, rigorous science and open scientific debate. Only in this way will we be able to advance the debate on livestock and climate change and inform policy, climate change negotiations and public opinion more accurately.

Conflict of interest

None.

References

- Danish Environmental Protection Agency, 2005. Denmark's Fourth National Communication on Climate Change under the United Nations Framework Convention on Climate Change. Environmental Protection Agency, Danish Ministry of the Environment, Copenhagen, Denmark.
- EA, 2009. Annual European Community greenhouse gas inventory 1990–2007 and inventory report 2009. Submission to the UNFCCC secretariat, European Environment Agency, Brussels, Belgium.
- FAO, 2006. Livestock's Long Shadow. Environmental Issues and Options. Food and Agriculture Organization of the United Nations, Rome, Italy.
- Fisher, M.J., Rao, I.M., Ayarza, M.A., Lascano, C.E., Sanz, J.I., Thomas, R.J., Vera, R.R., 1994. Carbon storage by introduced deep-rooted grasses in the South American savannas. *Nature* 371, 236–238.
- Goodland, R., Anhang, J., 2009. Livestock and Climate Change. What if the key actors in climate change were pigs, chickens and cows? *Worldwatch* November/December 2009, Worldwatch Institute, Washington, DC, USA, pp. 10–19.
- Herrero, M., Thornton, P.K., Gerber, P., Reid, R.S., 2009. Livestock, livelihoods and the environment: understanding the trade-offs. *Curr. Opin. Environ. Sustain.* 1, 111–120.
- IPCC, 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, NGGIP Publications, IGES, Japan.
- Perry, B., Sones, K., 2007. Poverty reduction through animal health. *Science* 315, 333–334.
- Plattner, G.-K., Stocker, T., Midgley, P., Tignor, M. (Eds.), 2009. IPCC Expert Meeting on the Science of Alternative Metrics. Intergovernmental Panel on Climate Change, Geneva, Switzerland. European Environment Agency Annual European Community greenhouse gas inventory 1990–2007 and inventory report 2009. Submission to the UNFCCC secretariat, European Environment Agency, Brussels, Belgium.
- Searchinger, T., Heimlich, R., Houghton, R.A., Dong, F., Elobeid, A., Fabiosa, J., Tokgoz, S., Hayes, D., Yu, T.-H., 2008. Greenhouse gases through emissions from use of U.S. croplands for biofuels increases land-use change. *Science* 319, 1238.
- Shindell, D.T., Faluvegi, G., Koch, D.M., Schmidt, G.A., Unger, N., Bauer, S.E., 2009. Improved attribution of climate forcing to emissions. *Science* 326, 716–718.