Intensive versus extensive livestock systems and greenhouse gas emissions

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The purpose of this document is to explore the different ways in which one might view the contributions that livestock in intensive and extensive systems make to greenhouse gas emissions. Why do people draw different conclusions about intensive versus extensive systems? How far do these conclusions reflect differing approaches to quantifying emissions, to considering land use, and to accepting future demand for animal source foods?

Differences in how we assess the impact of intensive and extensive systems hinge on the differences in our approach to:
a. quantifying greenhouse gas emissions from livestock,
b. in assessing how much and what kind of land livestock use and what effects they have on the quality of this land
c. the dynamics of demand for meat and dairy foods and our views on demand versus needs.

With respect to **a**, emissions from livestock, these can be measured either in terms of kg CO_2 eq per kg of meat or milk available for consumption, or emissions per area of land used. The former is focused on measuring impacts in terms of how much is consumed and the latter in terms of land area allocated to livestock farming. The relative merits of using a product- versus a land-based measurement very much depends on how and whether the land use and land quality, as well as consumption issues are also considered. Emissions per kg of product are relevant if we assume that demand for animal foods is growing and will continue to grow. Emissions per kg of land are important once issues concerning land quality (and the impact of livestock on this quality) and the multifunctional aspect of land use are included in the analysis.

In discussions around land use, the land take, and land use change impacts of livestock can be seen very differently. On the one hand, all land use by livestock can be seen as potentially problematic in view of current anticipated growth in livestock production, since by using a growing area of land, all livestock are seen as contributing to land use change. However another way of viewing the impact of livestock on land is by considering what types and qualities of land they use. Are they making use of prime arable land? Or are they using land that is unsuited to arable crop production? Are the livestock managed so as to enhance the quality of the land and to maintain the carbon storage properties of the land, or are they overstocked and contributing to land degradation?

Consumption, can be considered in static terms (the situation as it is now) or take into account the dynamics of demand. Demand for meat and dairy products is generally projected to go up due to projections around population and economic growth, but theoretically could also go down.

All these factors influence the way in which intensive and extensive systems can be viewed. The paragraphs below explore the interplay between them (measurement of GHG impacts; land; consumption trajectories) for the ruminant and monogastric (pig and poultry) sectors, thereby explaining how different conclusions as to the merits of intensive versus extensive farming arise, and underlining the difficulty of reaching simple conclusions.

a. Emissions per kg or per area

In the case of ruminants and their GHG emissions, extensive systems are usually found to have a lower *per-area* footprint than intensive grain-fed systems but a higher footprint expressed in terms of *kg/product*. As regards emissions per-area, this is because there are generally fewer of them for a given area of land, so their *overall* emissions for a given land area are lower. However, because their milk or meat yields are lower, more numbers are needed to produce the same amount of edible output (three extensively reared cows, for example might produce the same amount of milk as two intensively reared cows), which translates into more methane emissions for a given quantity of milk or meat. Given the importance of methane to the overall GHG contribution of ruminants, then overall GHG emissions per kg of milk or meat are higher. This is the case even allowing for the additional emissions generated during the course of producing and transporting the feeds which the intensively reared animals consume.

Hence, most LCA studies find that organically reared cattle emit more emissions per kg of meat or milk produced than their conventional counterparts, largely because they tend to be reared more extensively.[1] [2] The FAO's *Livestock Long Shadow* report calculates that intensive livestock systems contribute 5% to global GHG emissions, while extensive systems account for 13% of the total (The figures are 4% and 10% respectively if land use change impacts are excluded). It is not entirely clear how the FAO report defines intensive and extensive farming in this instance, since elsewhere in the report it classifies livestock production into: grazing, rainfed mixed, irrigated mixed and intensive landless systems and using this classification system it estimates that grazing systems account for 8% of global meat output, mixed systems 46% and landless systems 45%[3] . However, one might broadly deduce – although not with any degree of accuracy – that the meat output in intensive and extensive systems is roughly equal, if one attributes the bulk of mixed systems to the extensive 'side' – the rationale for this being that these systems mostly make use of crop residues rather than dedicated feed inputs. In other words, it finds that intensive systems contributed less to the problem of climate change than extensive systems.

In particular, emission from pigs and poultry (the animals most commonly reared in industrial intensive livestock systems), expressed in terms of CO_2eq/kg product are usually found, in LCAs, to have lower GHG emissions This is because their feed conversion efficiency is higher (less feed is required to produce the edible output that we eat than in the case of ruminants) and because they do not produce enteric methane. However the quality of the feed is critical here. Whereas ruminants are able to consume food and agricultural byproducts that humans cannot or will not eat (spoiled crops, citrus peel, rice husks and so forth), the diets of commercially reared pigs and poultry consist largely of cereals (such as wheat, barley, maize) which humans can consume directly, as well as soymeal. While soy is not just grown for feed and the oil fraction is used too (either for human consumption or for

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[1] For a review see: See Garnett T (2007). Meat and dairy production & consumption: Exploring the livestock sector's contribution to the UK's greenhouse gas emissions and assessing what less greenhouse gas intensive systems of production and consumption might look like, working paper produced for the Food Climate Research Network, University of Surrey, UK.

[2] Williams, A.G., Audsley, E. and Sandars, D.L. (2006) *Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities.* Main Report. Defra Research Project IS0205. Bedford: Cranfield University and Defra

[3] The figure, confusingly adds up to more than 100%.

biofuels), the economics of it are such the soy meal comprises about two thirds of the soy crop's value[4] , and in many years drives its production, although the growth in soy derived biodiesel is complicating the picture here. The use of prime arable land to grow feed for livestock has implications for land use, as we discuss below.

Non commercial, small scale pig and poultry systems as practiced in many parts of the developing world have a different profile. Pigs and poultry in these systems largely consume household and agricultural scraps and can therefore be seen as highly resource efficient (although there may be food safety issues at stake here). At a larger, more commercial scale, there is certainly potential for feeding more food manufacturing, catering and household food waste to pigs but this practice has been banned since 2003 in the EU (from 2001 in the UK) following the outbreak of Foot and Mouth disease. There have been calls since then to reinstate the practice in a properly supervised way[5] but so far there has been no change.

b. Land use and quality issues

As regards land use, and in particular the area of land required for livestock rearing, intensive ruminant systems are also found to use less land than extensive systems, even when the additional land needed to produce grains and protein feeds is taken into account. This is because they are reared more intensively on pasture (fewer animals per area) and the grass they consume is supplemented with feed grains that are grown intensively on arable land elsewhere. Since arable farming is more productive in calorie terms than grasslands (that is after all the reason why we grow wheat to eat rather than its wild grassy relative), less land is needed to feed an animal with grain than with grass. The consequence is that overall less land is needed. Pigs and poultry require less land still, since their feed conversion efficiency is greater; less feed is required to produce a given quantity of meat or eggs, as, being monogastrics, there is no 'wasted' energy in the form of enteric methane.

However this very simple quantitative analysis fails to take into account the fact that not all land types are 'equal.' With growing human populations, prime agricultural land for crop production (which supplies the bulk of our energy needs) is increasingly scarce, and it is questionable whether this land should be given over to produce feed that goes to feed animals. Owing to feed conversion losses during the course of converting plant-calories into animal-calories, the nutritional benefits we gain from eating the meat, or milk or eggs that results from these feed inputs, are lower than they would have been were we to have consumed the grain directly.

In a land constrained world, one could argue that the priority is to make the best use of the different qualities of land available. Feeding animals grains that could be consumed directly and more efficiently by humans can then be seen as a sub-optimal use of the prime arable land (see discussion in 2, below, for more) that we have. Not all land, however, can support crop production and the question then arises – what should be done with this poorer quality, more marginal land? Traditionally the answer has been to graze ruminants which then provide us with meat, milk and other outputs. This represents a form of resource efficiency – the land is being used to produce food that would otherwise need to be produced elsewhere – and that 'elsewhere' could either be existing prime agricultural land, where competition with grain production for human food consumption could arise, or on land deforested for the purpose. Moreover, if well managed, grazing livestock on pasture can yield other multiple benefits. There are arguments that grazing animals can help sequester carbon – although this is time limited and study findings are mixed and difficult to predict and quantify in this

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[4] FAO, 2008. Food Outlook: Global Market Analysis. Statistical Appendix Table A24 - Selected international prices for oilcrop products and price indices. Food and Agriculture Organisation, Rome, Italy.

[5] Stuart T. (2009). *Waste: Uncovering the global food scandal*, Penguin, London

respect[6] and any carbon gains need to be balanced against the methane and nitrous oxide emissions produced. Livestock also have a role to play in maintaining ecosystem services and the biological diversity of the landscapes that they have helped shape over millennia. It is arguable of course that if, instead of being grazed, marginal lands and grasslands are turned over to forestry or biofuel production, the vegetation and land would sequester greater quantities of carbon, while the methane and nitrous oxide emissions associated with ruminant production would also be avoided. Forested areas would also offer different ecosystem goods and services. However the food now not being produced on this land will need to be produced somewhere else, with possible implications for biodiversity and ecosystem functioning elsewhere. The land *quality* issue is thus critical and the value of ruminant livestock in improving resource efficiency and helping to maintain (if not enhance) soil carbon stocks is a subject of growing interest. [7][8] A land sensitive approach might involve growing grain for human consumption on prime quality land, while confining livestock to land that cannot be used for cropping.

However, although extensively reared livestock may have a vital role to play from the resource efficiency and carbon sequestration perspectives, these benefits can only be seen as unambiguously positive in a 'steady state' scenario, where no further expansion arises in order to meet growing demand for meat and where they are not overstocked and are managed properly. But we do not have a steady state – the last few decades have seen major expansion in livestock production, and as a result this expansion has led to changes in land use that have generated CO_2 emissions in addition to the animal's greenhouse gas emissions.

Moreover, while recent years have seen a rapid rise in intensive production (particularly intensive pig and poultry production) much of the expansion in land use has occurred through the increase in extensive livestock production, with only a small proportion attributable to intensive systems. The FAO'S *Livestock's Long Shadow* report finds that most of the expansion in feed supply (ie.supply of grains) has been achieved through intensification, in the form of plant breeding, greater fertiliser inputs, and mechanisation, rather than through an increase in the area cropped. Indeed while overall arable crop output grew by 46% between 1980 and 2004, the area cultivated shrank by 5.2%. This said, the overall picture masks regional variation. For example in Latin America, the cropped area expanded by 15% between 1980 and 2003, much of it at the expense of forest. In Sub Saharan Africa and Asia, the areas cropped increased by 22% and 12% respectively.

Of the land used world wide for livestock, the FAO estimates that livestock account for 70% of all agricultural land, or 30% of the land surface area of the planet. Of this 30%, the vast majority (26%) is pasture land used for grazing, with only 4% for grain feed-cultivation (this 4% equates to around 33% of all arable land use). As noted, when looked at in terms of global meat output, the FAO finds that extensive systems only provide us with 8% of total meat output, mixed systems 46% and landless systems 45%.[9] The conclusions that some might therefore draw are that extensive systems are responsible for around two and a half times more land use change (largely deforestation) than intensive systems (1.8 bn tonnes CO_2 eq as compared with 0.7).

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[6] Gill M, Smith P and Wilkinson JM (2009). Mitigating climate change: the role of domestic livestock, *Animal*, the Animal Consortium

[7] Gill M, Smith P and Wilkinson JM (2009). Mitigating climate change: the role of domestic livestock, *Animal*, the Animal Consortium

[8] Garnett T. Livestock-related greenhouse gas emissions: impacts and options for policy makers. *Environmental Science & Policy* 2009;**12**(4)**:**491-503

[9] The figure, confusingly adds up to more than 100%.

Once again, however, this analysis is too simplistic. For example, a simple conclusion that extensive systems have driven land use change ignores the fact that the drivers of land use change are complex and arise from the interaction of multiple social and economic factors. A simple conclusion for example does not take into account the possibility that intensive systems, with their lower employment- per-output rates, and higher profitability, have undermined small scale farming, so forcing small holders to expand onto more marginal areas simply to survive. The extensive pastoral systems are seen to be responsible for the ensuing deforestation or land degradation that emerges, when the real cause may have been the arable production. The complex social and economic dynamics between intensive and extensive systems are not clear, have not been researched in sufficient depth, and merit further investigation. The FAO report indeed notes that 'grasslands are increasingly fragmented and encroached upon by cropland and urban areas'[10]

Moreover, there are signs that arable crop production may in coming years increasingly be a driver of deforestation in its own right. A 2006 study into the causes of Amazonian deforestation finds deforestation for large-scale cropland accounted for 17% of forest loss in large clearings during 2001–2004 in the Mato Grosso region of Amazonia, signaling a shift from historic uses of cattle ranching and smallholder agriculture.

c. Demand for animal products

The dynamics of future demand for animal source foods add complexity to the discussions around intensive versus extensive production. Future projections suggest that demand for these foods is set to grow, and perhaps double by 2050.[11] If we are to assume that the growth in demand is inevitable, then feeding grains to livestock in intensive systems could, arguably be seen as the more carbon 'efficient,' approach since less land is used to produce a given amount of meat or milk. From this perspective, intensively reared ruminant production is less GHG-intensive than extensively reared ruminant production, and intensive pig and poultry production is, by a long way, more efficient still. In short, intensive pig and poultry production can be seen, from this perspective, as the 'least bad option.' This analysis holds true in the case of greenhouse gas emissions, but, we emphasise, not for other forms of air and water pollution, and not in the case of water use, where intensive systems are particularly demanding. There are other issues to consider, including animal welfare.

This perspective also assumes that we will actually be able to meet demand for food and for feed on the land available. However, others are skeptical that this will be physically possible. Keyzer *et al.*, [12] for example, argue that in future years it may well not be physically possible to feed enough livestock to meet demand. This is partly because *per capita* demand is likely to be higher than FAO models suggest and partly because feed/meat ratios in developing countries will increase in the next decades, rather than fall as is commonly assumed in most projection models, notwithstanding predicted technological progress in feeding and crop yield increases. This, the authors argue, is because the by-products and crop residues that are traditionally used for animal feeds are becoming increasingly scarce and can no longer be regarded as a free input. As a result, more dedicated feed crops will be grown. In conclusion the authors suggest that compared with other factors that are generally expected to affect the future world food situation, such as the GM issue and the impact of climate change on agriculture, the significance of rising demand for meat will be greater still. They cite a study which estimates the potential losses of cereal production as a result of climate change are minor compared with the projected livestock-driven increase in demand for feed cereal.

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[10] *Livestock's Long Shadow*, FAO, 2006, Rome
[11] *Livestock's Long Shadow*, FAO, 2006, Rome
[12] Keyzer M A, Merbis M D, Pavel I F P W, van Wesenbeeck C F A. (2005). Diet shifts towards meat and the effects on cereal use: can we feed the animals in 2030? *Ecological Economics* Volume 55*,* Issue 2, Pp 187-202

However, under an alternative consumption scenario, where demand is capped through a mix of focused policies and pricing mechanisms, then different possibilities emerge. In particular, the livestock-for-resource efficiency scenario emerges as one which holds potential. In this scenario, cereal crops are grown only for human consumption and grazing animals are confined to consuming grass, supplemented with byproducts (excluding soy). Livestock may also have a role to play in some mixed farming systems because of the soil fertility and draught power benefits they bring. In such a scenario, Confined Animal Feeding Operations (CAFOs) would be notably absent since, although highly efficient when defined on their own terms (ie. emissions per kg of output), they have nothing to offer in terms of soil efficiency, carbon sequestration, or biodiversity benefits and indeed cause multiple problems as regards unsustainable water use, and air and water pollution. This 'livestock for resource efficiency' scenario could yield multiple benefits in terms of ecosystems management, biodiversity preservation and GHG reductions, but the amount of meat and dairy products that would be produced and available per capita would be much lower than the level that current forecasts suggest will be demanded by 2050.

This, ultimately, is a scenario that takes as its framing perspective a sense that we have 'ecological limits.' Within those limits, the role that livestock plays is positive and, because numbers are lower and systems are extensive, many of the environmental and social problems arising from livestock production are reduced. It is important to stress that the resource efficiency scenario only works if demand were capped – otherwise, we would see a continuation of the deforestation and degradation, as well as the growth in emissions witnessed to date.

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