Unclassified **SG/SD/RT(2010)1**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

English - Or. English

GENERAL SECRETARIAT

SG/SD/RT(2010)1
Unclassified

Round Table on Sustainable Development

LIVESTOCK AND CLIMATE POLICY: LESS MEAT OR LESS CARBON?

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24 February 2010

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ACKNOWLEDGEMENTS

Thanks to those who provided comments and suggestions on the shape and substance of the paper, especially Simon Upton, Elke Stehfest, Tara Garnett, Hsin Huang, Jane Ellis, Wilfrid Legg and Amelia Smith. The paper does not, however, necessarily reflect their views and responsibility for its contents rests with the author.

The Round Table on Sustainable Development gratefully acknowledges financial support provided by The McCall MacBain Foundation and The European Climate Foundation.

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SUMMARY

Leading figures in the international climate change community argue that reducing meat consumption would be a valuable contribution to efforts to control greenhouse gas (GHG) emissions. What could or should be done with this advice? What other measures could be taken to reduce the impact of livestock agriculture on the environment, and what might they imply for policy makers, producers and consumers?

The case for addressing GHG emissions from livestock production is strong. Estimates suggest that livestock agriculture contributes between 8% and 18% of global GHG emissions. To stabilise atmospheric concentrations at 450 ppm CO2eq and limit global mean temperature change to near 2°C over the long-term, worldwide total emissions must decrease by at least 40% by 2050 compared to 2000 levels. All sectors of the economy need to be included to minimise the cost of reaching this target.

To demonstrate the implications of the global carbon constraint, if emissions from livestock agriculture were allowed to grow at a conservative rate of 1% per annum from now to 2050, they would be responsible for 50% of the atmospheric space available for anthropogenic GHGs. The space remaining would be smaller than OECD emissions are today. To put it another way, if livestock emissions could be held at year 2000 levels, the amount of atmospheric space freed up would be as big as total global transport emissions were in 2005.

In the context of agriculture, livestock comes under particular scrutiny because it is more emissions-intensive than many other forms of food production. Impacts on land use are of particular concern. Demand for land to grow feed crops or for pasture has been a major driver of land use change and deforestation, especially in developing countries.

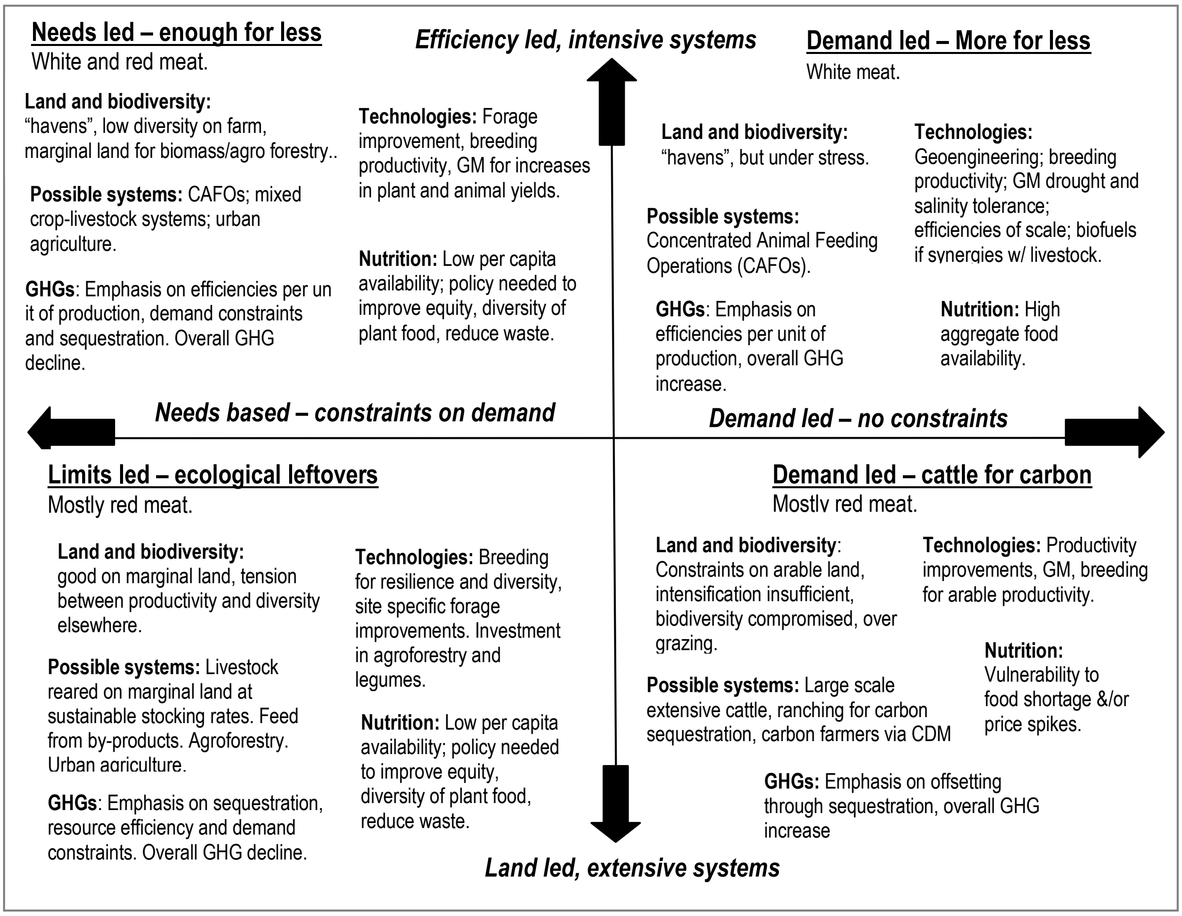
But, at the same time, livestock agriculture is indispensable for millions of people as a source of nutrition, a provider of ancillary services and a means of income. For farmers in developing countries, grassland- or rangeland-based livestock production is often one of the few viable agricultural options. Furthermore, food production needs to increase significantly in a world where the population is expected to rise to 9 billion by 2050.

For policymakers the key question is how to reduce livestock agriculture's greenhouse gas footprint while safeguarding the essential features of the sector and the services it provides? The answer to this question will vary geographically and depending on a range of policy objectives such as biodiversity and food security. Achieving the 'right' policy settings will depend on interactions between production systems and consumer demand. The diagram below provides a framework for thinking about these interactions between policy objectives, livestock systems, and food demand.

At one extreme, a demand led future for livestock production implies increased intensification of production with a focus on productive efficiency (top right quadrant in the diagram). GHG policy would need to focus on reducing emissions intensity of production but overall GHG emissions would increase. Ecosystems and biodiversity would be under increased stress. At the other extreme, policy could adopt a needs-based perspective on food systems and seek to constrain growth in demand for animal products. Rigorous supply-side constraints would limit livestock production to extensive systems on marginal land

where opportunity costs of alternative uses are very low. This ecological "limits-led" approach would dramatically reduce stress on ecosystems and reduce overall GHG emissions from the livestock sector.

Futures for livestock systems, consumer demand and GHG emissions
Adapted from T Garnett, unpublished, University of Surrey



In the industrialised world, which is the focus of this paper, dietary choices could have a substantial effect on GHG emissions. This implies demand-side policies to nudge consumers towards lower-emission food choices – *e.g.* choosing to eat less meat or choosing meat with a lower carbon footprint. Labels that show the carbon footprint of food products is one option being explored by retailers and governments in this regard.

A combination of carbon prices and consumer information could be the best bet for altering consumer behaviour. On their own, labels or other informational aids are unlikely to have a significant effect. Introducing a carbon pricing system in agriculture, which can feed into food prices, would help to underscore the messages informational policies communicate. Prices also help to recalibrate consumption of a wide variety of products – food and many others – based on their carbon content.

Labelling schemes would be tricky to implement. Substantial variation in carbon footprint can occur even between two ostensibly identical products due to variations in climatic conditions, animal genetics, soil types and farm management practices. Detailed information is needed to resolve this issue. The more accurate a footprint label, the more effective it can be in nudging consumers towards lower-emission food – but the more costly the system will become.

Other issues that will need to be addressed include the basis of comparison between products. Should a label be based on emissions per kilogram of product, per calorie or perhaps per standardised unit of nutritional value? Policy also needs to take account of the particularities of production and distribution systems in exporting countries and avoid situations where policy gives undue preference to domestic producers.

The biggest benefit from pricing emissions is likely to come from incentives for farmers in industrialised countries to reduce emissions and to take account of them when making land use decisions.

A key policy and technical challenge for moving forward is robust measurement of emissions along the supply chain. Labelling and pricing regimes are closely related in this regard. Trade-offs will need to be made, for example, between designing systems for monitoring and verifying farm emissions, which would create the most effective incentives, and the high transaction costs this could impose relative to regulating emissions in other sectors of the economy.

Monitoring emissions does not need to be based on detailed farm level measurement of attributes such as soil carbon, however. It could be based on monitoring farms, many of which are already regulated or subject to incentives in OECD countries. In this regard, much more research is needed to define standards and practices that are representative and reasonably accurate for a range of production systems, geographical locations and climatic conditions. This is a key challenge to tackle before agriculture can be fully included in an international climate change agreement.

Policies directed at farmers need to be seen as a package along with policies directed at consumers. Labelling is unlikely to deliver material responses from consumers unless complemented by price signals. Price signals will have little effect on farming practices if emissions are not being measured at the source. The market for measurement and mitigation technologies will be stunted if there is no emissions cost to farmers who do not make use of them.

A mix of policies might include:

- Farm-level measures
  - Incentives for adopting low-emission practices or meeting low-emission standards.
  - Charges for emissions and payments for sequestration, including for a range of alternative land uses.
  - Incentives and information to assist farmers in adaptation to climate change.
- Demand side measures
  - Emissions pricing, levied through upstream taxes or cap and trade schemes with point of obligation at wholesale.
  - Providing consumers with information about the emissions footprint of various foods.
- Research, technology and measurement
  - Providing facilities or support to improve options for measuring and monitoring emissions on farms.
  - Research, information and training for on-farm mitigation and soil carbon sequestration.
  - Research to develop animal diet/management practices to reduce methane/nitrous oxide emissions.

– Genetics to improve feed and nutrient conversion, and feed and forage digestion.

International coordination of these policies is important. Development of consumer information or labelling schemes, when coupled with emissions measurement problems, could easily lead to international disputes or undue adverse consequences for exporting nations. And without international coordination countries will be reluctant to install emissions pricing regimes.

Finding ways to increase greenhouse gas mitigation in the developing world will be crucial. Around 70% of the global mitigation potential in agriculture and more than 90% of global mitigation potential from avoided deforestation lies outside OECD and transition economies.

In this regard, efforts need to continue towards creating efficient and effective international mechanisms to deliver financial incentives to reduce deforestation in the developing world and encourage soil carbon sequestration. These may include market-based offset schemes. Within the OECD, particular attention should be paid to the value that comprehensive cap and trade schemes, including livestock agriculture, can add in terms of demand for emissions reduction projects in the developing world.

1. INTRODUCTION

1. Leading figures in the international climate change community argue that reducing meat consumption would be a valuable contribution to efforts to reduce greenhouse gas (GHG) emissions. The Chairman of the United Nations Intergovernmental Panel on Climate Change has gone so far as to say that "in terms of immediacy of action and the feasibility of bringing about reductions in a short period of time, it clearly is the most attractive opportunity".[1] It is hard to fault such straightforward logic – just as it is difficult to dispute that reducing fossil fuel consumption will help control climate change – but what could or should be done with this advice? What other measures could be taken to reduce the impact of livestock production on climate change, and what would they imply for policy makers, producers and consumers?

2. The case for addressing GHG emissions from livestock production is strong. Estimates suggest that livestock agriculture contributes between 8% and 18% of global GHG emissions – there is considerable uncertainty about the precise figure, but the order of magnitude is unambiguously large. To stabilise atmospheric concentrations at 450 ppm CO_2eq and limit global mean temperature change to near 2°C over the long term, worldwide total emissions must decrease by at least 40% by 2050 compared to 2000 levels. It may be unwise, therefore, to exclude a source as significant as livestock agriculture from mitigation efforts.

3. Livestock comes under scrutiny because it is more emissions-intensive than many other forms of food production (FAO, 2006). Per capita meat consumption in some parts of the world is also expected to rise as incomes and urbanization increase (FAO, 2006, Alexandratos 2009). Vegetarian diets or those low in animal products could yield similar nutritional and calorific values at a much lower cost to the climate. Section 2 summarises what is known about the role that livestock plays in agriculture and climate change and the potential benefits of dietary changes in industrialised countries.

4. Reducing food production is not a solution in a world where the population is expected to rise to 9 billion by 2050. And food systems that reflect long-standing and strongly expressed preferences cannot simply be 'optimised'. Consumption of animal products has deep cultural roots. How then can one influence consumer behaviour in favour of food with lower emissions intensity? A range of policy responses is already being explored, mainly consisting of carbon labelling and footprinting designed to assist consumers in choosing sustainable food products. Such policies face major challenges which need to be overcome if they are to be effective. Section 3 explores labelling and emissions pricing policies as a way to nudge consumers away from high-emission diets.

5. Another option for minimising the impact of livestock agriculture on climate change is reducing emissions from production. Livestock agriculture faces greater challenges than many other sectors in reducing its GHG footprint. A number of mitigation options exist, but their efficacy is often affected by local conditions and can vary considerably across very short distances. For example, in many cases farm-level measurement and verification of emissions is needed to incentivise low-carbon production.

6. Section 4 summarises various policy options for reducing emissions in the livestock sector – including ways of incentivising efficient soil and land management and minimising deforestation or other problematic land use change. The effectiveness of policy instruments to reduce emissions, the extent to which livestock agriculture can contribute to carbon sequestration and the interrelationship between domestic policies and international efforts to reduce GHG emissions related to livestock agriculture are also explored.

7. The final section provides an evaluation of what a balanced and effective strategy for reducing the impact of livestock agriculture on climate change might look like.

8. Throughout the paper the primary focus is on consumer societies in the industrialised world; those where meat consumption is high and the financial and institutional capability to address climate change greatest.

2. CLIMATE CHANGE AND DIETS: THE ROLE OF LIVESTOCK

9. The case for reducing the role of livestock agriculture in human food production can be broken down into three assertions regarding its sustainability:

- ***It is productively inefficient.*** Raising livestock consumes more physical resources than growing crops. Livestock production occupies 70% of the world's agricultural land, yet it provides only 20% of the calories in the global diet.[2] Around a third of the planet's arable land is committed to producing livestock feed; a proportion of edible calories are lost when converted in this way. This confers a sizeable opportunity cost against using land and other resources for livestock production when more food could be produced with the same resources (Table 1).

- ***It produces significant greenhouse gas emissions.*** Of the estimated 47 Gt of GHG emitted in 2005, 10-12% came directly from agriculture (Smith et al., 2007). Once land use change is taken into account, this figure could be as high as 30%.[3] The FAO (2006) estimates that livestock's share of total global land use change and forestry (LULUCF) and agriculture emissions "is over 50 percent" and that in "the agriculture sector alone, livestock constitute nearly 80 percent of all emissions". Goodland and Anhang (2009) make the even more startling claim that livestock accounts for 51% of global emissions from all sectors. On a volumetric basis, food production from plants has a considerably lower carbon footprint.

  The emissions impact of a red-meat diet compared with a vegetarian diet has been assessed as equivalent to choosing to drive an SUV over a sedan (Eshel and Martin, 2006). In terms of global impacts, one recent study suggests that if vegetable proteins were substituted for meat, emissions from agriculture would decline by nearly half. Such a dietary change would reduce the overall cost of mitigating climate change (Stehfest, 2009).

- ***It is an unnecessary source of nutrition in some parts of the world.*** A vegetarian diet can deliver optimal nutrition while avoiding some of the negative health effects associated with meat consumption (Garnett, 2009) and can do so at a much lower cost to the environment (Carlsson-Kanyama, 1998; Davis and Sonesson, 2008; Pimentel and Pimentel, 2003). Livestock production and consumption in high-income countries arouses public health concerns (Walker et al., 2005). Studies show a link between meat consumption and reduced longevity (Singh et al., 2003; Sinha et al., 2009); in particular, high levels of meat consumption and saturated fats are associated with chronic illnesses such as cancer and cardiovascular disease.

10. The implications of rising livestock emissions in a scenario that seeks to impose an overall carbon constraint are sobering. If emissions from livestock agriculture grew at a conservative rate of 1% per annum from now to 2050 they would account for 50% of global emissions (Figure 1.1), on the assumption that adjustments would be confined to all other sectors. This is of course not realistic, and livestock would need to adjust to increases in price of fossil fuel-based inputs anyway, but it does reinforce the need to tackle emissions from all sectors in a carbon constrained world. It is widely appreciated that a failure to stabilise climate change could put millions of people at risk of hunger and starvation (Parry et al., 2009); it would be ironic if that risk were exacerbated by a failure to constrain an important element of emissions stemming from food production itself.

Table 1. Productive efficiency of livestock agriculture
(Values and ranges indicative only)[4]

	Land requirement (m^2 per kg)	**Conversion of grain** (kg feed per kg live weight)	**Emissions** (kg CO_2e per kg)
Beef	20 - 23	7 - 10	16 - 40
Pork	7.4 - 8.9	3.4 - 6	3.28
Chicken	6.4 - 7.3	2 - 4	1.5 - 7.3
Sheep	14 - 30	na	10.1 - 17.0
Milk	1.2 - 12.0	1	3.1 - 7.3
Eggs	3.5 - 67	2	5.5
Wheat flour	1.4 - 1.5	--	0.5
Rice	0.5 - 2.5	--	2.9 - 6.4
Tomatoes	0.019 - 0.122	--	0.8 - 9.0
Potatoes	0.2 - 0.3	--	0.22

11. The main emissions from livestock agriculture are nitrous oxide (N_2O) from manure and agricultural soils and methane (CH4) from enteric fermentation in ruminant animals (beef, sheep, and goats). Livestock is estimated to contribute 37% of anthropogenic methane emissions and 65% of anthropogenic nitrous oxide (FAO, 2006).

12. Indirect emissions are also significant. Demand for land to grow feed crops or for pasture has been a major driver of land use change and deforestation, especially in developing countries. Deforestation of tropical forests is of particular concern because of their substantial biodiversity and much larger carbon stocks than other forests. The pressure to deforest coming from the livestock sector will grow as world demand for meat increases (Figure 1.2).

Fig. 1.1 Greenhouse Gas Emissions (Gt CO_2 eq)[5]

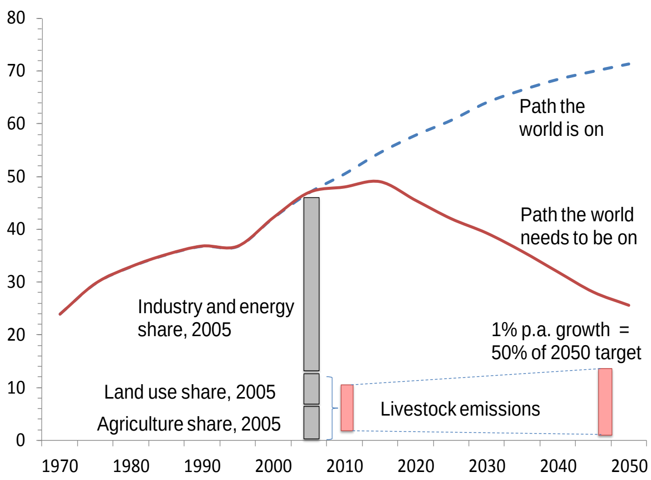
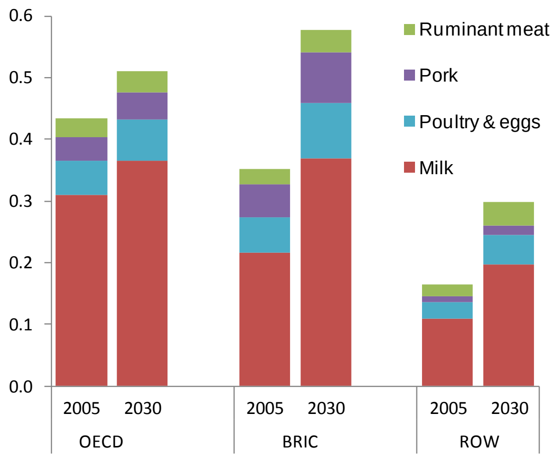


Fig 1.2 Production of Animal Products (Gt)



Source: OECD (2008), FAO (2006)

13. Intensification of production on existing land should reduce growth in land area used for livestock agriculture. Indeed, intensification will be necessary to meet growing food demand because most land suitable for agriculture is already in use (World Bank, 2009a). The OECD (2008) expects land use in

all of agriculture to expand by only 10% from 2005 to 2030 compared to a 46% expansion in meat production and a 48% increase in food crop production over the period. Further, emissions from land use change are expected to decrease even in the absence of any policy to halt deforestation. However, decelerated deforestation still represents a potentially large source of CO_2 emissions. Estimates suggest that halting deforestation could reduce GHG emissions by 1.5-3.0 Gt per year, which is substantial relative to global CO_2 emissions approaching 50 Gt per year (OECD, 2009). Moreover, there is an opportunity cost in some existing agricultural land in terms of the potential carbon sink that would result if it was returned to forest or other natural vegetation. While livestock agriculture is not the sole contributor to deforestation, it is an important factor.

14. Figure 2 summarises an integrated model assessment of the reduction in GHG emissions and reduced cost of climate change mitigation that would occur if humans followed a hypothetical "healthy diet" which restricted consumption of animal products. This "healthy diet" was based on recommendations from the Harvard Medical School (Willett, 2001). A comparison between the restricted meat diet and current average consumption patterns is shown in Table 2. The transition to this hypothetical diet is assumed to take place between 2010 and 2030, and where meat consumption declines it is replaced by protein from plant sources.[6]

Table 2. Meat consumption and "healthy diet" example [7]
(average grams per capita per day)

	OECD	Least Developed	World	"Healthy diet" scenario
Beef and sheep	72.9	15.3	31.0	17.1
Pork	88.0	3.8	41.6	15.5
Poultry and eggs	124.1	9.6	57.0	69.3

Source: Stehfest et al. (2009). FAOSTAT Food Balance Sheets.

15. Figures 2.1 and 2.2 show the impacts of this hypothetical dietary change on GHG emissions and emissions from land use in the absence of climate policies.

Figure 2. Climate benefits of changing the global diet
(Partial reproduction from Stehfest et al. 2009)

Fig 2.1 All GHG emissions
(Gt C per year)

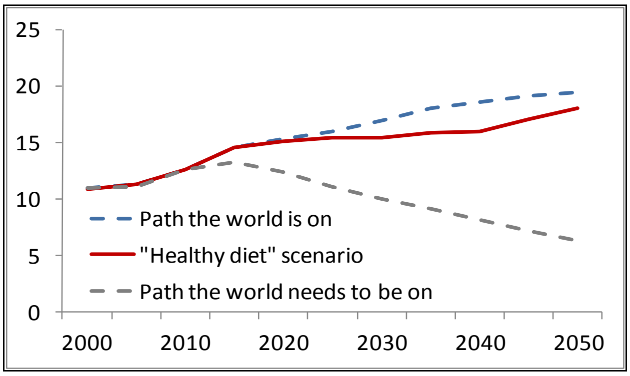
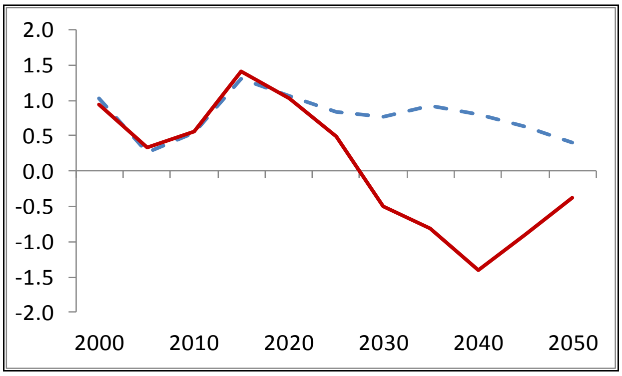


Fig 2.2 Land use CO_2 emissions
(Gt C per year)



16. Figures 2.3 and 2.4 then compare how the dietary change affects the cost of getting from the current emissions path to that required to stabilise climate change at reasonable levels (450ppm concentration of atmospheric CO_2, roughly consistent with 2° C increase in global average temperatures).

Fig 2.3 Carbon price under a climate stabilisation pathway
(1995 US$ per tonne)

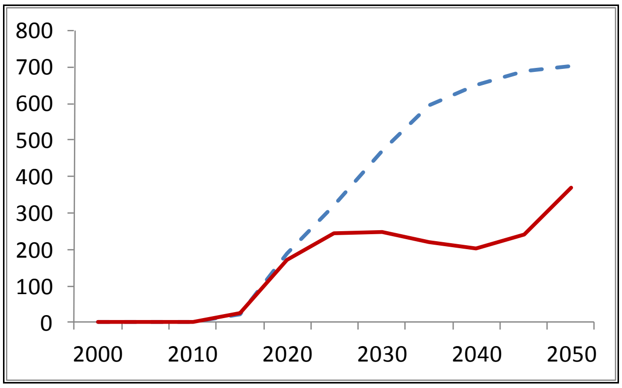
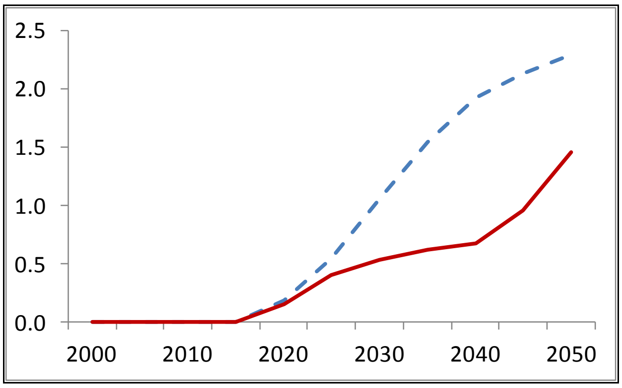


Fig 2.4 Mitigation costs under a climate stabilisation pathway
(1995 US$ trillion)



17. Overall, the analysis (Stehfest et al., 2009) shows that:[8]

- Emissions reductions required to get to a climate stabilisation path would be 31% less if dietary change occurred, even before the effects of climate policies.
- The biggest reductions in emissions, around two-thirds, would come from land use changes: avoided deforestation and increased sequestration of carbon in forests and other natural land cover as demand for livestock grazing land and feed crops declined.
- The economy-wide cost of mitigation would fall by around 50%.
- Cost savings would be larger than reductions in emissions because the reduced agriculture emissions would spare other sectors from employing increasingly expensive mitigation options.

18. This clearly shows the value that dietary change could have on reducing GHG emissions. To clarify, in this hypothetical scenario meat consumption increases in many low income countries while declining substantially in the OECD. As shown in Table 2, some people in developing countries could indeed benefit from diets that are richer in animal products.

19. Animal products play an important nutritional role for a large part of the world's population. Meat and milk, for example, provide a concentrated source of nutrients. In this regard it is not so much the consumption of animal products that needs to be balanced against the climatic impacts of emissions-intensive food production, but the immoderate consumption of animal products with a large emissions footprint. Animal products are not only of particular practical and nutritional importance in developing countries (Neumann et al., 2002) but can also be important in developed countries.[9]

20. In terms of productivity, while crops can on average deliver more food for less physical inputs, livestock can play a role in creating food by grazing on fodder unfit for human consumption on land which might otherwise not be used. An example of this was provided in a study of the US state of New York, where it was found that producing animal products from pasture could lead to greater productivity from overall land area (Peters et al., 2007). The role of ruminants (cattle, sheep, and goats) is crucial in this

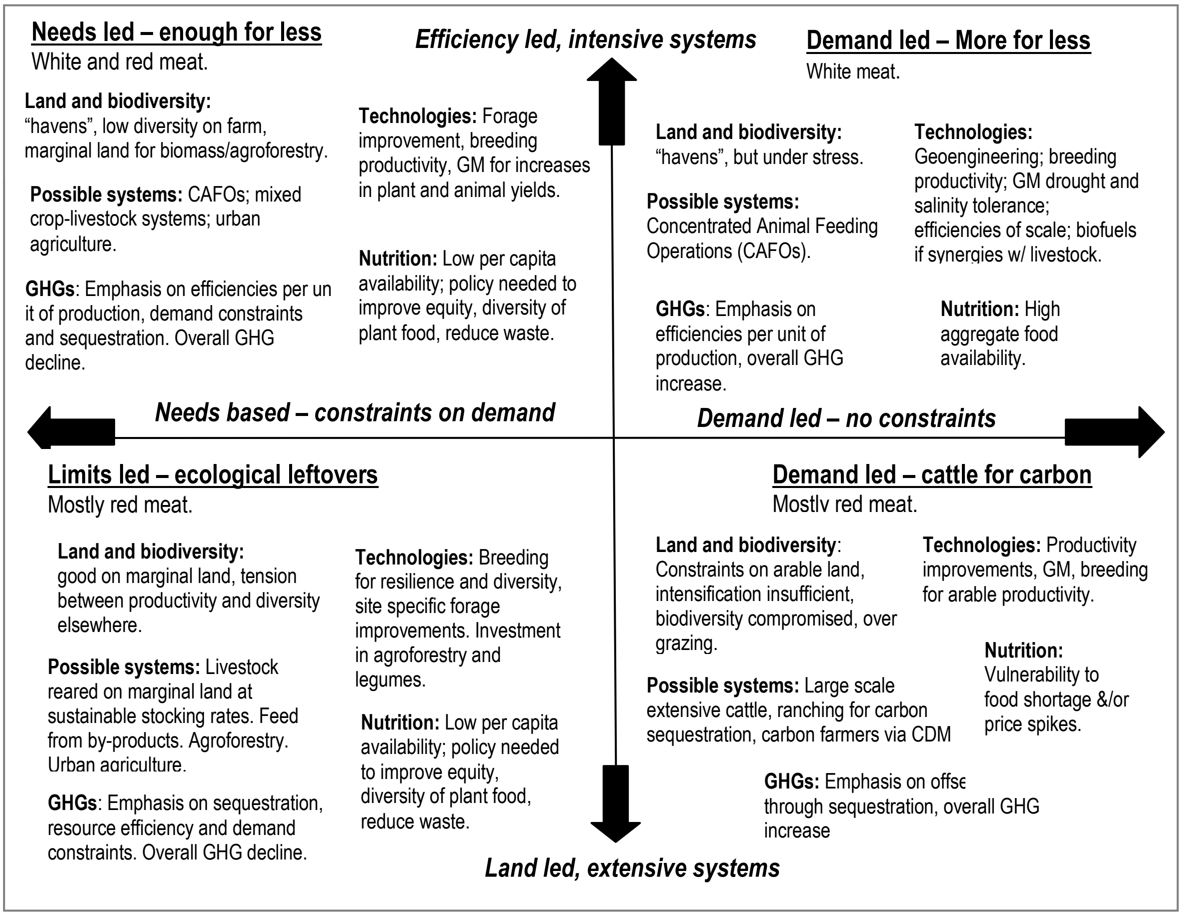
regard (Oltjen and Beckett, 1996). Moreover, for millions of farmers in developing countries grassland- or rangeland-based livestock production is one of the few viable agricultural options (FAO, 2009b).

21. In many societies livestock also delivers services beyond the conversion of forage into food.[10] In developing countries, livestock are used as a form of haulage and a source of soil nutrients (manure). Livestock also acts as store of value: as an insurance policy in times of crop failure and as a means of savings in under-developed societies and subsistence economies (World Bank, 2009b). While feeding human edible grains to livestock is sometimes said to be inefficient, it can provide a buffer against food shortages. Crop production dedicated to feeding livestock during good times can, in principle, be released for human consumption in times of poor harvest.

22. There are of course a wide variety of livestock production systems serving different purposes in different parts of world. One might ask whether some systems are more desirable than others. If productive efficiency and minimising farm emissions are the only issues at stake then intensively reared pork and poultry have an advantage over extensive systems and beef and sheep production. But, livestock production systems need to be considered alongside a range of policy concerns such as biodiversity and food security. It is also important to consider how policies can interact with supply and demand for animal products.

Figure 3. Futures for livestock systems, consumer demand and GHG emissions

Adapted from T Garnett, unpublished, University of Surrey



23. Figure 3 provides a framework for thinking about how different approaches to livestock production could play out in the future given a mixture of policy objectives and policy approaches. Each

quadrant contains a stylised scenario for a livestock production system, its consequent impacts on nutrition or food security, effects on land use and biodiversity, technological requirements, and associated GHG emissions. In practice, livestock agriculture will be a mixture of these, but the schematic illustrates many of the trade-offs at stake.

24. For example, intensive production systems focussed on meeting growing demand would maximise food availability, at least in the medium term (top right quadrant). Production which concentrated on pork and poultry products would reduce the livestock sector's emissions intensity but overall emissions would grow. Extensive agricultural systems could sequester carbon, but unconstrained demand growth could cause price spikes and undermine food availability (bottom right quadrant). The bottom-left quadrant is the scenario most sensitive to ecological limits; however, achieving this kind of outcome requires successful implementation of policies to constrain demand for livestock products, limit intensive production and ensure adequate food availability. This implies sweeping and complex changes in the context of existing supply systems, market conditions, and policy settings.

25. Intensive livestock systems tend to be more productive in physical terms and have a smaller GHG footprint per unit of product than extensive systems – substantially smaller if concentrated on pork and poultry production. The productivity of these systems depends on feed grains produced by limited high-quality arable land. "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" (Garnett, 2010). Extensive systems, on the other hand, can make use of lower quality or marginal land. "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" (Garnett, 2010). Thus, policies driven by a "land led" focus on sustainable use of limited land might tend to favour extensive systems.

26. In what follows, the emphasis is on considering opportunities and issues that need to be taken up in any effort to reduce the impact of livestock agriculture on climate change – something which has sadly been underdone relative to efforts to measure the size of the problem and to prescribe action in other high-emission activities.

3. DIETARY CHANGES: A ROLE FOR POLICY?

27. If dietary change in industrialised countries can deliver a reduction in GHG emissions, can government policies effectively and efficiently nudge consumers towards low-emission foods?

28. Consumer preferences have developed in ways that, for the most part, do not reflect the environmental and climatic impact of their food choices. This is partly because information on the environmental impact of food choices has not been available and the full economic costs of these impacts have not been faced by producers and thus not factored into prices. Introducing this information may steer consumers away from animal products and towards more sustainable food choices.

29. Giving consumers more information on the environmental impact of their consumption choices is amongst the policy options being explored by retailers and governments. One instrument under consideration is carbon footprint labelling. This would provide information on the emissions associated with a product's life cycle so that two products could easily be compared for their impact on global warming.

30. For evidence on the effectiveness of consumer information campaigns and labelling one can look to two other types of schemes: nutritional campaigns and nutrient and energy efficiency labelling schemes.

31. There is limited ex post research on the effectiveness of these kinds of schemes and very little evidence that nutritional labelling improves overall diet quality (Cowburn and Stockley, 2005). Most of the analysis conducted focuses on whether consumers recognise or read labelling information and whether they understand labelling information as opposed to whether they respond to it.

32. Studies do show that people are willing to pay a premium for labelled products, which suggests that they value and may respond to labelling information (Bolwig and Gibbon, 2009). Still, the empirical evidence on the use of nutritional information and the effectiveness of labelling and information in achieving social objectives is inconclusive (Grunert and Wills, 2007).

33. A number of studies provide strong evidence that buying behaviour is affected by nutrient information.[11] Bollinger et al (2010), in probably the most robust study of its kind, show that the mandatory calorie information policy in New York reduced calories purchased at Starbucks by 6% per transaction.[12]

34. However, most studies consider the impacts of labelling on single products or single store purchases with limited evidence as to overall changes to diet quality or health outcomes. This makes it difficult to assess the overall effectiveness of labelling as a policy instrument.

35. Furthermore, the quantitative effects of these interventions are not large in the context of reversing the problems that labelling or information campaigns were designed to address. Variyam and Cawley (2006), who consider country-wide evidence of the impact of the US National Labeling and Education Act (1990), find that mandatory nutrient labelling had a large (net) health benefit for a subset of the US population.[13] However, they also note that the effect of labelling was to reduce the rate of growth in obesity rather than obesity itself. In other words, while it was useful and beneficial, the information was insufficient to counteract the underlying causes of obesity.

36. Others studies suggest that behaviour is not substantially affected by nutritional information or labelling (*e.g.* Steenhuis et al., 2004; Cancer Institute, 2009) or, more importantly, that nutritional labelling may change behaviour without leading to increased overall consumption of healthy foods – *i.e.* a "rebound effect" where consumers increase consumption of healthier products in a particular food type but at the expense of choosing less of other healthier types of food (Teisl et al., 2001).[14]

37. One of the reasons put forward as to why nutrient labelling and healthy eating campaigns might have a limited effect in shifting dietary habits is that healthy diets are typically more expensive (Kirkpatrick and Tarasuk, 2003, Maillot et al., 2007). One study of French diets suggested a 10% increase in diet quality was associated with a 13% increase in diet cost (Drewnowski, A, and N. Darmon, 2005). This correlation has the greatest consequences for low income populations, where the tendency is to seek more "bang for the buck" by way of energy (*i.e.* calorie) dense foods which turn out to be high in sugar and comprised of a high proportion of processed animal products.

38. However, Gossard and York (2003), when examining empirically the influences on meat consumption in the United States, note that the view that meat consumption is associated with affluence is too simplistic:[15]

> "*Those who argue that meat consumption should be reduced because it is burdensome to the environment must recognize the social context in which this basic practice takes place, as meanings, customs, and traditions may shape or constrain consumer patterns.*"

39. It is easy to assume that the link between low incomes and poor diets is a function of education levels and knowledge – which also correlate with incomes. However, food consumption is more about attitudes informed by beliefs than knowledge (Shepherd and Towler, 1992). People may *know* about the nutrient value of food, but that knowledge may not result in action. As one study of meat consumption in the US observed: "nutrition education efforts should focus on bringing consumers' food choices in line with their nutrition knowledge" (Guenther et al., 2005).

40. Evidence that eco-labels are an effective policy tool is also somewhat equivocal. The market penetration of voluntary eco-labelling schemes has been cited as proof of their success. The logic is that retailers would not adopt such schemes if there were not a commercial benefit in doing so. However, "the fear of losing market share to eco-labelled competing products rather than the drive to increase market share has often motivated producers to obtain an eco-label for their products" (OECD, 1997), and 'while "there are specific instances – companies or product categories – where eco-labelling is having a significant impact, at the more macro level, it is hard to make such generalisations. This applies as much to potential environmental benefits as to economic ones."' (OECD, 2004).

41. Some empirical examples of specific eco-labels positively affecting brand choice do exist (Bjørner et al., 2004; Tiesl et al 2008; Balasubramanian and Cole 2002; Teisl et al. 2002; Marette et al. 2008; Shimshack et al. 2007). In one example, "dolphin-safe tuna" labelling increased both the market share of the labelled product and the product's share of household expenditure (Tiesl et al., 2002). This suggests that labelling could nudge consumers towards choosing lower footprint products for a given type of food (*e.g.* cheese) rather than a shift towards choosing low-emission foods in general. The size of any such effect is an open question.

42. Studies have shown energy efficiency information campaigns and labelling may be very cost effective in reducing energy consumption and greenhouse GHG emissions (Gillingham et al., 2004). However, energy efficiency information is less relevant in this context because it relates to consumer durables – *i.e.* energy-efficient appliances that can yield a monetary benefit due to lower energy consumption.

43. Much of the effectiveness of labelling or other information devices will depend on the intrinsic motivation of consumers – the extent of their gratification in knowing they are purchasing a low(er)-emission product. Without intrinsic motivation, active participation by consumers, feedback of some kind or commitment mechanisms, labelling is unlikely to be an effective tool of behavioural change (Dweyer et al., 1993).

44. "Consumers, in theory, can exercise sustainable choice. This can be stimulated via informative instruments and campaigns. However, consumers are, for a large part, 'locked-in' in infrastructures, social norms, and habits that severely limit consumer choice, in practice. Consumer behaviour change is only likely if three components are addressed simultaneously: motivation/intent, ability and opportunity. The alternative opportunity should at least be as attractive as the existing way of doing things – not only in terms of functionality, but also in terms of immaterial features such as symbolic meaning, identity creation, and expression of dreams, hopes and expectations. Relying on e.g. informative instruments only, is utterly insufficient." (Tucker et al, 2008)

45. Even if labelling has a limited impact on consumer choices, the existence of schemes such as eco-labelling have positive effects in terms of increasing the viability of a market for more sustainable products and research to create them (OECD, 2004). They can increase general awareness of the need to reduce GHG emissions and the carbon footprint associated with consumption beyond the products in question. And of course carbon footprint information is necessary for consumers who are already intrinsically motivated to choose low-emission products. Indeed, there is evidence to suggest that

consumers will assume higher priced products have better environmental credentials than lower priced ones (Brécard et al., 2009). Labelling could therefore be an important complement to price-based policy instruments (discussed further below).

46. In summary, labelling or information campaigns may well be a useful part of a package of policy measures to reduce consumption of animal products, improve diets and reduce the effects of climate change from livestock agriculture, but they are unlikely to have substantial material impact on their own.

47. However, labelling campaigns could also impose unintended and perverse costs. To avoid this, certain prerequisites need to be achieved and pitfalls avoided.

48. The most important prerequisite is accurate information on the GHG emissions themselves. This is a costly and complicated exercise, particularly where livestock products are concerned. More research is required before the carbon footprint of livestock products can be accurately calculated. “At the present stage of knowledge, ranking of food of animal origin on the basis of CO_2eq-footprints may lead to preliminary and possibly wrong conclusions” (Flachowsky and Hachenberg, 2009).[16]

49. Options for footprinting livestock products range from detailed, bottom-up, product-specific assessment to default values derived from typical product footprints or production standards which indicate whether a producer has met an emissions intensity standard. Based on the evidence of nutritional labelling in affecting consumer choice, footprint labelling will likely be more effective if it encourages consumers to consume “less carbon” rather than “less meat”. Ideally, this would mean using detailed bottom-up information on product-specific emissions. Such information would enable consumers to choose the lowest-emission products according to food type and would encourage firms and farmers to reduce their footprints.

50. Footprinting based on top-down analysis using typical (average or default) information would not be adequately sensitive to major variations in the principle source of many livestock emissions – those behind the farm gate (Roy et al., 2009). It would miss substantial opportunities to reduce the carbon footprint of food consumption associated with animal products. Furthermore, footprinting, like all single-criteria based indicators, would fail to account for other important criteria related to environmental sustainability such as prevention of build-up of chemical nutrients in waterways. It also does not account for the otherwise extremely low opportunity cost of grazing livestock on grassland and rangeland unsuitable for food crop production.

51. Life cycle assessment of food products shows substantial variation. In the dairy industry, for example, there is a 75% difference between the lowest and highest emissions intensity in milk production across countries (Sevenster and de Jong, 2008). This suggests that footprints should be differentiated by geographical origin.

52. Indeed, the variation of climatic conditions, animal genetics, soil types and farm management practices within a particular country can result in variations that are larger than international standards (see Basset-Mens et al., 2009a). Ideally these variations should be taken into account if labelling is to be effective in encouraging producers to reduce their carbon footprint. This would be costly, however, given the atomistic and heterogeneous nature of farming and the extent to which products from different farms are rapidly combined within the food supply chain. The depth of detail that is feasible in footprinting schemes is a key issue to be resolved. The more detailed the information the more effective it can be in reducing GHG emissions – but the more costly the system will become.

53. Detailed information is important not just for comparing livestock production systems but also animal products and other types of food where so-called “hot spots” in the production chain can make a

difference. Factors such as whether vegetables are produced in hot houses, frozen, air freighted or grown on deforested land can all result in plant-based food with a carbon footprint comparable to some animal products (Garnett, 2009, Davis et al., forthcoming).

54. The "functional unit" or basis of comparison between products on a carbon label can also make a significant difference in its interpretation. On the basis of emissions per unit of protein, a hothouse tomato may have a much larger footprint than an equivalent amount of pork. However, on the basis of a vitamin such as beta carotene, the tomato will appear less emissions-intensive (Table 3). The appropriate "functional unit" remains a key issue to be resolved in food labelling. This matters less if the objective of labelling is simply to promote "low carbon" consumption rather than "eating less meat".

55. Whatever the specifics, it will be important for any labelling scheme to be based on consistent international application and ideally a comprehensive and harmonised database of life cycle emissions information. "There is also need for common guidelines for communicating product carbon footprint information to increase its credibility, consumer and stakeholder acceptance, and, ultimately, contribution to combating climate change" (Bolwig and Gibbon, 2009).

Table 3. Emissions per unit of nutrient: an example
(Carlsson-Kanyama, 1998)

	Energy (MJ per kg)	Protein (g per kg)	β-carotene (µg per kg)	CO_2e per energy (g per MJ)	CO_2e per protein (g per g)	CO_2e per β-carotene (g per µg)
Tomatoes	0.83	9	5,730	4,000	370	1
Carrots	1.67	6	68,000	300	83	0
Potatoes	3.1	18	100	56	10	2
Rice	14.9	68	0	430	94	--
Pork	7.2	180	0	850	34	--
Dry peas	12.4	215	150	55	3	5

56. Footprinting schemes should take account of the particularities of production and distribution systems in exporting countries (Edwards-Jones et al., 2009). Possible adverse and unwarranted impacts of product labelling requirements on producers from developing countries are a particular cause for concern. These could arise, for example, from a tendency for bias in footprinting towards local information and production practices – *e.g.* exclusion of capital equipment from footprint analysis creating a bias against labour-intensive production systems. Or, worse, the close involvement of local producers could lead to 'industry capture' of the process with bias towards accounting for information which favours domestic producers and thus an increase in barriers to trade (Vitalis, 2002).

57. As noted earlier, labelling is likely to be effective only if it forms part of a package of measures to encourage behaviour change. One option consistently recommended by economists is price-based measures – carbon taxes or trading schemes – which would alter the cost of high-emission products relative to others. A combination of carbon prices and labelling could be the best bet for altering consumer behaviour.

58. Prices are especially useful in overcoming some of the "functional unit" problems associated with labelling or information campaigns. This is true not just for food choices but in other instances where consumers choose between products with no obvious physical basis for comparison. For example, the cotton fibre in a t-shirt manufactured in India is estimated to have a carbon footprint of 1.8kg of CO_2 per t-shirt (Steinberger et al., 2009). By weight – *i.e.* kg of CO_2e per kg of product – this footprint is around half that of a kilogram of beef at the farm gate in the United Kingdom and more than the footprint for pork

or poultry (Williams et al., 2006). While physical comparisons are fairly meaningless[17], an increase in price in both products would, through income effects, yield an implicit trade off between the purchase of a t-shirt purchase and that of a steak. This kind of recalibration of consumption across a wide variety of products based on their carbon content is the major benefit of a pricing regime. Comprehensive carbon pricing for all products, including food, could be important for helping to reduce rebound effects and targeting emissions hot spots in a way that labelling information cannot.[18]

59. The prospect of low income households facing rising food prices is likely to cause concern. Here again, the concept of a package of policy measures is key. With any carbon pricing regime it is important to assess and offset regressive price measures through changes to income tax and transfer systems. The trick is not to avoid sending the price signals on the grounds that food prices will rise (indeed, the imposition of labelling and information costs will push them up). Rather, it is to offset any undesirable social effects with as few distortions to the pricing system as possible.

60. Introducing a carbon pricing system for agriculture, which can feed into food prices, will be more complicated than it is for energy or industrial processes. This is further discussed in the next section, where policies for shifting producers towards more sustainable production are explored.

4. REDUCING EMISSIONS FROM LIVESTOCK PRODUCTION

61. A considerable number of the actions that could be taken to reduce the GHG impact of livestock consumption lie beyond the control of the consumer and in the hands of producers. In terms of magnitude, lowering the emissions intensity of livestock agriculture or reducing deforestation from the expansion of livestock agriculture could have effects equal to or in excess of feasible policy-induced dietary change.[19]

62. The global technical mitigation potential of agriculture (excluding fossil fuel offsets from biomass) by 2030 has been estimated to be roughly 9% of global emissions. Reduced deforestation could increase that figure to 14%.

63. The economic potential for mitigation, however, is lower. For example, if a price of USD 50 per tonne of CO_2 were levied on GHG emissions (*e.g*. through a tax or tradable permit scheme), the potential for reduced emissions from agriculture remains significant but falls to roughly 4% (Smith et al., 2007).

64. Soil carbon sequestration (enhanced sinks) represents most of the mitigation potential, with an estimated 89% contribution. Mitigation of CH_4 and N_2O emissions from soil accounts for 9% and 2%, respectively. Of course, strategies to mitigate GHG emissions in agriculture change across the range of prices for carbon. At low prices, dominant strategies are those consistent with existing production such as changes in tillage, fertiliser application, livestock diet formulation and manure management (OECD, forthcoming). Table 4 summarises some of the available options for mitigating GHG emissions in agriculture. At a more detailed level an extensive list of technically possible options for mitigating emissions in agriculture and land use exists (OECD, forthcoming).

65. Though it is difficult to accurately estimate the contribution of livestock agriculture to this mitigation potential, it is likely to be at least one-third and potentially much more (excluding avoided deforestation).[20]

66. However, choosing policies for mobilising mitigation is complicated by substantial variation in emissions from farm to farm and the large number of producers in most countries, as compared to sources of industrial emissions. This makes measuring and verifying emissions and mitigation complicated and costly.

Table 4. Sources of greenhouse gas emission/mitigation potential in agriculture

Measure	Examples
Cropland management	Agronomy; nutrient management; tillage/residue management; water management (irrigation, drainage); rice management; agro-forestry; set-aside, and use change
Grazing land management/pasture improvement	Grazing intensity; increased productivity (e.g., fertilisation); nutrient management; fire management; species introduction (including legumes)
Management of organic soils	Avoid drainage of wetlands
Restoration of degraded land	Erosion control, organic amendments, nutrient amendments
Livestock management	Improved feeding practices; specific agents and dietary additives; longer term structural and management; changes and animal breeding
Manure/biosolid management	Improved storage and handling; anaerobic digestion; more efficient use as nutrient source
Bio-energy	Energy crops, solid, liquid, biogas, residues

Source : IPCC, 2007b; OECD 2008

67. Measurement complications usually mean that command and control policies, such as setting emissions standards, can be cost-effective. But such policies may prove not to be in the presence of widely varying best practices and abatement costs (OECD, 2009). In agriculture "a practice effective in reducing emissions at one site may be less effective or even counterproductive elsewhere. Consequently, there is no universally applicable list of mitigation practices; practices need to be evaluated for individual agricultural systems based on climate, edaphic [plant and soil conditions], social setting, and historical patterns of land use and management". (Smith et al., 2007).

68. The usual economist's response, certainly where best practice is hard to identify, is to recommend introducing a tax or tradable permit scheme to put a price on emissions and let producers sort out for themselves where reductions are best made. This can be the most cost-effective way of reducing emissions, including in the agricultural sector (OECD, 2009; Neufeldt and Schäfer, 2008).

69. Putting a price on emissions is clearly the best approach in terms of creating incentive to reduce them, but the benefits of this need to be weighed against the potentially high cost of monitoring and verifying emissions on farms (MAF, 2009).

70. Where monitoring and verifying emissions is too costly, they can be measured and taxed (or permitted) at the processing stage on the basis of production volumes or on upstream production of emissions intensive inputs like fertilizer.[21] This removes much of the incentive for farmers to lower their emissions, especially in the case of soil management and methane, but could at least result in some of the environmental cost of emissions being reflected in product prices and a shift in profitability away from more emissions-intensive forms of farming.[22] In this respect it is a step in the right direction, if only an interim measure.

71. For livestock emissions to be taxed on the basis of outputs or inputs, a decision must also be taken as to the representative value of emissions embodied in a unit of output. In order to avoid perverse incentives, the best approach would be to evaluate emissions based on low-end estimates of a standardised product's carbon footprint by weight. While this would under-price the externality associated with livestock emissions, for example compared with evaluation based on estimated average emissions, it would avoid the problems of over-taxing efficient production and potentially yielding a competitive advantage to emissions-intensive producers.

72. Standardised charging based on output volumes could discourage some emissions reduction strategies, such as intensification.[23] But this may not be altogether undesirable from a societal perspective. Intensification can reduce the direct emissions footprint of livestock agriculture, but may not always be the best mitigation approach in terms of overall environmental efficiency, for example because of increased build-up of chemical nutrients in ecosystems and reduced energy efficiency (Basset-Mens et al., 2009b).

73. If a tax raises domestic prices, then processors or consumers may shift their demand for livestock products to countries that do not put prices on their agricultural emissions. This would be particularly deleterious if an increase in livestock production in developing countries were to lead to deforestation.

74. Two things could be done to avoid this problem. One would be to levy carbon taxes on all wholesaled products. This would be complicated for highly-processed foods – perhaps most problematic from a public health as well as environmental standpoint, given their volumes of production and potentially high energy-related emissions.

75. The other is for an internationally-coordinated response and agreement on standards for pricing or policies and measures relating to agricultural emissions. A lack of internationally-coordinated action has already inhibited adoption of emissions pricing schemes in the agricultural sector; for example, the decision was taken not to include agriculture in the EU ETS partly because the emissions were difficult to measure.[24] Consequently, in other OECD countries, concerns over incomplete international coverage of emissions pricing and undue competitive disadvantage have been a factor in preventing the inclusion of agriculture in emissions pricing programmes. Thus, one way to smooth the path might be to create an agreed standard for pricing agricultural emissions so that measurement problems are minimised and competitiveness concerns set aside. Emissions charges based on low estimates of emission factors and volume of output could be worth considering in this regard.

76. Emissions charging on the basis of output (rather than emissions per se) could also be supplemented by other incentives such as tax rebates for producers who sign targeted good practice agreements or by accepting the costs of detailed monitoring of on-farm emissions (OECD, forthcoming). This could be useful in mobilising soil management practices that increase sequestration.

77. As already mentioned, soil carbon sequestration is theoretically one of the most promising aspects of agricultural mitigation in some settings. Case studies show instances of grassland livestock systems where the net GHG balance is zero or even negative (Byrne et al., 2007; Soussana et al., 2007). But measuring and rewarding practices which enhance soil carbon is fiendishly difficult. Natural variations in soil carbon flux can be large even across short distances, and accurate gas exchange measurement techniques are expensive (Saggar et al., 2008).

78. Given the large mitigation potential but high cost and present low market value of measuring soil carbon, increases in publicly funded research could be valuable in reducing the cost of measurement systems. Similarly, support could be increased to R&D which furthers a range of promising mitigation activities such as biochar, which can increase soil carbon long term and increase yields (Johnson et al., 2007; World Bank, 2009a), and animal breeding and genetics to control methane emissions from enteric fermentation.

79. Sound measurement and monitoring of soil carbon would be an important part of any policy seeking to reward soil carbon sequestration because soil carbon storage is reversible.

80. Monitoring emissions does not, however, need to be based on detailed farm-level measurement of attributes such as soil carbon. It could be based on monitoring farm practices including nutrient purchase, manure management or feed use. These practices are already regulated or subject to incentives,

such as cross-compliance, in many OECD countries (OECD, 2003; OECD, 2010). In some cases existing approaches could be adapted to the objective of reducing GHG emissions. A standards and practices approach would not be as accurate as detailed measurement but could be more efficient. Accuracy could be enhanced by systematic sampling of soil carbon content, for example. However, much more research is needed to define standards and practices that are representative and reasonably accurate for a range of production systems, geographical locations and climatic conditions. This is a key challenge to tackle before agriculture can be fully included in an international climate change agreement.

81. Policy needs to deliver effective signals about efficient land use through penalties and incentives related to the environmental costs involved in deforestation or opportunity costs from farming of marginal land. Incentive schemes such as carbon credits for aforestation could provide valuable income for land that is otherwise not profitable while also delivering an environmental service. Such schemes could also potentially raise returns to more productive land. As for soil carbon, the reversibility of sequestration in forests means measurement and monitoring is important.

82. Land use policies need to pay careful attention to the potential for “leakage” when the displacement of land use activities is not taken into account – *e.g.* where agricultural land is aforested in one area only to cause increased deforestation elsewhere. To overcome this problem, land use policy should include penalties for deforestation which are commensurate with incentives to aforest or reforest. It is also important to try to set regulatory or project boundaries as wide as possible.

83. In general, policies which create incentives or subsidies need to be very carefully managed and targeted. It is already the case that some countries use environmental cross-compliance requirements as a prerequisite to receiving support payments. These kinds of policies have limitations. Indeed, phasing out environmentally harmful production support and stricter implementations of already existing environmental policies would limit the need for such requirements (OECD, 2003). Incentives for reducing emissions, such as carbon credit or offset schemes, will be much more cost effective if complemented by emissions charges (Lewandrowski et al., 2004).

84. Policy makers need to be mindful of the effects that policies have on facilitating a geographical distribution of livestock production which minimises emissions. At present, geographical patterns of production are distorted by policies in the industrialised world which give preference to the agricultural sector and those in the developing world which tend to discriminate against it (Anderson et al., 2009). Ideally, these distortions would be removed to facilitate production increasing where it is most efficient or less emissions-intensive.

85. Finding ways to increase GHG mitigation in the developing world is important. Around 70% of the global mitigation potential in agriculture and more than 90% of global mitigation potential from avoided deforestation lies outside OECD and transition economies (Smith et al., 2007; Naaburs et al., 2007).

86. The international effects of policies also need to be considered carefully in the context of deforestation. Policies which restrain demand for future offset credits from developing countries will limit the effect of those schemes in raising the value of forested land and thus increase deforestation. Exempting sectors such as livestock agriculture from emissions trading schemes or limiting the purchase of international offset credits could have this effect.[25]

87. The same applies to any future carbon market instruments that incentivise soil carbon sequestration projects in agriculture in the developing world. While such projects are not currently recognised under the international Clean Development Mechanism (CDM), the potential for mitigation is large and potentially on par with that of the energy sector (World Bank, 2009a).

88. Soil carbon sequestration has not been included in the CDM because of difficulties in measurement and monitoring. These measurement issues reflect those at the domestic level but on a much larger scale and with a greater degree of difficulty. However, the FAO (2008) has suggested that viable schemes for leveraging offset finance could be constructed based on combining field measurement of soil carbon with model-based measurement approaches aggregated over a wide area. Such schemes could exist in the context of the CDM or a new sectoral approach on financing and mitigation for agriculture. The FAO suggests a comprehensive approach including the "establishment of a holistic accounting and trading regime for terrestrial carbon". They point out that getting such projects off the ground could provide significant emissions reductions and developmental benefits in developing countries. Ongoing support from the developed world for such schemes would help increase their viability and eventual uptake.

89. The agricultural land use management practices that have implications for soil carbon fall into the UNFCCC's "Land Use and Land Use Change and Forestry" (LULUCF) sector. Accounting for the contribution of agriculture to meet emissions reduction targets by sequestering carbon in soils (*i.e.* LULUCF) is voluntary in the Kyoto Protocol. In addition, there is still a lack of agreement on key definitions and categories used to compare land areas. As a result, of the 39 Annex I parties that ratified the Kyoto Protocol, only four elected to report agriculture-related activities in LULUCF.[26] As noted in *Environmental Performance of Agriculture in OECD Countries Since 1990*, there is a lack of consistent data on carbon stocks on agricultural soils, and only a few countries report soil organic carbon data to the UNFCCC.

90. This prevents full exploitation of emissions reductions through the management of soil carbon in agricultural land (OECD, 2009). While public policy plays the key role in implementing climate policy, climate change is a global issue that needs to be solved at the multilateral level, and national policies should be consistent with international commitments. Domestic efforts could provide impetus for improving international accounting, but it is preferable that domestic and international efforts be in step.

5. IS THERE AN OPTIMAL POLICY MIX?

91. To date, agriculture has often escaped the regulatory controls on emissions that have emerged for other sectors of the economy. This is a mistake, as not addressing agricultural emissions will increase the cost of overall mitigation efforts (OECD, 2009a). An optimal policy mix for reducing the climate impact of livestock agriculture needs to be identified, taking into account the feasible set of changes that could be achieved.

92. A mix of policies might include:

- Farm-level measures
  - Incentives for adopting low-emission practices or meeting low-emission standards.
  - Charges for emissions and payments for sequestration, including for a range of alternative land uses.
  - Incentives and information to assist farmers in adaptation to climate change.
- Demand-side measures
  - Emissions pricing, levied through upstream taxes or cap and trade schemes with point of obligation at wholesale.
  - Providing consumers with information about the emissions footprint of various foods.
- Research, technology and measurement

- Providing facilities or support to improve options for measuring and monitoring emissions on farms.
- Research, information and training for on-farm mitigation and soil carbon sequestration.
- Research to develop animal diet/management practices to reduce methane/nitrous oxide emissions.
- Genetics to improve feed and nutrient conversion, and feed and forage digestion.

93. These policies need to be constructed as part of a package. Information is unlikely to deliver material responses from consumers unless complemented by price signals. Price signals will have little effect on farming practices if emissions are not being measured at the source. The market for measurement and mitigation technologies will be stunted if there is no cost to farmers who do not make use of them.

94. The key policy and technical challenge for moving forward is robust measurement of emissions along the supply chain. Labelling and pricing regimes are inextricably linked in this regard.

95. At the same time, the wait for perfect information systems could be very long. Interim measures are needed which can expedite price signals and information to consumers. One option is a tax or tradable permit scheme with point of obligation beyond the farm gate.

96. International coordination of these policies is important. Development of labelling schemes coupled with emissions measurement problems could easily lead to international disputes or undue adverse consequences for exporting nations. Without international coordination, countries will be reluctant to install emissions pricing regimes.

97. Efforts need to continue to create efficient and effective international mechanisms to deliver financial incentives for reducing deforestation in the developing world and encouraging soil carbon sequestration. These may include market-based offset schemes. In the case of soil carbon sequestration it may be some time before the technical prerequisites are in place to operate such a mechanism, but the payoff for additional effort is potentially large.

98. Including agriculture in cap and trade schemes could be given particular attention for the value that such schemes can add in terms of demand for offset projects in the developing world, such as those aimed at reducing deforestation.

99. What should not be in the policy mix is perhaps as important as what is. In this regard, this paper did not canvass concerns over the need to reduce emissions in the transportation of food, popularly known as ‘food miles’. Targeting these emissions is unlikely to be of much practical value as long as emissions from transport fuels are taxed or otherwise regulated.[27]

100. Higher prices based on the carbon content of foods would enable consumers to choose based on their own preferences. This would be more efficient than policies dedicated to changing consumer behaviour. That is not to say that changes in social norms will not shift towards low meat consumption as people become aware of the environmental impact of livestock agriculture – it simply suggests that, in the context of climate policy, the more effective emphasis will be on less carbon rather than less meat.

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ENDNOTES

1 See www.guardian.co.uk/environment/2008/sep/07/food.foodanddrink.

2 See FAO (2006) and FAOSTAT food balance sheets for 2005.

3 The extent of uncertainty and 'headline' numbers in the literature is startlingly large and obfuscatory. For example, the oft-cited FAO study "Livestock's Long Shadow" estimates that livestock contributes 14% of global GHG emissions and as much 18% if land-use change is included. The 14% figure, which is for livestock alone, is 2 percentage points larger than the agricultural total estimated by Smith et al (2007) for the IPCC fourth assessment report. Scherr and Sthapit (2009) provide an estimate that land use change, both for and not for agriculture, contributed 31% of global GHG emissions. The EPA (2006) notes that agriculture contributes 32% of global GHG emissions. Such differences may arise through different base years, sectoral definitions and other reasonable parameter choices and assumptions. Nonetheless, this makes interpretation troublesome.

4 Based on estimates that use a variety of measurement techniques and information specific to particular geographical locations and farming techniques. Information sourced from Sonesson et al (2009), Gerbens-Leenes and Nonhebel (2002), Williams et al (2006), FAO (2006), Foster et al (2006).

5 Projected growth in livestock emissions based on a 1% annual growth rate. This is deemed conservative relative to those presented in Fisher et al (2007) for the Intergovernmental Panel on Climate Change, where typical projections were for a 1.5% compound annual growth rate.

6 This stylised scenario is used to explore the effects of diet on global emissions. It does not assess policies or implementation costs associated with bringing about dietary changes.

7 Based on food supply quantities for final consumption as reported in FAOSTAT Food Balance Sheets.

8 The full set of scenarios analysed in the paper include an assessment of the impact of diets with no meat but other animal products and an assessment of the impacts of a world without meat products from ruminant animals.

9 "It is widely recognized that the intake of animal foods is the most important dietary determinant of the iron status of a population" (Reddy et al 2006). See also Gompakisa et al. (2007), a study on iron deficiency in Greece; and Dunnigan et al. (2005), a study nutritional rickets in the UK. Elmadfa and Singer (2009) note that vegetarians and especially vegans need to carefully plan their diets or take supplements to avoid vitamin B12 deficiencies. O'Neil et al. (2009) show that, amongst low income mothers, higher levels of dairy product consumption were associated with "higher MAR scores and improved intakes of Ca, K and Mg, which have been identified as shortfall nutrients in the diets of adults". In essence, while optimal vegetarian food may be physically available in a society, low incomes or poor discipline can lower the nutrient quality of a vegetarian diet. It has also been argued that as a policy priority meat ranks lower as a major public health concern when compared against the effects of behaviours like smoking (Boyle et al. 2008).

10 By-products or other non-food animal products are also of value.

11 See Ippolito and Mathios (1990 and 1995), Mathios (2000), Kiesel and Villas Boas (2009), Bollinger et al. (2010), Variyam et al. (1996).

12 This estimate of change is at the high end of similar empirical estimates. However, this study, based on millions of observations, is the most robust evidence available.

13 Specifically non-Hispanic white women who use nutrient labels. Variyam and Cawley (2006) find no significant effect for all other groups.

[14] Studies that show no effect tend to be less sophisticated than those which show behavioural effects. However, more sophisticated studies also show that evidence of behavioural change is not the same as evidence of policy effectiveness. This is, however, quite separate from the value to consumers of having information which may be strongly positive, *i.e*. behaviour changes or achieving policy objectives are not the final word on whether labelling is beneficial from the consumer's perspective.

[15] See also Guenther et al., 2005 for a similar assessment of factors that influence meat consumption in the United States.

[16] See also E. M. Schau and A. M. Fet (2008) on improvements needed to facilitate inter-product footprint comparisons.

[17] The t-shirt example is somewhat stark, but one reason for targeting meat – a high-emission product which is arguably over-consumed in rich countries – might also apply to t-shirt purchases. In 2008 the UK imported 9 t-shirts per capita (net imports). Emissions reductions caused by lower t-shirt demand are of no lower atmospheric quality than emission reductions from eating less meat.

[18] See Thiesen et al. (2008) and Steinberger et al. (2009) for examples of the risks associated with rebound effects from labelling.

[19] Wallén et al. (2004) show that adoption of a "sustainable diet" in Sweden (including a 36% reduction in meat consumption) would result in a 5% reduction in GHGs.

[20] Based on a calculation where mitigation potential is attributed in the same broad manner as emissions — *i.e*. accounting for emissions from feed production. Mitigation potential specific to livestock is only a small part of overall mitigation potential, around 200 Mt or 3% of the technical potential in agriculture. However, grazing land management yields around 25% of the technical mitigation potential. Cropland management has similar mitigation potential, though only around 13% of cropland area produces feed for livestock, so here the mitigation potential related to livestock might be 3%. Manure management and set asides and agroforestry are small, adding perhaps another 2%. This leads to an estimate of 33-36% of technical mitigation potential related to agriculture.

[21] Industry and officials in New Zealand, as the first country in the world to legislate inclusion of agriculture in an emissions trading scheme, grappled for some time with this question of where to place the point of obligation: on the farm (at high cost but with increased incentives to reduce emissions) or on the processor. The decision was taken to begin by measuring emissions on the basis of output delivered to downstream processors with an intention to move to farm-level monitoring once the information systems were in place to deal with it.

[22] The precise effect will vary according to current and alternative land use, and the current distance between profitability of one land use over another. Returns to land are likely to decline and therefore so would the price of land. In general, this would make forestry or agroforestry more economic – especially if emissions regulations include incentives for aforestation – but would also discourage intensification and on-farm investment.

[23] In the US, for example, intensification reduced emissions from dairy livestock per kg of output by nearly two-thirds between 1944 and 2007 (Capper et al., 2009). Also, Allard et al. show that intensively managed paddocks contribute higher carbon sink activity, although there is a trade off between this and CH_4 and N_2O emissions. The net effect is likely to be site dependent.

[24] There is a certain irony in the fact that countries interested in labelling the carbon content of products are unable to institute full emissions pricing on the basis that they cannot measure emissions.

[25] Constructing environmentally effective and economically efficient international offset schemes is complicated; details on these are beyond the scope of this paper. For more on international financing mechanisms and deforestation see Karousakis and Corfee-Morlot (2007).

[26] "Annual compilation and accounting report for Annex B Parties under the Kyoto Protocol", FCCC/KP/CMP/2009/15.

[27] Weber and Matthews (2008) found that if US consumers cut their red meat consumption by around a fifth and ate chicken or fish instead, this would have the same effect on GHG emissions as total (unfeasible) localisation of food supplies to minimise transport emissions. This result reflects both the relative efficiency of long haul transport and the

small part that transport plays in the carbon footprint of animal products. See also Baroni et al. (2007) for an example of emissions reductions and reduced environmental impacts in the EU from a change in diet.