Impacts on livestock agriculture of competition for resources

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Introduction

All agriculture of necessity impacts on its immediate, proximate and distant environments. Growing awareness of the impacts of anthropogenic climate change has directed attention to the impacts that agriculture has on greenhouse gas emissions and to the options for mitigation and adaptation that could accrue. With the two major agricultural greenhouse gases both being intimately associated with livestock production, there has been real pressure on animal production systems to address the problems of methane and nitrous oxide emissions. Whilst understandable in the current political climate, I believe that such an approach is incomplete unless it looks at climate change impacts alongside the other impacts (both positive and negative) that livestock agriculture causes. The concept of a systems-based approach to costs and benefits forms the basis of "Sustainable Agriculture". Unfortunately this approach gives rise to two major problems. The first is the need to compare benefits and disbenefits that often have different currencies. For example, appropriate levels of grazing are essential to preserve pastoral flora and maintain landscape and biological diversity in unimproved grasslands. However, the greenhouse gas emissions "footprint" of extensive systems is significantly higher than that of more intensive systems when expressed per unit of agricultural production. How much extra methane is a rare orchid worth? How does its worth diminish as it becomes more widespread? Currently we do not have such a common currency, although some researchers are considering how this might be developed (Pretty, 2007).

The second major problem is that the weight given to various elements of sustainability will differ in both time and space. UK livestock production systems for example are not significantly constrained by water availability. By contrast, the production of many of the components of bought-in feed for UK livestock occurs in countries where water is a major limitation, yet this does not figure in most discussions of the sustainability of UK systems. The end result of this is that it is unwise in my view to consider the mitigation of the greenhouse gas footprint of livestock agriculture in isolation and much preferable to consider it as one element of improving sustainability (Pollock and Pretty, 2007). Under these circumstances, the important issues are those which may have a negative impact on sustainability, and particularly how they interact with one another. The livestock sector is particularly vulnerable to change, given that it competes substantially with direct human feeding for key resources. The purpose of this summary is to identify and discuss key elements of this competition and consider where they may impinge on mitigation or adaptation to climate change. Unfortunately most of the changes that we are likely to see over the next 50 years are going to make both mitigation and adaptation more difficult and do, in my view, present real challenges to the livestock industry.

Competition for feed

Current intensive livestock production systems, even those involving ruminants, rely substantially on bought-in feedstuffs. Maize, wheat and soybeans are major components of animal feed worldwide, together with residues such as rape meal and molassed beet. It is possible to run ruminant (and to a lesser extent poultry and pig-based) systems exclusively on pasture and foraging, but productivity is low in comparison. Mixed farming, where animal and crop-based enterprises coexist, is a half-way house and Wilkins (2007) argues strongly for the virtues of such an approach. However, in all cases grain fed to animals is grain that cannot be fed to humans. Demand for animal products is increasing worldwide, driven mainly by increasing prosperity in Asia and to a lesser extent South America, and IFPRI have estimated that an extra 300 MT of grain will be needed by 2050 just to feed to livestock. At the same time, overall human demand for arable crops is increasing, driven mainly by population growth, predicted to reach 9 billion within the 21st century. Feeding large amounts of grain to livestock is the basis of most intensive production systems. These will generate the lowest greenhouse gas footprint per unit of production, but may not be sustainable even in the short-term, as the UK pig industry is discovering. Wheat prices have more than doubled within the last 12 months, and whilst increased plantings will go some way to stabilize prices, it is difficult to see a return to a situation where bought-in feed represents a small proportion of enterprise costs. This is an excellent example of the "sustainability dilemma" The development of eco-efficient livestock systems (Wilkins, 2007) is a logical response to increased prices and reduced security of bought-in feed but will, inevitably, lead to an increase in greenhouse gas emissions per unit of production.

Competition for water

The competition for water between different strands of human activity will be one of the defining issues of the 21st century. In a detailed analysis of the impact of this on pastoral agriculture, Rosegrant *et al* (2005) suggest that global demand for non-irrigation water will increase by two-thirds by 2025 if current trends continue. Modeling this against water availability suggests that agricultural demand will increase much more slowly, limited by availability and price. This in turn will have a constraining effect upon crop production and will compound the issues discussed above in terms of increased competition for the outputs of arable agriculture. These authors argue further that any steps taken to use water more sustainably will require some element of water pricing to reflect its true cost of delivery. This could further impact on elements of livestock agriculture in that it has been calculated that 14 times as much water is needed to deliver the same amount of profit from irrigated pasture as from fruit and vegetable production. Pasture irrigation is rare in developing countries but widespread in the USA and Australia. Were this to become uneconomic because of proportionate water pricing, then it would significantly impact on the global supply of animal products.

Rainfed agriculture is seen by Rosegrant *et al* (2005) as the key to sustainable development of livestock production. Direct water consumption by livestock is small (les than 2% of total water consumption) but intensive animal production systems consume much more in total. Estimates vary between 3500 and 20500 litres of water per kg product, the vast majority of which is used in irrigated pasture and feed crops. However, the overall productivity of such systems, particularly in warmer climates is lower, and direct effects of climate change on patterns of rainfall are likely to reduce production even more in lower latitudes. It is very difficult to estimate the economic impact of a switch away from irrigation within the intensive production cycle, but it seems to me inevitable that it will make animal products more expensive and supply more uncertain. Temperate areas with large acreages of grassland and abundant rainfall such as New Zealand and parts of Northern Europe may well benefit under such a scenario, but increased difficulties in other areas will more than compensate. Here the "sustainability dilemma" is that the need to manage water supplies more sustainably will inevitably impact on agricultural production in general and livestock production in particular at a time when demand is growing significantly

Competition for land

Even a crowded country like the UK has only a small part of its landscape urbanized. Some 85% of the UK land area is rural, with over 50% as grassland. Although increased economic development and increasing population will worsen this situation, it will not change it radically. However, I believe that competition for land will impinge directly on agriculture in general and rain-fed pasture agriculture in particular. There are two reasons for this. The first is that there is increasing recognition of the importance of agriculture in delivering a range of ecosystem services (clean water, clean air, biodiversity, landscape diversity, recreation opportunity etc) and the second is competition between food and non-food agriculture.

In terms of the former, there are actions that can be taken to mitigate the impact caused by increase in intensification and increase in cultivated area. These are discussed in Firbank *et al* (2007) and include a range of habitat management approaches coupled with greater precision in the use of inputs. However, there is an in-built tension in that successful agricultural techniques like weed control, winter sowing and the shift from hay to silage inevitably increase the proportion of incoming solar radiation that is captured by the agricultural food chain at the expense of that captured by the "natural" food chains that coexist. This was demonstrated very clearly by Firbank (2003) in studies on the implications on farmland biodiversity of improved weed control using herbicide-tolerant crops. Thus there is a production cost to ecological management of farmland. This cost will vary with site and system, and its impact will depend upon the proportion of land under cultivation within any given region. In addition, certain agroecosystems are more important in ecosystem service terms than others and may be more fragile. In general terms, extensive pastoral systems utilizing rain-fed unimproved pastures represent unique reserves of biodiversity that are dependent upon intermittent grazing. Once again the tensions between increased demand and conservation are clear, and greenhouse gas mitigation options that rely on intensification to reduce animal numbers and increase animal productivity will exacerbate the problem.

The competition between food- and non-food agriculture potentially impacts even more starkly on pastoral agriculture. First generation biofuels use materials (starch, sucrose and edible oils) that are also foodstuffs. Second generation fuels will rely on the ability to ferment recalcitrant lignocellulose to give simple sugars, and thence ethanol or butanol. Globally this feedstock will come from wood (which is already in short supply) or from energy grasses such as Miscanthus which will have to be cultivated (for the reasons discussed above) on land currently used for rain-fed pastoral agriculture. It is ironic that the chemistry of ruminant digestion is precisely the chemistry that the fuel biotechnologists wish to use to generate second-generation biofuels. Currently, the technology is imperfect but progress is inevitable. Countries like the USA, with large areas of rangeland will increasingly face stark choices about what that land will be used for, and I fear that, in the name of climate change mitigation, the impact on fragile agroecosystems will be very large.

Conclusions

Reducing greenhouse gas emissions from agriculture is a laudable and necessary objective. It should be done, however, in the knowledge that:

- There will be disbenefits as well as benefits
- The disbenefits will be compounded by issues relating to competition for resources
- Pressures to increase production will grow at the same time as pressures to reduce footprint will intensify
- The intensive livestock sector is particularly vulnerable to these conflicting pressures

Implications

This summary reflects the views of the author and is not based on any external support or funding. The conclusions are open to debate and disagreement. If, however, the conclusions are borne out by events in the next few years, the implications for the industry, the food chain and policy makers are considerable. The delivery of a more sustainable food chain for livestock products will require policy and regulatory change, changes in consumer behaviour and awareness and forward planning on behalf of the industry.

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