Industrial Livestock Production: The Twin Myths of Efficiency and Necessity

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Abstract

It is widely assumed that food production must increase by 70% to feed the growing world population and accordingly that further industrialisation of livestock production is essential. This would result in poorer animal welfare as even with good stockmanship industrial systems generally have a low potential for delivering satisfactory welfare outcomes.

In fact a large increase in food production is not necessary. We already produce more than enough to feed the population of 9.6 billion expected by mid-century. However, over half this food is wasted: 25% perishes post-harvest or is thrown away at retail or consumer levels. 36% of the world's crop calories are fed to animals but three-quarters of this is wasted due to the low efficiency with which animals convert cereals to meat and milk. The challenge lies not so much in producing more but in wasting less.

If waste in all the above forms were just halved the anticipated population of 9.6 billion could be fed without increasing production. Further industrialisation of animal farming would not be necessary. Nor is it desirable as it is an inefficient use of the world's resources. Industrial livestock production is dependent on feeding grain to animals. For every 100 calories fed to animals in the form of human-edible crops, we receive just 17-30 calories in the form of meat and milk. This is a wasteful use not just of these crops but of the land, water and energy used to grow them.

Keywords: *animal welfare, industrial livestock production, animal feed, cereals, crop calories, world population*

Introduction

Reports regularly claim that a huge increase in food production is needed – the figure most often quoted is 70% - in order to feed the growing world population which is expected to reach 9.6 billion by 2050 (Burney et al, 2010; UN Food and Agriculture Organisation, 2012; Expo 2015 EU, 2015). On this basis policy makers argue that further industrialisation of agriculture is necessary as it is assumed that industrial agriculture is more efficient than less intensive models. However, any expansion of industrial livestock production would be detrimental to animal welfare as even with good stockmanship industrial systems generally have a low potential for delivering satisfactory welfare outcomes.

This paper seeks to demonstrate that industrial livestock production is intrinsically inefficient and moreover that a massive increase in food production is not needed to feed the anticipated world population of 9.6 billion.

The inefficiency of industrial livestock production

Industrial livestock production is widely assumed to be efficient in part because of its ability to raise a large number of animals in a relatively small space. However, industrial livestock production is inherently inefficient due to its dependence on feeding human-edible crops to animals. The land used to house the animals may be small but a huge amount of arable land is required to grow the crops needed to feed the animals.

Industrially raised animals are mainly fed on concentrates which are predominantly made up of cereals and vegetable proteins such as soybean meal. For pigs farmed industrially nearly all the feed is concentrates (Mekonnen & Hoekstra 2012). The same is true for industrially produced broiler chickens and laying hens in most regions.

Grain comprises a high proportion of the diet of intensively raised cattle. Data from DairyCo (2013) in the UK shows that high-output cows receive 2629 kg DM (dry matter)/cow/year of non-forage feed while cows at grass receive much less – 1087 kg DM/cow/year. In U.S. beef feedlots the usual practice is to gradually decrease the proportion of forage in the feed over time, eventually reaching rations that can be as high as 90% grain (Shields & Orme-Evans).

Huge quantities of cereals and soy are used as animal feed. European Commission (2015) data show that 55% of EU cereal production is used as animal feed. Globally the figure is 36% (Cassidy et al, 2013). 98% of global soybean meal is used as animal feed (Soyatech, 2015).

Earlier studies on conversion rates of feed to meat tended to assess the efficiency of feeding human-edible crops to animals by comparing the quantity of cereals fed to animals with the quantity of meat produced. The United States Department of Agriculture (2008) reported that it takes up to 2.6 kg of feed to produce 1 kg of chickenmeat, 6.5 kg of feed to produce 1 kg of pigmeat and 7 kg of feed to produce 1 kg of beef using typical U.S. intensive animal production methods (Table 1).

Smil (2000) considered the amount of feed required to produce 1 kg of genuinely edible meat i.e. not including material that is not normally eaten, such as bone. Smil calculates that producing 1 kg of edible meat in the U.S. by industrial methods requires 20 kg of feed for beef, 7.3 kg of feed for pigmeat and 4.5 kg of feed for chickenmeat (Table 1).

Table 1. Quantity of crops needed to produce 1kg of intensively produced meat

Type of meat	Quantity of crops needed to produce 1kg of intensively produced meat	Quantity of crops needed to produce 1kg of intensively produced EDIBLE meat
Chicken meat	2.6 kg	4.5 kg
Pig meat	6.5 kg	7.3 kg
Beef	7.0 kg	20.0 kg

Sources: USDA 2008 & Smil 2000

Rather than looking at conversion efficiencies from the point of view of weight (amount of crops needed to produce 1kg of meat), more recent studies tend to consider calorie or protein conversion efficiencies. Smil (2000) and Lundqvist (2008) produced the data set out in Table 2.

Table 2. Losses in the world's calorie supply from poor feed conversion and waste at different stages of production

Stage of production	Food energy losses and waste (calories/capita/day)
World edible crop harvest	+ 4600
Minus: post-harvest losses	-600
Minus: animal feed	-1700
Plus: meat and dairy products	+500
Total before distribution	2800
Minus: food wasted in distribution, retail or households	-800
Net available for consumption	+2000

Source: Smil 2000, Lundqvist 2008

Table 2 shows that global food losses post-harvest and in distribution, retail and households amount to 1400 calories/capita/day. Another 1700 calories/capita/day are fed to animals but of these only 500 calories/c/d are delivered for human consumption as meat and dairy products. This means that for every 100 calories fed to animals in the form of human-edible crops, we receive just 30 calories in the form of meat and dairy products.

It is clear from the data in Table 2 that 1200 calories/c/d – 26% of global production of 4600 calories/c/d - are being wasted by being fed to animals. This is not the amount fed to animals; it is the amount that is wasted due to animals' low efficiency in converting plant to animal matter.

A report by the United Nations Environment Programme (2009) suggests that the conversion rate may be even lower than the 30% referred to above. It estimates that a kilo of cereals provides six times as many calories if eaten directly by people than if it is fed to livestock. This indicates that for every 100 calories fed to animals in the form of human-edible crops, we receive just 17 calories in the form of meat and dairy products.

The above data shows that the nutritional value consumed by animals in eating a given quantity of cereals is much greater than that delivered for humans by the resultant meat and dairy products. This has been recognised by the United Nations Food and Agriculture Organisation (2011) which has said that "When livestock are raised in intensive systems, they convert carbohydrates and protein that might otherwise be eaten directly by humans and use them to produce a smaller quantity of energy and protein. In these situations, livestock can be said to reduce the food balance".

Cassidy et al (2013) have calculated calorie and protein conversion rates for different types of animal products when human-edible grain is fed to animals. Their study found that for meat the conversion efficiency is poorer than the 17-30% indicated by earlier studies. It concludes that for every 100 calories of grain fed to animals, we get only about 40 new calories of milk, 22 calories of eggs, 12 of chicken, 10 of pork, or 3 of beef (Table 3). Similarly for every 100 grams of grain protein that we feed to animals, we get only about 43 new grams of protein in milk, 35 in eggs, 40 in chicken, 10 in pork, or 5 in beef.

Table 3. Livestock conversion efficiencies of human-edible grain in calories and protein

	Dairy	Eggs	Chicken	Pork	Beef
Calorie conversion efficiency (%)	40	22	12	10	3
Protein conversion efficiency (%)	43	35	40	10	5

Source: Cassidy et al. (2013)

The nitrogen use inefficiency of feeding crops to animals has been examined by the European Nitrogen Assessment (Sutton & van Grinsven, 2011). This reports that 11.8 million tonnes per year of nitrogen in crops are used as feed for EU livestock but that only 2.3 million tonnes of this nitrogen is returned in meat etc for human consumption i.e. the nitrogen use efficiency of feeding human-edible crops to animals is just 19%.

The feeding of cereals to animals has been widely condemned as inefficient. A Chatham House report concludes that this practice is "staggeringly inefficient" (Bailey et al, 2014). The International Institute for Environment and Development (2015) stresses that using cropland to produce corn, soybeans and other crops for animal feed rather than to grow food for direct human consumption is "a colossally inefficient" use of resources.

The sheer scale of the losses entailed in feeding cereals to animals means that this practice is increasingly being recognised as undermining food security. Olivier De Schutter (2010), former UN Special Rapporteur on the right to food, highlights the importance of "reallocating cereals used in animal feed to human consumption". He stresses that "continuing to feed cereals to growing

numbers of livestock will aggravate poverty and environmental degradation" (De Schutter, 2014a). Chatham House points out that the "use of crops and arable land for livestock production indirectly places rich meat and dairy consumers in competition for calories with poor crop consumers" (Bailey et al, 2014).

The United Nations Food and Agriculture Organisation (2013) warns that further use of cereals as animal feed could threaten food security by reducing the grain available for human consumption.

Detrimental impact on natural resources of using human-edible cereals as animal feed

This core inefficiency brings other inefficiencies in its train. Feeding cereals to animals – which is at the heart of industrial farming - is a wasteful use not only of these crops but of the land, water and energy used to grow them. Moreover, industrial livestock production leads to high levels of soil degradation and water pollution.

Overuse and pollution of water

The United Nations (2011) states: "intensive livestock production is probably the largest sector-specific source of water pollution". A key study analysed the water footprint of food production (Mekonnen & Hoekstra, 2012). It concluded that animal products from industrial systems generally consume and pollute more ground- and surface-water resources than animal products from grazing or mixed systems. The study concludes that the anticipated further intensification of animal production systems arising from growing global meat consumption will result in increasing blue (volume of surface and groundwater used) and grey (pollution caused) water footprints per unit of animal product. The authors explain that this is due to the larger dependence on concentrate feed in industrial systems.

Overuse of arable land and degradation of soils

Cassidy et al (2013) calculate that worldwide a hectare of cropland produces on average sufficient calories to feed 10.1 people. But the calories delivered for human consumption, after accounting for animal feed, biofuels and other industrial uses, only feed six people per hectare. Additional demand for feed grain will drive expansion of cropland into forests, savannahs and grasslands leading to greenhouse gas emissions and pressure on wildlife through habitat loss (United Nations Environment Programme, 2014).

The need to grow huge amounts of grain to feed industrially farmed animals has fuelled the intensification of crop production with its use of agro-chemicals and monocultures. This has eroded soil quality, undermining the ability of future generations to feed themselves. A recent study reports that UK agricultural soils are in poor condition (Edmondson et al, 2014). It identifies modern agriculture and intensification as being responsible for the erosion of UK soil quality. It concludes that "modern agriculture, in seeking to maximize yields ... has caused loss of soil organic carbon and compaction, impairing critical regulating and supporting ecosystem services".

If pressure to farm arable land intensively was eased, soil quality could be restored by the use of rotations, legumes, fallow periods, green manure and animal manure.

Efficient forms of livestock feed

Livestock play an efficient role in the food system when they are fed on materials that cannot be eaten by humans. Moreover, the potential for good animal welfare is generally better in systems that use such feed materials than in industrial farming.

Ruminants that are raised on pastures or other grasslands convert grass and other inedible vegetation into food that we can eat and are able to use land that is not suitable for other forms of food production. In addition, semi-natural grasslands support biodiversity and store carbon. However, care must be taken to avoid overgrazing which in marginal lands can lead to desertification. Nor should new pastures be created by deforestation.

The World Bank (2009) is extremely positive about the benefits of integrated crop-livestock farming as crop residues can be used to feed animals. Moreover, their manure, rather than being a pollutant, fertilises the land and improves soil quality.

Other efficient forms of feed are by-products such as brewers' grains and, subject to strict safeguards, unavoidable food waste. Bajželj et al (2015) identify grazing on pasture and use of crop residues and processing co-products as efficient forms of feed. They say that "together these support about 30% of current livestock production; the remaining 70% has to be seen as a very inefficient use of land to produce food".

How much additional food is needed to feed the growing world population?

It is often asserted that, in order to feed the anticipated world population in 2050 of 9.6 billion, food production is going to have to increase by around 70%. It is important to verify if this figure (or other figures which range from 60-110%) is correct as a great deal of today's food policy is predicated on the assumption that a huge increase in production is needed.

Sufficient food is already produced to feed well over 9.6 billion people. Estimates of the number of people that could be fed from current food production vary from at least 10.4 billion to 14 billion (author's calculations based on Cassidy et al, 2013 & De Schutter, 2014b).

It is widely recognised that considerable savings can be made in reducing the food waste that occurs through post-harvest losses and at the distribution, retail and household levels ('waste in the conventional sense'). However, policy makers largely ignore the waste entailed in feeding human-edible crops to animals. However, this waste is as great as, or greater than, waste in the conventional sense (Figure 1).

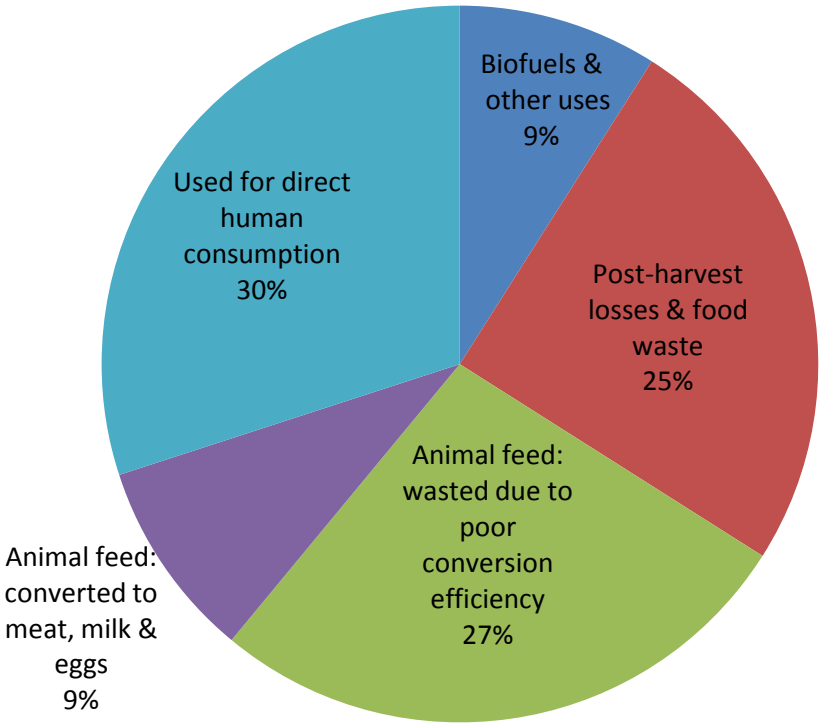
Cassidy et al (2013) calculate that 36% of the world's crop calories are fed to animals but, as indicated earlier, at best only 17-30% of these calories are returned for human consumption as meat or milk. The effect of this is that 70-83% of the 36% of the world's crop calories that are used as animal feed are wasted; they produce no food for humans. This means that 27% (70-83% of 36%) of the world's crop calories are wasted by being fed to animals; just 9% of global crop calories produce meat and milk for human consumption

A report by the High Level Panel of Experts on Food Security and Nutrition (2014) states that worldwide 25% of food calories are lost or wasted post harvest or at the distribution/retail and consumer levels. A further 9% of global crop calories are used for biofuels or other industrial uses (Cassidy et al, 2013). The remaining 30% of global crop calories are used for direct human consumption. In addition, as indicated above, 9% of global crop calories deliver meat and milk. To sum up, 39% of the world's crop calories produce food for human consumption. The remaining 61% is wasted either in the conventional sense or by being used as animal feed or biofuels (Figure 1).

Figure 1. Use – and waste – of calories produced by world's crops

61% of global crop calories are wasted: lost post harvest, thrown away, used as biofuels or fed to animals without being returned as meat or milk

39% of global crop calories are used for human consumption either directly or as meat or milk



Based on data from UNEP, 2009; Lundqvist et al, 2008; Cassidy et al, 2013 & High Level Panel of Experts on Food Security and Nutrition, 2014

If various forms of waste were halved enough food would be released to feed the anticipated population growth of 2.6 billion.
The UN Environment Programme (2009) calculates that the cereals which on a business-as-usual basis are expected to be fed to livestock by 2050 could, if they were instead used to feed people directly, provide the necessary food energy for over 3.5 billion people. If a target were adopted of halving the amount of cereals that on a business-as-usual basis would be used for feed by 2050, an extra 1.75 billion people could be fed.

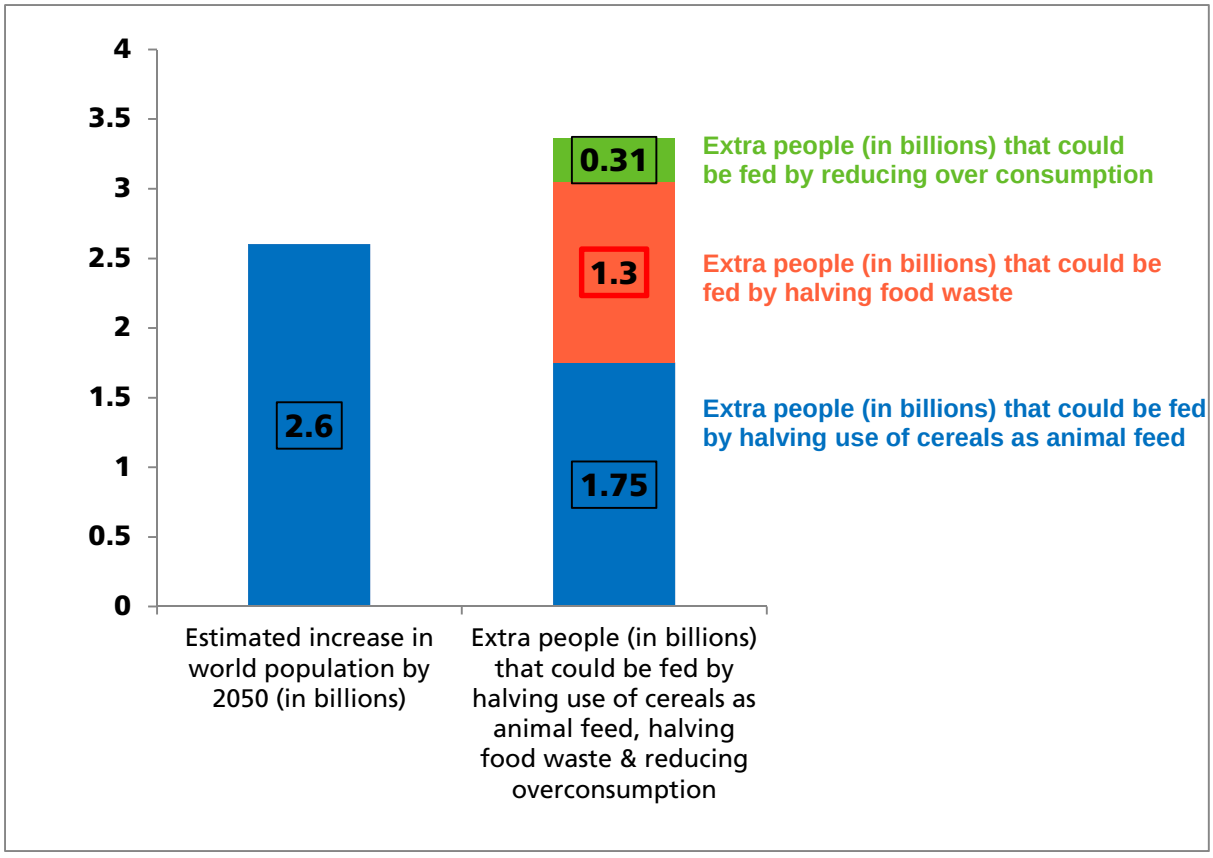
Cassidy et al (2013) produce a similar figure. They calculate that shifting the crop calories used for animal feed and other uses (biofuels and other industrial

uses) to direct human consumption could potentially feed an additional ~ 4 billion people. The High Level Panel of Experts on Food Security and Nutrition (2014) states that worldwide 25% of food calories are lost or wasted in the conventional sense. If loss and waste could be halved an extra 1.3 billion people could be fed. This is a very cautious estimate; the figure may well be higher.

Based on figures in an interim report by the World Resources Institute (2013), we calculate that an extra 310 million people could be fed if the number of people who are expected to be obese and overweight by 2050 were reduced by eliminating obesity and halving the number who are overweight.

If the above forms of food waste were halved, an additional 3.36 billion people could be fed, more than the anticipated growth in population of 2.6 billion.

Figure 2. Feeding the 2.6 billion extra people anticipated by 2050



Based on data from: UNEP, 2009; World Resources Institute, 2013; & High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, 2014

This paper does not seek to argue that no additional production is required. Increased production may be needed in specific cases or certain regions particularly in sub-Saharan Africa but, in light of the various forms of loss and

waste referred to above, the claim that a 70% increase in global food production is needed by 2050 substantially overestimates the quantity of extra production needed. The (arguably erroneous) 70% figure leads policy makers to place undue emphasis on further intensification while giving insufficient weight to the need to farm in ways that do not undermine the natural resources on which our continuing ability to produce food depends.

Smallholder livestock farmers in the developing world must be helped to increase their productivity in ways that are appropriate for their circumstances. This should not entail the introduction of industrial livestock systems as these exclude participation of the poorest farmers. They are out-competed by industrial production which provides little employment.

A constructive approach would be to help small-scale farmers provide improved healthcare and nutrition for their animals through better disease prevention and management, the expansion of veterinary services and the cultivation of fodder crops such as legumes. Better animal health and nutrition result in increased livestock productivity and longevity. This will improve smallholders' purchasing power, making them better able to buy the food that they do not produce themselves and to have money available for other essentials such as education and health care.

Animal welfare implications

Further industrialisation of livestock production would have a detrimental impact on animal welfare. Extensive indoor systems and outdoor systems have the potential, if well-designed and well-managed, to deliver good welfare outcomes. However, even where stockmanship is good, industrial systems have little potential to provide satisfactory welfare. For example, for hens kept in cage systems and pigs housed without effective enrichment the performance of natural behaviour is impeded to such an extent that welfare is compromised (European Food Safety Authority (EFSA), 2004; Spoolder et al, 2011; ANSES, 2013).

Industrialisation is driving zero grazing in the dairy sector. However, research shows that a compared with cows raised in grazing systems, cows in confinement systems with no or limited access to grazing have increased levels of lameness, mastitis, uterine disease, early pregnancy loss, certain infectious diseases (e.g. salmonellosis) and mortality (EFSA, 2009; Arnott et al, 2015).

The health of intensively farmed animals is often seriously impaired by genetic selection for fast growth or high yields. EFSA (2009) has concluded that "long term genetic selection for high milk yield is the major factor causing poor welfare, in particular health problems, in dairy cows". A UK study into leg disorders in broilers found that, primarily due to high growth rates, 27.6% of the chickens had levels of lameness that are likely to be painful (Knowles et al, 2008). The high productivity of modern laying hens causes osteoporosis which results in a high level of bone fractures (LayWel, 2006).

Conclusion

It is often asserted that a very substantial increase in food production (a 70% rise is commonly cited) is needed to feed the growing world population which is expected to reach 9.6 billion by 2050. This assumption is playing a major role in shaping global food policy. In particular, policy makers maintain that further industrialisation is essential to produce the required additional food.

This would have an inimical impact on animal welfare as even with good stockmanship industrial livestock systems generally have a low potential for delivering satisfactory welfare outcomes. In addition, industrial production is inherently inefficient due to its dependence on feeding human-edible crops to animals. The nutritional value consumed by animals in eating a given quantity of cereals is much greater than that delivered for humans by the resultant meat and milk. Feeding cereals to animals is a wasteful use not only of these crops but of the land, water and energy used to grow them. Moreover, industrial livestock production leads to high levels of soil degradation and water pollution.

We already produce enough food to feed well over 9.6 billion people but around half of it is lost or wasted post-harvest or at retail and consumer levels or by being fed to animals or by being used for biofuels. We do not need to produce large amounts of extra food; we just need to use the food we produce more sensibly. In particular, we should adopt a target of halving food waste in all the above forms.

Increased production is needed particularly in certain regions but nowhere near 70% more. The 70% figure has led to the adoption of a productionist agenda by policy makers which fails to recognise that, to achieve food security, we need to focus not just on the quantity of food produced but also on its nutritional quality, decent livelihoods for small-scale farmers in the developing world and

the health of the natural resources – soil, water, biodiversity – on which our continuing ability to produce food depends.

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