WP

ENVIRONMENT

Intensive poultry production

In contrary to what environmentalists want the world to believe, British scientists have proven that intensive (housed) poultry production has a much smaller impact on global warming than organic or free-range production. Additionally, poultry production proves to be more environmentally efficient than any other source of meat production.

By Wiebe van der Sluis

Global warming has been an issue of major importance for many years already. Scientists from all over the world are continuously studying the problem and coming up with life-threatening scenarios. Several non-governmental organisations often blame agriculture as being a major contributor to global warming through the use of large-scale modern technologies. However, it can sometimes be questioned whether their claims and statements are based on sound science. It is for this reason that the British Department of Environment, Food and Rural Affairs (Defra) asked the Cranfield University in Silsoe to determine the environmental burdens and resources used in the production of agricultural and horticultural commodities. The result is an impressing report and an interesting computer model to conduct additional and alternative calculations using the principles of Life Cycle Assessment (LCA). The outcome includes good news for the poultry industry.

Measuring sustainability

The research team addressed key questions underpinning the development of sustainable production and consumption systems. It quantified in detail the resource use and environmental burdens arising from the production of 10 key crop and livestock commodities from various production options in England and Wales.

All inputs into on-farm production for each commodity were traced back to primary resources such as coal, crude oil and mined ore. This also includes all activities supporting farm production, such as feed production and processing, machinery and fertiliser manufacture, fertility building and cover crops. In addition, a breakdown was made for organic production as well as variations on non-organic (or contemporary conventional) production systems.

The analyses are assembled in a Microsoft Excel spreadsheets to allow users to change key variables, including: the balance of organic and non-organic production at a national scale; N

Aggregation of burdens

The use of resources and emissions to the environment are collectively termed environmental burdens. The Cranfield researchers therefore initially quantified emissions to the environment by individual chemical species, whether they are from farms, industrial processes or transport. Several of these are aggregated into environmentally functional groups of which the major ones used are:

Global warming potential (GWP_{100}): GWP is calculated using timescales of 20, 100 and 500 years, but the report only used the 100 year one in the "headline values". The main agricultural sources are nitrous oxide (N_2O) and methane (CH_4) together with carbon dioxide (CO_2) from fossil fuel. It is quantified in terms of CO_2 equivalents (*Table A*).

Eutrophication potential (EP): The main agricultural sources are nitrate (NO_3) and phosphate (PO_4) leaching to water and ammonia (NH_3) emissions to air. It is quantified in terms of phosphate equivalents: 1kg NO_3-N and NH_3-N are equivalent to 0.44 and 0.43kg PO_4 respectively.

Acidification potential (AP): The main agricultural source is ammonia emissions, together with sulphur dioxide (SO_2) from fossil fuel combustion. Ammonia contributes despite being alkaline. When deposited or when in the atmosphere, it is oxidised to nitric acid. It is quantified in terms of SO_2 equivalents: 1kg NH_3-N is equivalent to 2.3kg SO_2.

Abiotic resource use (ARU): The use of natural resources was aggregated using the method of the Institute of Environmental Sciences (CML) at Leiden University. Their data put many elements and natural resources onto a common scale that is related to the scarcity of the resources. It is quantified in terms of the mass of the element antimony (Sb), which was an arbitrary choice. Their data includes most metals, many minerals, fossil fuels and uranium for nuclear power.

Primary energy use: The major agricultural fuels include diesel, electricity and gas. These are all quantified in terms of the primary energy needed for extraction and supply of fuels (otherwise known as energy carriers). The primary fuels are coal, natural gas, oil and uranium (nuclear electricity). They are quantified as MJ primary energy, which varies from about 1.1 MJ natural gas per MJ available process energy to 3.6 MJ primary energy per MJ of electricity.

Land use: The use of land for crop production is reported assuming average yields for Grade 3a land. Yields were scaled up or down using linear coefficients for other land grades (*Table B*) and required land use per one tonne of crop is one of these grades. However, for animal grazing systems, owing to the network of rearing systems, land use is calculated as a proportion of each grade of land.

Table A - Global warming potential (GWP) factors for major gases using the intergovernmental panel on climate change values (IPCC 2001)

Substance	GWP 20 years, [kg CO_2-equiv]	GWP 100 years, [kg CO_2-equiv]	GWP 500 years, [kg CO_2-equiv]
CO_2	1	1	1
CH_4	62	23	7
N_2O	275	296	156
N2O-N	432	465	245

Table B - Factors used to scale yields on different grades of agricultural land

Grade	Scaling Factor
2	0.88
3a	1.00
3b	1.08
4	1.12

better for global warming

Table 1 - Main burdens of animal products (from current national balance of systems) per functional unit produced (1 tonne dead weight, 20,000 eggs, and 10,000 *l* milk)

Impacts & resources used	Beef	Pig meat	Poultry meat	Lamb meat	Eggs	Milk
Organic share in parenthesis	**0.8%**	**0.6%**	**1%**	**1%**	**1%**	**2.5%**
Primary energy used, GJ	27	23	15	26	14	26
GWP_{100}, t CO_2	15	4.9	3.6	17	3.8	11
Eutrophication potential, kg PO_4	101	32	26	153	26	45
Acidification potential, kg SO_2	162	83	61	130	70	94
Pesticides used, dose ha	1.3	1.8	1.5	0.9	1.3	0.8
Abiotic resource use, kg antimony	34	41	28	29	36	31
Land use (1)						
Grade 2, ha						0.25
Grade 3a, ha	0.68	0.67	0.63	0.53	0.6	1.0
Grade 3b, ha	0.9			1.4		
Grade 4, ha	0.7			1.2		
Grade 5, ha	1.4			2.9		
N losses						
NO_3-N, kg	160	33	30	290	26	62
NH_3-N, kg	73	32	23	51	28	38
N_2O-N, kg	12	2.2	3.4	13	3.6	6.6

(1): Grazing animals use a combination of land types from hill to lowland. Land use for arable feed crops was normalised at grade 3a.

supply to crops; balance of housing types in animal production; use of Combined Heat and Power systems (CHP) in greenhouses, etc.

The computer model can be accessed via the Cranfield University website at www.cranfield.ac.uk (then search for IS0205 and LCA).

Animal production

The Cranfield study included four field and protected crops and six animal commodities: poultry meat, pig meat, sheep meat, beef, milk and eggs. Poultry meat was assumed to be a composite of chicken and turkey meat. The other commodities were all produced by one class or species of stock. Similarly, all eggs are assumed to be produced by chickens. The functional units taken are 1 tonne of carcass dead weight, 10,000 *l* milk, or 20,000 eggs to reflect the way that each commodity is traded, but the system boundary is the farm gate.

In addition to field emissions there are direct and indirect emissions from the animals (indirect ones coming from manure). These emissions are: methane (enteric and manure), nitrous oxide (manure in housing, storage and land application) and ammonia (same sources as nitrous oxide). Nitrate can also be leached from land-applied manure. Animal production also requires feed processing (on or off the farm) and some overseas imports, for example whole soybeans (organic) and soybean meal after oil extraction (in Britain) for non-organic. Bedding is also used, mainly straw – a by-product of cereal production.

Contribution to global warming

Unlike most of industry and domestic activities, the Global Warming Potential (GWP) from agricultural commodities is dominated by nitrous oxide (N_2O) and not by cardon dioxide ($CO_{2)}$ from fuel use. The British researchers conclude, for example, that 80% of the GWP from wheat production (both organic and non-organic) relates to N_2O from the nitrogen cycle. A similar pattern occurs with animal production as they live on crops. In contrast to the GWP, the contribution from tomato production (as with most greenhouse products) is high due to the CO_2 from the use of natural gas and electricity. Their contribution to GWP is even higher than that of poultry (9.4 compared to 3.6 tonnes CO_2.

Poultry meat production appears to be the most environmentally efficient on the livestock side. It is followed by pig

A carbon-nitrogen footprint

The balance of global warming gas emissions and fossil fuel consumption is quite different from most industries, which consume energy (most from fossil C-based fuel) and thus emit CO_2 as the main gas contributing to global warming. In agriculture, N_2O dominates with substantial contributions from methane. Consequently, a carbon footprint inadequately describes agriculture; it has a *carbon-nitrogen footprint*. Indeed, the nitrogen fluxes in agriculture (and other types of land) also contribute to eutrophication and acidification. The majority of environmental burdens arising from the production of agricultural food commodities arise either directly or indirectly from the nitrogen cycle and its modification, in organic and non-organic systems.

Table 2 - Comparison burdens of production of some alternative poultry meat systems (per tonne)

Impacts & resources used	Non-organic	Organic	Free-range (non-organic)
Primary energy used, GJ	15	17	15
GWP_{100}, t 100 year CO2 equiv.	3.6	4.8	4.2
EP, kg PO_4- equiv.	26	48	36
AP, kg SO_2 equiv.	61	110	94
Pesticides used, dose ha	1.5	0.1	1.9
ARU, kg antimony equiv.	28	41	31
Land use, ha	0.57	1.3	0.74
N losses			
NO_3-N, kg	30	60	36
NH_3-N, kg	23	43	38
N_2O-N, kg	3.4	5.0	4.4

Table 3 - Comparison burdens of production of some alternative egg production systems (per 20,000 eggs)

Impacts & resources used	Non-organic	Organic	100% cage, non-organic	100% free-range, non-organic
Primary energy used, GJ	14	15	14	13
GWP_{100}, t 100 year CO_2 equiv.	3.8	4.2	3.6	4.1
EP, kg PO_4 equiv.	26	38	24	29
AP, kg SO_2 equiv.	70	84	66	76
Pesticides used, dose ha	1.3	0.0	1.2	1.5
ARU, kg antimony equiv.	36	39	38	32
Land use, ha	0	1.15	0.50	0.66
N losses				
NO_3-N, kg	30	48	25	29
NH_3-N, kg	23	33	26	31
N_2O-N, kg	3.4	3.7	3.3	4.1

meat and sheep meat (primarily lamb) with beef the least efficient (*Table 1*). This positive outcome results from several factors, including the very low overheads of poultry breeding stock (about 250 d.o.c per hen each year vs one calf per cow); very efficient feed conversion; high daily weight gain of poultry (made possible by genetic selection and improved dietary understanding).

Organic versus non-organic

Poultry and pigs consume high value feeds and effectively live on arable land, as their nutritional needs are overwhelmingly met by arable crops (produced both locally and overseas). Ruminants, however, can digest cellulose and therefore make good use of grass, both upland and lowland. Much of the land in the UK is not suitable for arable crops, but is highly suited to grass. One environmental disadvantage, however, is that ruminants emit more enteric methane. This contributes to the ratios of GWP produced to primary energy consumed, being about 80% higher for ruminants than poultry meats.

Although it is often believed that the GWP effects can be reduced by adopting organic production systems, the reality of this Cranfield report proves the opposite for poultry. Most organic animal production reduces primary energy use by 15-40%, but organic poultry meat and egg production increase energy use. Although intital figures indicated an increase by 30% and 15%, respectively, revised calculations still indicate an important advantage for non-organic. (*Table 2 and 3*). The benefits of the lower energy needs of organic feeds are over-ridden by lower bird performance.

Organic poultry has a higher food conversion ratio and a longer growing period for the heavier chickens that are produced, resulting in a net increase in energy requirement for organic poultry meat production. The scenario of increasing the proportion of free-range chickens (in the non-organic sector) to 100% may increase energy use and most burdens, but still less than organic.

Organic egg production needs more energy than non-organic and increases most environmental burdens (except pesticides), but the land area needed more than doubles. More of the other environmental burdens were larger from organic production, but abiotic resource use was mostly lower (except for poultry meat and eggs) and most pig meat burdens were lower. GWP from organic production ranged from 42% less for sheep meat to 33% more for poultry meat.

Conclusions

In conclusion, the Cranfield report states that poultry meat and egg production is the most environmentally efficient animal protein production system.

It also proved that intensive (housed) poultry production has much less impact on global warming than organic or free-range production.

Another important conclusion is that the relative burdens of GWP, acidification and eutrophication between organic and non-organic field-based commodities are more complex than energy. Organic production often results in increased burdens, from factors such as N leaching and N_2O emissions from clover leys and lower yields.

It should therefore be clearly understood that N_2O is the single largest contributor to GWP, although it is also the emission about which there is the least understanding about its reliable quantification.

Finally, it has to be accepted that organic production always requires more land (65-200% extra), while organic field crops and animal products mostly consume less primary energy than non-organic counterparts owing to the use of legumes to fix N rather than fuel to make synthetic fertilisers. But in most cases poultry meat and eggs are positive exceptions. ■