FACTORY FARMING AND THE ENVIRONMENT

A REPORT FOR
COMPASSION IN WORLD FARMING TRUST

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Factory Farming and the Environment

Boxes

Note on units of measure

1 hectare (ha) = 10,000 square metres = 2.47 acres
100 hectares = 1 square km
1 tonne (metric ton) = 1000 kg = 0.98 ton
1 billion = 1000 million

Summary of report and conclusions

Intensive farming systems exist to increase yields and reduce apparent costs but they frequently compromise both the health and the behavioural and physiological needs of farm animals. This "factory farming" is also environmentally damaging for a number of reasons:

- Intensively farmed animals are concentrated, often indoors, at stocking densities that are too high to be environmentally sustainable, on agricultural operations that are too small to grow their feed or absorb their manure
- Production and transport of high energy and high protein animal feed crops consume scarce resources of land, water and energy worldwide
- Intensive feed production involves the use of artificial fertilisers, insecticides and herbicides, the loss of meadows and the removal of hedges, ditches and field margins. These farming practices damage wildlife habitat and reduce biodiversity
- Surplus nutrients from factory farms pollute rivers, lakes, groundwater and seawater, damaging plant and animal life and contaminating sources of drinking water
- Factory farming is an important source of emissions of carbon dioxide, methane, nitrous oxide and ammonia, variously associated with global warming, ozone depletion and acid rain

Compassion in World Farming Trust believes that all farm animals should have access to the outdoors, comfortable bedding, natural light and ventilation and sufficient space allowance to permit natural behaviour and exercise.

Compassion in World Farming Trust believes that the Common Agricultural Policy (CAP) should be reformed with the aim of discouraging the overproduction of animals and that the UK and European governments should actively promote low-input, extensive livestock systems and mixed farming.

Compassion in World Farming Trust believes that farm animal cloning is a threat to biodiversity and to animal welfare and deplores the UK government's support of farm animal cloning research.

Compassion in World Farming Trust believes that UK planning law should be reformed to make all planning applications for livestock farms subject to detailed animal welfare and environmental impact assessments.

Compassion in World Farming Trust believes that the UN Food and Agriculture Organisation should oppose the spread of factory farming worldwide and should actively promote agricultural practices that respect the environment and farm animal welfare.

Compassion in World Farming Trust believes that trade policies to protect the environment and farm animal welfare should be given recognition within the World Trade Organisation.

1. Introduction: the environmental costs of factory farming

The factory farming of animals for food (intensive animal husbandry) is at the heart of modern agriculture. It is fundamental to the way in which modern agriculture operates and to the way modern agriculture impacts on the natural environment.

In recent years we have seen a steadily increasing stream of warnings from official sources in the UK and Europe, as well as from environmental protection groups, of the damage that intensive agricultural methods are doing to the natural environment and to other species[1-6]. Animal factory farming has a central position in this debate. As a recent report sponsored by the United Nations Food and Agriculture Organisation (FAO) has put it:

> "The balance between human needs and natural resource requirements will depend, to a significant extent, on what we do with animal production" [7].

The intensification of UK and European agriculture has led to the now-familiar problems of chemical pollution of water, air and soil, habitat destruction and to the loss of biodiversity and landscape features. *Factory Farming and the Environment* aims to highlight the fundamental connection between these well-known and well-documented environmental problems and the factory farming of animals. Over the last 50 years mixed farming of crops and animals has declined significantly and the majority of animal production now takes place in large specialised units. The UK now holds a total of over 200 million farm animals (poultry, pigs, dairy and beef cattle and sheep) at any one time, the great majority of them kept in intensive or semi-intensive production systems.

Keeping animals in intensive systems has several important consequences. To start with, these animals need to be provided with high-nutrient food in order to achieve high productivity. In total, over 75% of UK agricultural land is devoted to animal feed production, either in the form of grazing, forage or other crops. Further supplies of feedstuffs are imported from all over the world. The demand for animal feed has largely been met by intensive arable farming and intensive grassland management, using inputs of artificial fertiliser, herbicides and insecticides. The industrialisation of farming as a whole is inseparable from our decision to keep animals in intensive systems.

A further result is that most of the nutrients from the high quality feed end up as waste products in the animals' manure. Far too much of this high-nutrient manure may accumulate in the relatively small areas of land where farm animals are confined and the manure and nutrients become pollutants in the general environment. There is a direct link between our demand for the maximum productivity from farm animals and environmental pollution.

Factory farming of animals is characterised by an approach where the animals are regarded not as sentient beings but as units of production which are required to yield the maximum return on inputs. The inputs have become very expensive, often encouraged by subsidies, and the outputs are expected to be correspondingly high. Inevitably, the health and welfare of the animals may take second place to the concern to maximise returns and Compassion in World Farming Trust opposes factory farming for that reason. There are also costs in terms of animal and human diseases, as we have shown in our two previous reports *Factory Farming and Human Health*[8] and *Factory Farming and the Myth of Cheap Food*[9]. CIWF believes that if we consider the environmental and health costs, together with the costs in suffering to the animals, there is an overwhelming case for moving towards extensive, mixed farming systems.

In this report CIWF sets out the environmental consequences of the specialisation and industrialisation that now characterise animal farming in the UK and the European Union and makes the case for change. Until now, as the European Commission has admitted[6], agricultural policy has favoured intensive farming. Extensive farming and mixed farming, which have a higher potential for good animal welfare, must be encouraged under agri-environment schemes. Together with this, there must be clear labelling of the production method of animal products, so that consumers have a real choice about whether or not to buy products that are damaging to animal welfare and the environment.

2. What is animal factory farming?

The essential characteristic of intensive animal farming that concerns us here is that animals are kept at an unnaturally high stocking density and very often indoors away from any natural source of food. The environmental problems inherent in the factory farming approach come from the need to produce the animals' feed and dispose of their wastes.

Factory farmed animals are fed "for production", not just to keep them alive and healthy. Feeding farm animals has the aim of maximising yield and huge resources worldwide are devoted to providing high quality, specialised feed to maximise the animals' physiological performance. Factory farmed animals are required to grow fast and produce the maximum possible meat, milk, eggs or offspring, as required. The result has been that feed production has become a major contribution to the environmental damage caused by agriculture today.

2.1 Crowds of animals

In intensive systems, the animals are kept at such a high concentration that the area of land they are kept on cannot provide all their food. Feed production is therefore separated from the animals and feed is enriched and specialised to maximise yields. Because of the concentration of animals, the concentration of animal wastes is very high. A survey in *Animal Science* in 1996 summarised the situation in relation to factory farmed pigs and poultry:

> With housed pigs (as with poultry) the number of pigs in a unit is completely unrelated to either farm area or to the area of land needed to meet the animal food requirement.[10]

This contrasts with traditional animal husbandry, where animals live on a large enough area of land so that their food can be provided from it and their manure absorbed on the same land. A 1995 survey from Edinburgh University on farming and the environment described the development of animal farming from the mid-century as including:

> systems for animal containment, such as battery cages for hens; stalls and tethers for sows; wet slurry systems for handling the excreta of cattle and pigs; and the synthesis of artificial compounds and drugs to counterbalance the negative effects of dense livestock concentrations…. The negative consequences of what has come to be seen as self-evidently unsustainable were knowingly put aside in order to achieve the more pressing short-term goals of readily available food for a hungry nation, and of import saving. [11]

In fact, the 'negative consequences' of factory farming have been known to governments for a very long time. As long ago as 1979 the Royal Commission on Environmental Pollution[12] under Sir Hans Kornberg reported on "the vastly expanded use of agrochemicals and fertilisers, the trend towards large, intensive livestock units and the related problems of farm waste disposal". The Commission also reported that they had found some of the conditions of factory farmed animals to be "repugnant"[12].

Table 1. Increase in stocking density between 1960 and 1975 in England and Wales. Source: Royal Commission on Environmental Pollution, 1979[12].

	1960	1970	1975
Dairy herds of over 100 head on less than 60 ha (150 acres)	12	128	342
Pig herds of over 1000 head on less than 8 ha (20 acres)	0	126	284

Although intensive farming of animals is now the norm in the UK and throughout the developed world, it is perhaps taken furthest in the United States. For regulatory purposes, US farms are now officially referred to as 'animal feeding operations' (AFOs) and animals are referred to as 'animal units'. One thousand 'animal units' (AU) is defined as 1000 beef cattle, 2500 pigs and up to 100,000 chickens, for example[13]. Large animal farms that grow no feedstuffs are referred to as 'concentrated animal feeding operations' or CAFOs.

Looking beyond the most industrialised countries, intensive animal farming is rapidly spreading worldwide. The FAO, World Bank and United States Agency for International Development (USAID), in a wide-ranging 1996 report *Livestock and the Environment*, defined 'industrial' animal farming as that where less than 10% of the animal feed is produced within the production unit. All over the world, such units are often situated near to urban centres or to ports in order to facilitate the transport of feed and products. Industrial livestock production is the fastest growing form of animal farming, responsible for 43% of the world's meat in 1996, up from 37% in the period 1991-93. This includes half of the world's total pigmeat and poultry meat, 10% of all beef and sheepmeat and two-thirds of all eggs[1].

If current trends are followed, industrial livestock production can only increase in order to meet the global demand for animal food products. The meat and milk consumption *per capita* in developing countries is currently less than a third of that in developed countries. The implications in terms of resources needed to provide feed and to deal with waste products led the FAO to conclude that worldwide:

> livestock production has become an important factor in environmental degradation[7].

The following sections briefly outline the features of animal farming in the UK and Europe that are most relevant to the quality of the environment. But it is important to bear in mind that from an environmental point of view factory farming has to be seen as a worldwide problem.

MAFF census of UK farm animals, June 1998[14]

Cattle and calves	11.5 million
Sheep and lambs	44.5 million
Pigs	8.2 million
Chickens	147.5 million
Other poultry	17.5 million

These are the numbers of animals alive on 1st June. The total number of pigs and poultry produced in a year is much larger – about 16 million pigs and 850 million poultry were slaughtered in 1998[15].

The intensification of animal farming that has occurred over the last decades is unacceptable from the point of view of the health and welfare of farm animals and is also a cause of continuing environmental degradation worldwide.

2.2 Chickens

The poultry meat and egg industries have become increasingly specialised and concentrated over the last 50 years. In the UK the number of broiler chickens (meat birds) slaughtered per year has increased by over 80% since the end of the 1970s[16]. At any one time there are now almost 100 million broiler chickens and around 30 million egg-laying hens in the UK[15]. In the European Union as a whole, there are over 250 million laying hens and over 600 million broilers being fattened at any time[17].

In the UK, most chickens are kept in very large operations. In 1995, according to ADAS, 99% of the UK broiler flock and nearly 98% of UK laying hens lived in operations of over 1000 birds[18]. Seventy-six percent of laying hens now live in operations of over 20,000[19,15]. Sixty-one percent of broiler chickens live in operations of over 100,000 birds[15]. Most of these birds are confined permanently in sheds, often without natural light and mechanically ventilated. Only about 13% of laying hens live in free-range systems in the UK. Around 84% are kept in battery cages in the UK[19] and the proportion in other European Union countries is even greater. In one shed there may be as many as 90,000 laying hens in rows of tiered cages. Following a Council of Ministers decision in June 1999, the battery cage system will be phased out in the EU by 2012.

Researchers at the Scottish Agricultural College have estimated the true stocking density of intensively farmed poultry. Compared to the maximum allowed density of free-range hens, which is 1000 hens per hectare of outside range (or 1 hen per $10m^2$), the density of the battery system can be 220,000 per hectare (220 hens per $10m^2$). The stocking density in broiler sheds can be 150,000 per hectare (150 chickens per $10m^2$)[10].

Laying hens and broiler chickens
The laying life of a battery hen in her cage is around one year, lasting from about 20 to 72 weeks of age. Broiler chicks are fattened from 1 day old to around 2kg weight and are slaughtered at approximately 6-8 weeks old, in typically an 8-week ‘crop cycle’. Because of this fast turn-around, the total yearly production of broilers in the UK is around three quarters of a billion and around 4 billion for all EU countries[17]. At the end of each production period the whole unit is normally cleared and all the birds taken for slaughter together, after which the unit is cleaned and restocked with chicks or pullets.

2.3 Pigs

There are about 8 million pigs at any one time in the UK, and about 120 million pigs in the current EU15 countries in 1996[20]. Some EU countries, such as the Netherlands, Belgium, Denmark and Germany have a considerably higher number of pigs than the UK compared to their population and size. The great majority of pigs are kept indoors in intensive systems.

Table 2. Numbers of pigs in selected European countries at any one time.
Source: European Environment Agency: *Europe’s Environment: Statistical Compendium* (1998)[20].

Country	*Number of pigs* (1996)
Belgium	7.2 million
Denmark	11.1 million
France	15.0 million
Germany	24.2 million
Netherlands	14.2 million
Spain	18.6 million
UK	7.6 million

As with poultry, there has been a steady trend to concentration in the pig industry. The pig population in the EU12 countries increased from 60 million at the end of the 1970s to 108 million in 1996[21]. The number of farms has more than halved since 1975 and the number of pigs per farm has increased substantially[22]. In the areas of high concentration, there were on average 2-5 pigs per hectare of agricultural land in East Anglia and north western Spain, between 500 and 100 per hectare in Brittany and rising to over 1000 per hectare in areas of Belgium and the Netherlands[21]. In the UK, 68% of fattening pigs lived in herds of 1000 or more pigs in 1998[15].

Pig farming

In the UK and Europe a sow used for breeding gives birth to around 25 piglets a year[23]. Around 30% of UK breeding sows are now kept outdoors, but their piglets are usually weaned at 4 weeks or less[23] and transferred indoors. There the piglets (growers) may live in a crowded and barren environment until they are sent for slaughter at about 6 months old. The majority of sows and their piglets spend their lives indoors. Although the very restrictive sow stall and tether system has been banned in the UK from January 1999 it is still the dominant system for sow housing in Europe, accounting for at least 95% of sows in Belgium and the Netherlands according to a 1998 survey in *Pig News and Information*[24]. Tethers are being phased out in the EU by 2006, and some European producers are now moving towards group housing of sows. In the sow stall system the sow is restrained in a narrow metal-barred pen in which she cannot turn around for the 16 weeks of each pregnancy. She is normally reimpregnated within a week or so of weaning[23]. For birth and lactation, most sows are confined in farrowing crates, which are similar to sow stalls and at present remain legal in the UK and the rest of the EU.

A 1999 European Commission report on agriculture and the environment comments:

> The large number of pigs per hectare may have a high impact on the environment in some regions of the EU. Air and soil especially need constant protection against the negative influences from intensification[22].

Pigs in the USA

In the US, pig rearing in small mixed farms has been replaced by very large specialised units, which may sell over half a million pigs per year. In North Carolina there was an 8-fold increase in the average number of pigs per farm between 1970 and 1991. A 1995 report from the University of Iowa tells us that "Swine production in the United States is very rapidly becoming more specialised, concentrated and industrialised"[25].

The state of Iowa has 14.5 million pigs at any one time and 1200 farms designated CAFOs*. North Carolina had 10 million pigs in 1998, up from 3.7 million in 1991[26]. In 1995 the top 2 counties in North Carolina's "hog belt" had over 1 million pigs each, or over 1200 pigs per square mile of the county[27]. One of the world's largest slaughterhouses, in Bladen County, kills 24000 pigs every day of the year[26].

*Concentrated Animal Feeding Operations

2.4 Dairy cows and beef cattle

There were around 12 million cattle in the UK in 1998, mostly specialised into milk or beef production operations. About 3 million of these are dairy cows[14] . The intensification of the dairy industry has more than doubled the average herd size, both in the UK and the EU as a whole since the mid-1970s[22], and greatly increased milk production per cow. A cow is now expected to produce 35-50 litres of milk per day[28,29]. This has required both selective breeding for large udders and very high milk-yield and the provision of large quantities of high quality feedstuffs to fuel the metabolic demands of continuous pregnancy and lactation. Dairy herds have become concentrated onto smaller parcels of intensively cropped and often artificially fertilised grassland and the majority are housed indoors during the winter, mostly in cubicles[11,30,31]. In the UK, 46% of dairy cows now live in herds of over 100[15].

Table 3. Twenty five years of intensification in the UK dairy industry. Source: Farm Animal Welfare Council, 1997[30].

	1970	1995
Average herd size (cows)	30	71
Average milk yield per cow per year (litres)	3750	5395

The dairy cow's food is designed for high production. A recent report from the agricultural research institute ADAS illustrates this approach. ADAS explains that a cow will produce 40 litres of milk a day if she is given several kilograms of either soya, fishmeal, linseed or lupin a day as a feed supplement, but that feeding the same amount of rapemeal will only produce 35 litres of milk a day. Since soya is the least costly of the best feedstuffs, feeding soya will "maximise [profit] margin a cow"[32].

'zero grazing' dairy cows
Intensively reared cattle are increasingly being kept separated from pasture or forage. A United States Department of Agriculture (USDA) survey of dairy cows in 1996 found that only 58% of operations pastured their cows for 3 months a year or more. Less than half of these pastures provided all the bulk feed for the cows during the pasturing period[33]. At most 50.2% of lactating cows had access to pasture on a daily basis during the summer[34]. In three out of four regions surveyed (the exception being the Midwest) no more than half of operations fed their cows with feed grain grown on the operation. Larger operations of over 100 cows were the most likely to feed their cows a total mixed ration (84% of operations of over 200 cows)[33].

Intensification of the beef industry has aimed for higher meat yield per animal, requiring better quality feed and, as in the case of dairy cows, the intensive management of grass and grazing land to increase the number of animals it can support. Most beef cattle are kept in housing during the winter and some are housed all the year round. The extreme development is in the feedlots of the USA and Australia, where large concentrations of beef cattle are confined in bare paddocks or yards and fattened on grain or concentrate feeds.

Feedlots
In the United States nearly 10 million cattle at any time are held in feedlots of over 1000 animals, according to the USDA's June census for 1998. They are referred to as "cattle on feed". About 2 million fed cattle a month are marketed[35]. According to a *Daily Mail* investigation in June 1999, there are a total of 42,000 feedlot ranches in the US cattle states, where most cattle are treated with growth hormones[36]. Each animal may eat 1400 kg of feed in the 'finishing' period[37]. Diseases of feedlots can include digestive disorders, pink eye and respiratory diseases, associated with unsuitable high-grain diet, dust, flies and overcrowding[38]. A 1993 review by US feedlot veterinarians of the records of 5 large western feedlots showed that 13% of nearly 2 million cattle were treated for illness. Lameness was common, caused for example by hard feedlot surfaces penetrating the sole and leading to toe absesses. Other causes of lameness were footrot, cattle damaging their hooves against the walls and floors of crowded feedlots, muscle damage caused by rough handling and injection site damage[39]. According to a 1995 USDA report, feedlot cattle are commonly given injections of vaccines against clostridial (bacterial) infections and viral infections such as diarrhoea and respiratory diseases, as well as of vitamins and antibiotics[40], which are all necessary to counteract the animals' crowded and unhealthy living conditions. Half of feedlot cattle are given antibiotics in their feed or water[40].

2.5 Sheep

Sheep farming is still extensive but it shares some of the characteristics of intensive farming such as increases in stocking density and the use of some imported feedstuffs. The number of sheep in the UK has increased by about 82% between 1960 and 1995[3] and by 8% between 1995 and 1998[20]. There were about 44 million sheep and lambs in June 1998[15]. The UK and Spain are the European Union's largest sheep producers. The total number of mainly adult sheep and goats recorded by Eurostat in the EU in December 1996 was over 100 million, with the UK accounting for around a quarter of the total[20]. Subsidies are paid per sheep and this is widely believed to have encouraged overstocking and overgrazing. The Royal Society for the Protection of Birds (RSPB) is one of the organisations concerned about damage to wildlife habitats caused by high concentrations of sheep and recommended recently that subsidies should be paid according to the area farmed and not according to the number of sheep a farmer keeps[3].

Welfare of sheep
The Farm Animal Welfare Council's 1994 report noted that a ratio of 1 shepherd to 1000 ewes is now common. The welfare problems of sheep identified by the FAWC included an average deathrate of newborn lambs of 10-15% and often much higher, a high deathrate of ewes in lambing (accounting for 75% of all deaths of ewes) and a high incidence of lameness[41]. There are also anecdotal reports of neglect of sheep in response to subsidy incentives[42]. The FAWC recommended that headage subsidies should be dependent on good husbandry.

Many of today's intensively farmed animals live in overcrowded, barren and unhealthy conditions. Compassion in World Farming Trust believes that all farm animals should have access to the outdoors, comfortable bedding, natural light and ventilation and sufficient space allowance to permit natural behaviour and exercise.

3.0 Growing animal feed

We have seen that factory farming of animals usually involves separating the animals from their natural sources of food and feeding the animals a "high production" diet. The need to produce large quantities of high-protein and high-energy feedstuffs for factory farmed animals is a fundamental cause of the environmental damage done by intensive farming today.

We start by considering how feed is produced and what methods (such as use of insecticides, herbicides and fertilisers) are used in production. Then we go on to look at the consequences of mass animal feeding. For our farming methods to be sustainable, all the inputs such as feed and chemicals need to be harmlessly absorbed by the animals or the environment. Far from this, animal factory farming has given us a catalogue of unintended side-effects and potentially damaging waste products to be disposed of.

3.1 Protein and productivity

Like humans, farm animals need to eat protein to grow and maintain body tissues and carry out biochemical functions. Most or all of this protein would normally come from plants. Farm animals' bodies convert the plant protein they eat into animal protein, such as muscle, milk and eggs, which is then eaten by humans. For farm animals to be very fast-growing and high yielding, they have to be fed a high protein diet. As we will see, this is part of an environmentally damaging cycle of overproduction and waste of nutrients.

UK farm animals are fed a number of plant foods such as cereals (wheat, barley, oats and maize), forage crops (grass, forage maize and legume forage crops such as clover) and also higher protein plants such as oilseed rape or soyabean. These plants vary in the amount of protein and also the usefulness of the protein they contain. Soyabean meal contains 55% crude protein, compared to 17% for grass and 12% for wheat or barley. Proteins consist of different types of amino-acids and those that cannot be synthesised in the animal's own body are called essential amino acids (EAAs). These need to be obtained from the diet. Grass is a good source of protein for ruminants, although the protein content decreases later in the year and when grass is stored as silage for feeding during the winter. Cereals are generally low in certain of the EAAs, whereas soyabeans and oilseed rape are generally high in protein and contain a good proportion of the EAAs. Soyabean is the main protein for inclusion in pig and poultry feeds and worldwide it is the most important high-protein feed ingredient. However, soyabeans can only be grown in a warm climate. In the UK around 1 million hectares are planted with non-grass forage crops and pulses for feed[43,15] and around 40% of the total cereal crop is used for animal feed[43].

The seach for low-cost protein led to the practice of recycling farm animal meat and bone meal (MBM) into commercial animal feed, now banned in the UK in the wake of the BSE outbreak. Animal protein is widely used in feed in the form of waste products such as blood meal, feather meal and fishmeal. Recent scandals in France[44.45] and Ireland[46,47] have concerned the use of sewage and animal remains such as washings and body fluids from animal cadavers and abandoned pet dogs in farm animal feed. Fishmeal is fed to dairy cattle and breeding ewes and can be 5-10% of compound pig and poultry feed. Dairy cattle may eat half a kg of fishmeal a day and ewes may eat up to 1 ¾ kg a week[48].

Because we make such high demands on our animals in terms of growth and productivity, they need to eat large quantities of protein. The environmental group Friends of the Earth estimates that each kilogram of beef produced in Europe needs 5 kg of high-protein feedstuffs[49]. A dairy cow on a high intensity farm is likely to eat approximately 4700 kg of grass and silage and nearly 1650 kg of concentrate protein feed a year, according to scientists at Wageningen Agricultural University in The Netherlands[50].

Compassion in World Farming Trust believes that the growing of excessive quantities of high protein feedstuffs to increase the productivity of intensively farmed animals is an inefficient and environmentally damaging use of agricultural resources.

3.2 Land use for animal feed

One of the important environmental consequences of our decision to keep ever-increasing numbers of farm animals is that very large areas of land are needed to grow the necessary crops for animal feed. On a world scale, livestock production makes heavy demands on land use. According to the FAO, sixty percent of the world's agricultural land is used for grazing livestock[51] and ¼ of the world's croplands is used for animal feed. In total, 2/3 of the world's agricultural area and 1/3 of the total global land area is used for maintaining livestock[1].

The UK and the EU as a whole devote most of their agricultural area to providing animal feed. Fig. 1 shows the approximate proportions of UK agricultural land used for feed crops, grass and grazing. Total grassland and grazing land amounted to 67% of the total in 1998, according to the MAFF census[15]. Wheat and barley together accounted for 18% of all agricultural land or 66% of cropland. In 1998, 39% of the wheat and 51% of the barley produced were used for domestic animal feed[15]. In total at least three quarters of the UK agricultural land is used for domestic animal feed.

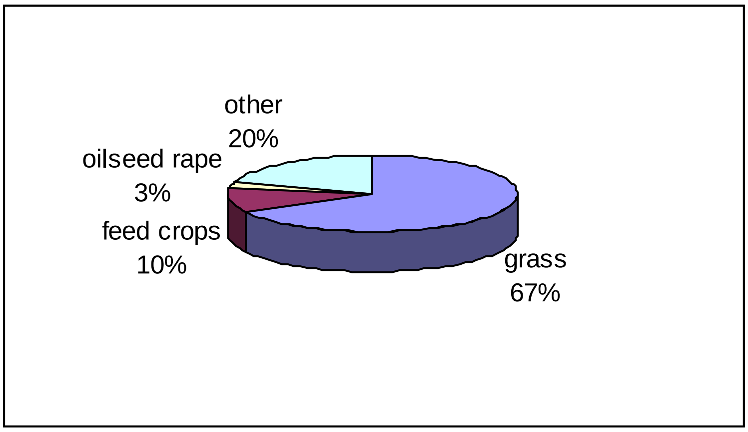

Figure 1. Uses of UK agricultural land. 'Grass' includes temporary grass, permanent grassland and rough grazing. 'Feed crops' include cereals and forage crops.
(Adapted from MAFF et al., *Agriculture in the United Kingdom 1998*[15], also using data from Entec Ltd., *Home Grown Proteins for Animal Feed,* 1998[43]).

In the EU too, according to the industry publication AgraEurope in 1996, nearly three quarters of the agricultural land is used to produce animal feed[52]. Thirty-five percent of Europe's cereals are blended into animal feedstuffs[21]. Between 1975 and 1990, according to the European Commission, over 4 million hectares of meadowland was ploughed up across Europe – much of it for the production of high-yield fodder crops such as maize. Fodder production has also become more intensive [53]. In spite of this, neither the UK nor the EU as a whole grows enough plant protein to feed all its animals. Both are large net importers of proteins and non-grain feeds such as soyabean, as we discuss in the next section.

Intensification means that fewer and fewer animals live only on forage crops grown locally. As a result, during the last 30 years there has been a large growth in production of specialised commercial compound feeds (or concentrate feeds) to deliver the desired quantities of protein and energy for animal growth and productivity[21]. The main components of compound feed are high energy crops and high protein crops. High energy crops are usually cereals or cereal substitutes, such as cassava, and high protein crops are often soyabean or other oilseeds such as rapeseed. A study coodinated by the FAO and the World Bank estimates that concentrate feeds now account for about 40% of all feed in the developed countries and 12% in the developing countries[1].

In each of the economically most important areas of the world (Western Europe, North America, Central and South America and East Asia) FAO figures show that between 33% and 35% of the arable land was taken by animal feed production in the early 1990s. One third of the world's grain harvest is eaten by farm animals. Between the mid-1980s and early 1990s consumption of concentrate feeds grew by between 3% and 7% a year in Asia and Australasia. The global use of oilseeds, cakes and meals almost doubled in the 25 years up to 1990[54]. Ninety-five percent of US soya production of nearly 100 million tonnes per year currently goes into animal feed around the world[55].

Table 4. Percentage of world production of selected crops and fishmeal used for animal feed, 1993. Source: FAO, World Bank and USAID, 1996[54].

Crop	*% global production used as feed*
wheat	20
maize	73
All cereals (average)	44
Oilseeds [1]	10
Oilmeals [1]	95
fishmeal	93

[1] includes cottonseed, groundnut, palm kernel, rapeseed, sunflower and soyabean.

The fact that a significant proportion of the world's total agricultural resources has to be used to provide high-quality feedstuffs is an indictment of our current animal farming methods. Compassion in World Farming Trust believes feed production has also made a major contribution to the environmentally damaging intensification of arable farming.

3.3 The failure of self-sufficiency

The agricultural policies of the UK and the EU were designed to pay large subsidies to farmers in order to gain national self-sufficiency in food. The figures show just how far this has failed in terms of feeding Europe's intensively farmed animals (Tables 5 and 6). Both the UK and Europe are net exporters of grain, but we are dependent on imports for a large proportion of our protein for animal feeds.

In 1995 the UK imported all of its 3 million tons of maize gluten, sunflower, soyabeans, molasses and other oilseeds for animal feed[43]. According to a 1999 Report from the European Parliament, the EU imported 70% of its total protein used for animal feed in the year 1995/96. The EU's 1995/96 trade deficit with the US in materials imported for animal feed was 5 billion ECU[21]. The European Parliament commented:

> European agriculture is capable of feeding Europe's people but not its [farm] animals[21].

Table 5. UK production and consumption of protein seed crops for animal feed, 1995. Source: Entec, 1998[43]

	UK production (1000 tonnes)	*main animal feed usage*	*UK use for animal feed (processors and home fed) (1000 tonnes)*
wheat	14314	59% poultry, 29% pigs	5166
barley	6830	56% poultry, 24% pigs	3384
oats	618	-	213
oilseed rape	1041	78% cattle, 16% pigs	679
beans + peas	687	pigs, cattle, poultry	194
maize gluten	-	90% cattle	548
sunflowers	-	69% cattle, 14% sheep	532
soyabeans	-	55% poultry 32% pigs	1120
molasses	-	68% cattle 30% sheep	481
other oilseeds	-	93% cattle, 4% sheep	480

Note: For comparison, UK production of grass was 66498 thousand tonnes and production of other forage crops was 5618 thousand tonnes.

Table 6. EU's trade deficit in agricultural products for animal feed with the USA, 1995/96. Source: European Parliament, 1999[21] .

protein rich oilseeds (mainly soya)	2.1 bn ECU
animal feed (corn gluten feed and oilseed cake)	1.2 bn ECU
cereals (including maize and maize products)	0.5 bn ECU
fish products	0.2 bn ECU

The protein content of a crop is typically only 20-40% of its gross weight. On this basis, the European Parliament has calculated that in 1995 Europe imported 97% of its soyabean protein (the world's main source of protein for animal feed), 62% of its sunflower protein, 23% of its rapeseed protein, 28%

of its legume protein (peas, beans, etc.) and 53% of its fishmeal protein used for animal feed (Table 7). In total Europe imported 70% of the high quality protein used in animal feed. EU consumption of soya cake alone has risen from 38.5 million tonnes in 1990/91 to 40.5 million tonnes in 1992/93 and 43.5 million tonnes in 1994/95[21].

Table 7. EU production and consumption of selected protein-rich raw materials for animal feed 1995/96 (1000 tonnes of protein). Source: European Parliament, 1999[21].

raw material	*protein production*	*protein consumption*	*% consumption grown in Europe*
soya (seed+cake)	345	11554	3
sunflower (seed+cake)	538	1401	38
rapeseed	1551		77
legumes	803	1122	72
fishmeal	369	794	47
all proteins			30

Note: Quantities are given in 1000 tonnes of protein, not weight of raw materials.

3.4 The global trade in feedstuffs

Where do Europe's imports of animal feed come from? Several organisations have made estimates of the amount of agricultural land throughout the world which is utilised by Europe to feed its farm animal population. Europe imports most of its soya from the USA, Brazil and Argentina. The EU has only 300,000 hectares of land producing soyabeans compared to nearly 26 million hectares in the USA, 12 million in Brazil and over 6 million in Argentina[21]. These distant lands used to bail out the European factory farming system have been named the 'ghost acres' of Europe[56].

Much of our feed imports come from countries which suffer from poverty and environmental degradation. A report for Friends of the Earth has estimated that in 1995 the UK alone made use of over 400,000 ha of land for growing the soyabeans we imported, over half of them in Brazil. Brazilian smallholders have been displaced to make way for the soyabean plantations and have often moved to the North East of the country, where they may become involved in rainforest destruction[49]. *The Oxfam Poverty Report* in 1995 commented that Brazil's soya trade:

> proved considerably more efficient at feeding European cattle than maintaining the livelihoods of poor Brazilians[57].

On 1995 figures, it is estimated that the UK's annual import of feedingstuffs is equivalent to the use of 1.75 million hectares (17500 km^2) of land[49]. This area is equivalent to adding 35% to the current UK land under tillage or adding 28% to the 6 million hectares of UK arable land[15].

The EU statistical office recorded that in 1997 European Union countries were provided with nearly 90,000 tonnes of sunflower seed and cake by the countries of central and eastern Europe. Senegal and Argentina provided 34,000 tonnes and 81,000 tonnes of groundnut cake respectively. Thailand and Indonesia provided 2.6 million tonnes of cassava (a cereal substitute). Indonesia and the Philippines provided over 300,000 tonnes of coconut cake and nearly a million tonnes of palmnut residue was provided by Indonesia, Malaysia, the Philippines and Thailand together[58].

In addition to plant-based materials, in 1998 the UK imported 92% of its fishmeal, according to the GAFTA/FIN *Fishmeal Update*[48], mostly from non-EU countries such as Iceland, Norway, Peru and Chile.

The fact that Europe needs to import 70% of its high quality protein for animal feed underlines the failure of agricultural policies that have encouraged overproduction and over-specialisation. Compassion in World Farming Trust believes that the the EU's Common Agricultural Policy should be reformed with the aim of discouraging overproduction of animals and promoting extensive farming and mixed farming.

3.5 The cost of high inputs

Farming methods in the last half century have changed rapidly as a result of policies which have favoured food production at the expense of the conservation of biodiversity and the protection of the landscape. *British Government Panel on Sustainable Development, 3rd Report, 1997*[59]

We have seen that animal factory farming depends on a large supply of high-quality feedstuffs at sufficiently low cost. Compassion in World Farming Trust argues that this need has been one of the main motives behind the industrialisation of arable farming and its destructive environmental consequences. Intensive arable farming and intensive grazing depend on monocultures and high inputs of fertilisers, herbicides and other pesticides, all of which are now known to be damaging to wildlife and to the quality of the soil, water and air. They also use fossil fuel energy and water.

In many cases, the use of costly inputs has been encouraged by subsidised guaranteed prices introduced from the 1940s, which provided farmers with money to invest in agrochemicals and intensification[31,60]. The European Commission's 1999 report *Directions Towards Sustainable Agriculture* acknowledges that

> A high level of price support in Europe has favoured intensive agriculture and an increasing use of fertilisers and pesticides. This resulted in pollution of water and soils and damage done to certain ecosystems; resulting high treatment costs had to be borne by consumers or taxpayers[6].

Production of animal feed, which takes up large amounts of agricultural land, has made a major contribution to the intensification of agriculture. Below is a summary of the inputs that are needed in order to feed our intensively farmed animals and some of the results for the environment:

Inputs
land – crops, forage and grazing
fertiliser
insecticides, fungicides
herbicides
water
fossil fuel energy
transport

Environmental results
monocultures – crops, grazing
loss of hedges, ditches and landscape
loss of wildlife habitat and food
loss of species
pollution of water and soil
soil damage and erosion
loss of water reserves
deforestation
greenhouse gas emissions

The results of intensive farming have been spelled out by experts such as the British Government Panel on Sustainable Development's 3rd report in 1997. The report lists as causes of the "adverse impact of agriculture on biodiversity": mechanisation, specialisation, higher use of agrochemicals and nutrients, simpler rotations and damage inflicted on habitats for example by land drainage[59].

In 1999 the European Commission also gave a detailed account of how intensive agriculture has damaged Europe's environment. The Commission tells us that the destruction of hedges, stone walls, ditches, the drainage of wetlands and the loss of field margins and fallows have led to loss of habitat for birds, plants and other species. Excessive use of water for irrigation, especially in Mediterranean countries, has led to falls in the water table and salinization by seawater invading underground supplies. The use of fertilisers and pesticides in Europe has tripled overall since the 1950s. Although the volume of pesticides being used has decreased, modern pesticides are more efficient and the report warns that the environmental effects have probably not been reduced. Soil erosion is increasing, due to compaction by heavy machinery, improper irrigation and use of monocultures[6].

Compassion in World Farming Trust believes that, having recognised the environmental damage caused by high-input farming, the UK government and the EU should take urgent steps to promote lower-input farming and extensive livestock systems.

3.5.1 Fertilisers and pesticides

According to reports published in *Nature*, the world use of nitrogen fertilisers is estimated to have risen 6.9 times since 1960 and now amounts to over 70 million tonnes of nitrogen a year. The world use of phosphorus fertilisers increased by 3.5 times since 1960. The *Nature* report notes that a doubling of world food production using our present methods would require another 3-fold increase in nitrogen and phosphorus use[61,62]. The UK alone used 1.3 million tonnes of nitrogen fertiliser in 1994, 8% more than in 1980, and 400,000 tonnes of phosphate (as phosphorus pentoxide, P_2O_5)[20].

There are now 450 active chemical ingredients approved by MAFF as pesticides (mainly insecticides, fungicides and herbicides)[63]. This number has increased more than 5-fold from 83 ingredients in 1965[63] and has increased 30-fold from 15 ingredients in 1950[12]. By 1994, winter wheat received on average 8 chemical sprays, including 3 fungicides[31]. According to the Environment Agency of England and Wales, pesticides have a high potential to pollute water, may be persistent in the environment and their breakdown products may be toxic to some plants and animals. The EU Drinking Water Directive (80/778/EEC) allows up to 0.1 microgram per litre of an individual pesticide in drinking water[63]. In view of the high levels of pesticide usage, it may not be surprising that chemists at the Swiss Federal Institute for Environmental Science and Technology have found that rain in Europe often contains higher levels of dissolved pesticides than the limit for drinking water[64].

In 1997 a total of 59,000 kg of the highly toxic chemical lindane, associated with hormonal and immune system damage, birth defects and breast cancer, was used in the UK to treat wheat, maize, linseed and oilseed rape[65]. This is in spite of the fact that the use of lindane in sheep dip was discontinued in the mid-1980s. Faced with increasing evidence of its harmful effects, in 1999 the UK government banned the use of lindane for seed treatment[66].

A major use of pesticides is for animal feed production. According to the industry publication *Agrow-World Crop Protection News*, 1.7 million ha of UK fodder crop and grassland were sprayed in 1997 and the use of herbicide is still increasing. The area of UK fodder crops treated with pesticides has increased by 56% since 1993. Herbicides accounted for 71% of the area sprayed and 93% of the total pesticides used[67]. The two crops which account for the highest percentage of herbicides sales worldwide are soya and maize[68] – two major components of animal feed.

Fertilisers and pesticides reduce biodiversity. In the UK, the agricultural writer Graham Harvey has described the effects of fifty years of excessive use of fertilisers and pesticides in crop production and grazing as ‘the killing of the countryside’[31]. Nitrogen fertiliser application to wheat in the UK has increased 6-fold and application to temporary grass has increased 7-fold since the 1950s. Application to permanent grassland went up by 38 times, with a doubling of the area treated, between the mid-1960s and the mid-1980s. 85% of all grassland in England and Wales is now treated with nitrogen fertiliser[69]. The effect of this nutrient-enrichment has been to knock out the less competitive plants and with them their associated insects. Harvey explains that the result has been to reduce the biodiversity of grazing areas to monocultures:

> The aim of our production-fixated livestock industry is simple - to fill the green fields of Britain with a single species, the fast-growing perennial ryegrass.[70]

He continues:

> For a century now we have known that artificial fertilisers despoil the environment. Yet Britain's farmers have felt it necessary to demonstrate the fact afresh in every corner of the land[71].

A major concern about the use insecticides and herbicides is the damage they do to biodiversity by reducing food and habitat for other species. Although the directly toxic effects of persistent pesticides such as DDT were recognised by the 1960s, for a long time the indirect effect of pesticide use was not recognised[31].

3.5.2 Biodiversity

One of the best-known long-term results of pesticide use is the decline in the numbers of farmland birds. In 1998 the British Trust for Ornithology (BTO) published a major review of the conservation status of breeding birds since 1972. Twenty species of birds were placed on the BTO's 'High Alert' list because of severe populations declines of over 50% in the last 25 years[72]. The declines are particularly prevalent among seed-eating species, among farmland species and among grassland or marshland species and include tree sparrows, bullfinches, spotted flycatchers, lapwings, skylarks and linnets[2]. Bird conservation experts have little doubt that changes in farming practices associated with intensive agriculture are the main cause of this decline. Farmland birds feed on seeds, invertebrates, or both. These sources of food have been lost from farmland because the diversity of plant and insect species has been reduced by intensification and the use of monocultures. A study of sparrows, finches and buntings drew this conclusion:

> [T]hose birds that were most reliant on farmland have declined more steeply than the others. Thus the farmland environment has become a much poorer place for these seed-eating birds, almost certainly as a result of agricultural intensification[73].

In a recent report, *The Future of Livestock Farming in the UK*, the Royal Society for the Protection of Birds (RSPB) lists seven changes in farming practice which directly or indirectly reduce biodiversity and remove the food and shelter that birds need. These are: grassland improvement, increased use of artificial fertilisers, increased animal stocking densities, the use of silage instead of hay, decline in mixed farming and loss of arable cropping, removal of hedgerows, copses and rough areas and disposal of increased quantities of animal waste and silage effluent. Livestock at very high densities may even trample the nests and chicks of ground-nesting birds[3]. Each of the items in the RSPB's list is the direct result of the drive to more intensive animal farming.

Animal feed crops have been some of the first targets for genetic engineering, another agricultural development that threatens biodiversity. An estimated 30% to 50% of the US soyabean crop and 40% of the maize crop - both major components of animal feed - is now genetically engineered[55,74]. Four of the ten farm-scale trials of genetically engineered crops approved in England by the summer of 1999 were reported to be fodder maize and the remainder were oilseeds[75]. Expert bodies such as the UK government Advisory Committee on Releases to the Environment (ACRE) and the RSPB have warned that one of the main dangers of the genetic engineering of crops is that it will further decrease biodiversity[4,76].

Factory farming depends on monocultures , whether these are feed crops, grasses or the animals themselves. Of the 250,000-300,000 known plant species only a few hundred are used to any extent in agriculture and only a handful feed most of the world's population, according to an industry analyst writing in *Nature Biotechnology*[77]. Our monocultures of these handful of crops are now taking up a significant proportion of the world's total land area. Worldwide, farm animals have also been specialised and standardised at the expense of traditional breeds which are able to cope with local conditions and lower quality food. In Spain, for example, traditional breeds have fallen from 72% to 19% of the national cattle herd in the last 30 years[78]. Animals from specialised breeds, sometimes referred to by the farming industry as 'genetically superior', have been selected for their high productivity in intensive farming conditions. According to *Farmers Guardian*, dairy cows of 'very high genetic merit' (giving very high milk yields) may be unable to cope with high forage diets or diets containing lower quality ingredients[79]. Using these high-yielding animals is likely to increase the farmer's dependence on inputs of fuel, fertilisers and pesticides to grow the animals' feed and machinery such as ventilators or sprinklers to control the animals' environment[80].

In this context, the biotechnology industry's investment in farm animal cloning research, in order to create herds of genetically identical animals, cannot be seen as environmentally acceptable. Compassion in World Farming Trust deplores the UK government's support for farm animal cloning research.

3.5.3 Water and energy resources

Water and energy from fossil fuels are important natural resources that are heavily used in modern agriculture. A number of studies have tried to estimate the quantities used in intensive animal farming. As we have seen before, the evidence points to animal feed production as a major and inefficient usage of water and energy resources.

In common with other countries, the UK is in principle committed to reductions in the use of fossil fuels, such as petrol, natural gas and coal, as a source of energy, and to increasing energy efficiency in industrial and domestic consumption. Fossil fuel energy is a major input of intensive livestock production systems. Electricity and petrol are used directly by farms and indirectly in the manufacture and transport of the various inputs that are bought in. Energy is needed to fuel vehicles and machinery, to manufacture agrochemicals and veterinary products, to grow, process and transport feed, to build, heat and ventilate farm buildings and to transport equipment, products and wastes to and from the farm. Once again we find that the production and transport of animal feed is the main use of energy in animal farming[1]. A detailed FAO-sponsored study of livestock systems calculated the amount of fossil fuel energy that is needed in the industrial production of beef, veal and sheepmeat (Table 8). Fossil fuel energy is used in various processes involved in producing animal feed and in breeding and maintaining the animals during fattening. The results showed that feed accounts for over 70% of the total energy used in producing these meats. Feed takes 90% of the total energy use for veal production. Veal also consumes over twice as much energy as sheepmeat or beef per kg live weight[81].

Table 8 Fossil fuel energy input needed for intensive meat production. Source: Brand and Melman, 1993[81].

	Energy input (M joules/kg live weight)		
	Beef	*veal*	*sheepmeat*
Animal feed (production, transport, processing)	11.5	41.7	14.0
Breeding	1.3	1.5	0.8
Fattening (buildings, equipment, fuel)	2.7	3.6	4.5

Agriculture is also the world's main consumer of water. It has been estimated that 65% of all freshwater withdrawn worldwide per year is used for agricultural irrigation, compared with 24% for industry. Agricultural irrigation accounts for 87% of freshwater that is consumed and is not recoverable. Irrigated land now produces around 33% of the world's food supply. At the same time, water is becoming an increasingly scarce resource, with water use worldwide having tripled during the last twenty years[82]. A UN agency recently predicted that a continuing increase in irrigation will mean that in 25 years time demand for freshwater may be 50% more than the resources available. Over 40 countries could suffer from "absolute" or "extreme" water scarcity. The UN says that shortages are made worse by pollution, inefficient use and unsustainable use of groundwater[83].

Agriculture contributes significantly to the unsustainable use of groundwater, which has accumulated in aquifers over millions of years and renews itself only slowly. A 1997 review of water resources from Cornell University tells us that 68% of the groundwater withdrawn in the United States is used for agriculture. Sixty-six percent of irrigation water in Texas and 38% in California comes from groundwater[82].

Growing crops need very large quantities of water, whether it is provided by irrigation or by rain. Average precipitation or rainfall for most continents is 700 mm per year, which is equivalent to 7 million litres falling per hectare. The American 'corn belt' receives 8-10 million litres per hectare per year. It is considered that a region of land needs at least 5 million litres per hectare for productive agriculture to be possible, although some crops and animals can be farmed with less than half that amount of rainfall. Much of the water used for agriculture is not recoverable, because it passes through the plants and evaporates from the leaves and stem as the plants transpire. This means that millions of litres of water are consumed per hectare of crop. For example, it has been estimated that 1 hectare of US maize (corn) transpires 4 million litres of water in the growing season while another 2 million litres of water evaporates from the soil. Soyabeans need 4.6 million litres of water per hectare for transpiration. Wheat needs 2.4 million litres per hectare[82].

What are the implications of these figures for animal production? Taking into account the large amounts of feed that highly productive animals need to eat, it has been calculated that 1 kg of animal protein typically takes 100 times as much water to produce as 1 kg of plant protein[84]. To take the example of beef, the production of 1 kg of beef would need 100 kg of forage and 4 kg of grain. This means that the production of 1 kg of beef takes between 100,000 and 200,000 litres of water, depending on the growing conditions[82].

Table 9. Quantities of water needed to produce one kg of crop. Source: Pimentel, 1997[82].

Crop	*Litres water/kg of crop*
Beef	100000
Soyabean	2000
Maize (corn)	1400
Wheat	900
Potato	500

If crops are irrigated, they also use energy for pumping the water. Partially irrigated wheat consumes over 4 times more energy than rainfed wheat[85]. If water has to be pumped from some way below the surface, the energy cost may be increased 3-fold[86].

Irrigation can damage the soil by causing either waterlogging or salinization. Surface water and groundwater used for irrigation contain dissolved salts and these are left in the soil when the water is transpired by plants or evaporates. Salinization is seriously affecting soil in Southern Europe, according to the European Environment Agency[87]. Worldwide it has been estimated that half of all irrigation systems are affected by salinization with the loss of 2 million hectares per year from agriculture[88].

The current world usage of water and fossil fuel energy to produce excessive quantities of animal feed is inefficient and unsustainable. Compassion in

World Farming Trust believes that the present trend towards increasing intensification of animal farming needs to be reversed in order to ensure a sustainable future for agriculture.

4.0 Outputs - wastes, emissions and pollution

4.1 Waste nutrients and the environment

The concentration of large numbers of animals in unnaturally small areas and the need for large amounts of feed are confronting us with major pollution problems. In Europe, according to the European Parliament, there are ‘hot spots’ of farm animal concentrations in Brittany, Belgium, the Netherlands and areas in the north of Germany, Italy and Spain, where animal stocking densities are highest. These are often the same areas that have high levels of nitrates in the environment[21]. When Europe imports 70% of its protein used for animal feed, it is also importing large quantities of nitrogen which can end up as an environmental pollutant.

Nitrogen and the nitrogen cycle

Nitrogen is involved in animal production in several interconnected ways, which we can separate for convenience into:

- Nitrogen in plants, animals and animal feed
- Nitrogen in waste, such as manure
- Nitrogen in fertilisers

Nitrogen (N) is essential for plants and animals and is an important component of protein molecules. Humans and farm animals need to eat proteins in the form of plants or animal products. In contrast, plants can synthesise proteins from their simplest components but they need nitrogen compounds in order to do this. Nitrogen gas (N_2) exists abundantly in normal air but plants can only use nitrogen after it has been ‘fixed’ as a nitrogen compound such as ammonia (NH_3) or ammonium (NH_4^+) in the soil. One of the main ways this is done is by nitrogen-fixing bacteria in the roots of leguminous plants such as peas and clover. Plants take up nitrogen from the soil in the form of nitrate (NO_3^-). The limiting factor for plant growth is usually the supply of nitrates and, in smaller quantities, of phosphorus (P) and other nutrients. Phosphates are needed by plants and animals for essential biochemical processes such as cell division, energy production and photosynthesis.

The ‘nitrogen cycle’ is the series of natural chemical processes by which nitrogen is ‘fixed’ from the atmosphere into nitrogen compounds, is then used by plants to make plant proteins and to make animal proteins when animals eat plants, and then returns to plant-usable nitrate. Plant and animal proteins are broken down in processes of excretion or decay and the nitrogen in them forms ammonium which is then oxidised to form nitrate. The nitrates in the soil can then be used by plants again, or they may be ‘denitrified’ in further chemical reactions and return to gaseous forms of nitrogen in the atmosphere. Artificial nitrogen fertilisers are produced by fixing atmospheric nitrogen by industrial chemical processing, and are usually in the form of ammonium salts such as ammonium nitrate and ammonium phosphate. Human interference in the natural nitrogen cycle has greatly increased both the amount of nitrogen available and its mobility.

Factory farms cause pollution of the environment because the nutrient input to the farm (in fertiliser, feed and manure) is greater than the nutrient output from the farm (in animal or plant products). Large amounts of organic nitrogen-rich material is imported to animal production units as feed. Nitrogen fertiliser may also be used for growing feedstuffs. Large amounts of organic nitrogen-rich waste (manure, waste feed, dead animals) have to be disposed of. When animals are living and excreting in housing, yards or bare paddocks, there are no growing plants to take up the nutrients from their manure. Although in principle manure can be transported to be used as fertiliser for crops on other farms, in many regions it is not economic to transport manure and inorganic fertilisers are used instead. Graham Harvey summarises the problem:

> While [animals] are concentrated on big, specialist units their waste products will always pose a pollution threat to rivers and streams. Arable crops grown in isolation from livestock will continue to need heavy inputs of chemical fertiliser, much of which will inevitably end up damaging the environment[89].

Farm animals only absorb and utilise a small amount of the nutrients they eat. Animal feed is rich in nitrogen and phosphate. Any nitrogen and phosphorus that is not used by the animal for body growth or milk or other production is excreted in faeces and urine. A dairy cow excretes much more nitrogen than she uses in producing milk or body tissue. One dairy cow excretes 138 kg of N and 14 kg of P in a year, according to the *Journal of Dairy Science*[90]. This is estimated to be between 75% and 85% of the nitrogen[90] and 40% of the phosphorus[50] in a dairy cow's diet. Beef cattle, pigs and poultry also excrete between 58% and 78% of the nitrogen in their feed[91].

Table 10. Percentage of protein in feed excreted by animals in faeces and urine. Source: Tamminga, 1992[91].

	% nitrogen excreted
Lactating cow	73-81
Beef cattle	78
Lactating sow	75
Growing pig	68
Laying hen	68
Broiler chicken	58

Agricultural scientists as well as environmentalists now see the high losses of nutrients from livestock farms as a serious problem. There have been numerous studies of ways to make the nutrient input and output balance and minimise the nitrogen lost. Strategies to reduce manure and nutrient output include changes to the animals' diet and feeding enzymes that increase the animals' food absorption. However, to date the frequent conclusion is that intensive farms have a built-in surplus of nutrients, mainly due to fertiliser and feed, which is potentially polluting. A lecturer at a 1999 ADAS conference on *Agriculture and the Environment* told his audience that many pig and poultry feeds have "protein levels which are far too high, resulting in excessive nitrogen excretion"[92]. The opinion of this agricultural scientist from the Agricultural Economics Research Institute in the Netherlands is that:

> Nitrogen pollution resulting from agricultural activities has been observed in large areas of Europe and is a major threat to the quality of the European aquatic environment (ground water, surface water and marine waters). The share of agriculture in total run-off of nitrogen discharge [into waters] is assessed to be around 60%. Intensive livestock production is an important source of the pollution, owing to an insufficient area of land available to these farmers on which to apply the manure[93].

His report continued:

> This is particularly relevant in regions where pig and poultry production is highly concentrated…[such as] the Netherlands, Belgium, Denmark, Germany, the southern part of the UK, the western part of France (Brittany), the Po valley area of Italy and parts of Catalonia…Nitrogen surpluses are observed to be most critical on pig and poultry farms as a result of their high stocking density compared to the nitrogen requirements of the available farmland[93].

The trouble with nutrients: nitrogen and phosphorus

Although both the nutrients N and P are essential to plant and animal life, excessive concentrations of N and P act as pollutants and are environmentally damaging in several ways. The trouble arises when the supply of nutrient nitrogen or phosphorus from manure or artificial fertilisers (in the form of nitrate or phosphate salts) is greater than the plants can use, or when ammonia gas is created from manure or stored slurry.

An estimated half to two-thirds of applied nitrogen fertiliser worldwide is not put to use by crops and gets into non-agricultural ecosystems[61]. There it can damage the balance of species because those plants that can tolerate high levels of nutrients flourish at the expense of others. Nitrogen and phosphorus can get into surface water (rivers and lakes) by running off in rain and can 'leach' through the soil into groundwater (underground aquifers). Excess nutrients in the soil also inhibit the natural process of biological nitrogen fixation. An important 10-year crop study published in *Nature* in 1998 found that conventional high-intensity farming reduced the long-term fertility of the soil compared to organic systems and that 60% more nitrogen was leached into groundwater[61,94].

Nutrient enrichment ('eutrophication') of rivers, lakes and seawater can cause large growths of algae and other aquatic plants that are able to use the nitrogen. This can result in the death of existing plant and animal life in the water because the new plant growths may block out the light and use up the oxygen in the water during respiration and when they decay. Blooms of blue-green algae may be toxic to animals, including humans, and to fish. 60-70% of blue-green algal blooms produce toxins, according to a National Rivers Authority report in 1990[95]. In the USA the coasts and rivers associated with high livestock production, such as those of North Carolina, have suffered large scale fish kills from blooms of the highly toxic algal organism *Pfiesteria piscicida. Pfiesteria* emits a toxin that causes skin lesions on fish and then feeds on them[96].

Ammonia gas from manure or slurry contributes to acid deposition (acid rain) which occurs when oxides of sulphur and nitrogen in the atmosphere (typically from burning of fossil fuels) produce sulphuric and nitric acid and acidify the ground or rivers. These acids can dissolve out metals, particularly aluminium, from the soil and the metals are washed into rivers, where they poison fish. Meanwhile, plants are damaged by being deprived of the metal ions in the soil that they need for growth.

Agricultural experts in The Netherlands, a country with a high density of farm animals and also some of the highest nitrogen surpluses in Europe[93], are particularly concerned by the problem of farm pollution. Their results show that pollution by surplus nitrogen and phosphate is an almost inevitable result of factory farming. A 1995 study of the nutrient balance on dairy farms calculated that typical inputs, consisting of the nitrogen in fertiliser, manure, feed and nitrogen deposition on soil amounted to 504 kg of nitrogen per hectare per year. Most of this was from fertiliser and feed. Outputs of nitrogen in the form of milk and animals amounted to only 111 kg N /ha/yr, leaving a large surplus of 393 kg N/ha/yr to be disposed of[97].

Scientists from the Wageningen Agricultural University calculated in 1996 that a typical high intensity dairy farm in The Netherlands feeds a standard ration of grass, silage and concentrates that has an inbuilt surplus of 20kg of phosphate (as P_2O_5) per hectare. This is 4 times what it needed to be in order to meet Dutch government requirements for pollution reduction at that time[50].

One serious polluting effect of the nitrogen surplus is that it may be emitted as ammonia gas which causes acid rain. The same Wageningen University study estimated that over a quarter of the 400 kg of surplus N per hectare on intensive dairy farms in The Netherlands is emitted as ammonia. Animal farming, particularly dairy farming, accounts for 94% of the total emissions of ammonia in the Netherlands. Ammonia emitted within the Netherlands is responsible for 36% of the total acid deposition in the Netherlands (44% of the acid deposition is caused by gases emitted in other countries)[50].

A further effect of surplus nitrogen in the Netherlands is groundwater pollution. By 1990 pollution of groundwater due to manure and fertiliser use had raised the nitrogen level to 112mg N/litre, more than twice the EU maximum permitted level in drinking water. In the same year it was estimated that 270,000 hectares of grassland and maize land in the Netherlands was saturated with phosphate, which was likely to leach into groundwater[50].

The Wageningen University study concluded:

> In intensive livestock farming regions a major cause of environmental acidification and pollution of ground and surface water is attributable to animal husbandry[50].

Nitrate pollution can come from both “diffuse” sources of pollution (such as run-off and leaching) and from “point” sources of pollution (such as slurry spills). The River Tamar in Devon has suffered major slurry spills in 1998 and 1999. In December 1998 a dairy farm waste lagoon at Holsworthy was allowed to overflow into a stream when the lagoon pump was not working properly, badly polluting the river downstream of the farm. In July 1999 a slug of farm waste and slurry pollution moved down the river from the Bridgerule area and removed 85% of the river oxygen. The Environment Agency estimated that around 16 km of the river were polluted and nearly 10,000 fish were killed[98].

Slurry is a liquid mixture of urine and faeces and is very high in nitrogen and potentially highly polluting to soil and water. Large amounts of slurry production is a feature of indoor housing of animals without straw. Slurry is stored in tanks or lagoons, sometimes under the animal housing, and is used for spreading as fertiliser on fields. Accidental spills or leaks of slurry from lagoons into waterways can cause major pollution and damage to wildlife. A measure of the pollution potential of organic matter in water is the ‘Biological Oxygen Demand’ (BOD), which is the amount of oxygen taken up by microorganisms in the polluting material. The BOD for slurry from pigs or cattle is between 30 and 100 times greater than for untreated household sewage[99]. Over half of the nitrogen in animal slurry is in the form of ammonium (NH_4^+) which tends to convert to ammonia (NH_3); as much as 30% of the total N in slurries may escape into the environment as ammonia gas[11].

Silage is another potential pollutant. Silage is conserved and fermented grass (or other forage crop) now commonly fed to housed cattle in winter instead of hay. Silage making and hay-making are both methods of conserving grass for the winter, but silage-making is less weather-dependent than hay-making and allows several cuts of grass to be made in the season. Because of these advantages the tonnage of silage has increased nearly 8-fold from 1971 to 1991 and by 1994 it accounted for 92% of the total tonnage of conserved grass. The moisture content of the ensiled grass is typically 70% or more by weight which can produce tens of litres of liquid waste (known as silage effluent) per tonne of ensiled grass[100]. According to the Environment Agency[101] silage effluent can be 200 times more polluting than untreated sewage. It is also acidic and highly corrosive and when mixed with slurry it produced toxic gases[102]. Like slurry, if silage effluent gets into water courses, it rapidly removes the dissolved oxygen from the water[103]. A study commissioned by English Nature and others in 1997 reported that silage effluent caused over 200 water pollution incidents in the UK in 1996[104].

There is no doubt among agricultural scientists or environmentalists that excessive concentrations of intensively farmed animals are a major source of waste nutrients which are polluting the environment. Compassion in World Farming Trust believes that, rather than funding research on how to make factory farming less polluting, governments should be actively promoting a reduction in animal numbers throughout Europe and a move towards extensive animal farming and sustainable mixed farming.

4.2 The manure mountain

We have seen that intensively farmed animals produce very large quantities of excreta that is rich in nutrients and potentially polluting to the environment. This section gives details on the amounts typically produced by different farm animals, using data from the UK and the USA.

ADAS scientists in the UK, among others, have shown that manure from laying hens and broilers is potentially the most polluting because it contains the highest percentage of nitrogen and phosphate. A battery hen's manure contains 4.2% nitrogen and 2.8% phosphate, around seven times more than in cattle manure. In turn, a dairy cow produces the most excreta relative to her weight. A dairy cow is approximately the same weight as 250 laying hens. She produces 57 litres of excreta a day, about twice as much as the 29 litres a day excreted by 250 laying hens[99]. According to the ADAS figures, the UK's 3 million dairy cows could produce as much as 62 billion litres of excreta a year. The UK's 30 million laying hens could produce 1.3 billion litres of excreta a year.

How sustainable is the UK's production of manure? MAFF estimated in 1993 that manure accounted for a quarter of the total of 2.0 million tonnes of nitrogen applied to agricultural land as fertiliser[105]. The limit of sustainable manure spreading in areas vulnerable to nitrate pollution has now been defined as 250 kg N/ha/year following the 1991 EU Nitrates Directive (91/676/EEC)[106]. A study of the UK situation in 1996 from the Scottish Agricultural College tells us that the total land needed for sustainable disposal of the nitrogen from the UK pig herd is nearly 0.2 million hectares. For the UK poultry flock nearly 0.8 million hectares would be needed[10]. Given that the total arable land area of the UK is 6.3 million hectares[15], the sustainable disposal of pig and poultry manure needs over 15% of our total arable land.

Biological oxygen demand (BOD)
Typical levels of BOD in milligrams per litre for some human and farm wastes[99]:

Raw domestic sewage	300-400
Cattle slurry	10000-20000
Pig slurry	20000-30000
Silage effluent	30000-80000

In the United States, manure pollution is raising serious concern. The US Department of Agriculture has stated:

> The continued intensification of animal production systems without regard for the adequacy of the available land base for recycling presents a serious policy problem[13].

A major US study of the problem of animal farm pollution commissioned for Senator Tom Harkin of Iowa[13] set itself to calculate the amount of solid manure, nitrogen and phosphorus excreted by the 8 billion broilers and turkeys and the 200 million pigs and cattle produced yearly in the USA (Tables 11 and 12).

The Senate Committee report[13], published in 1997, estimated that 1.4 billion tonnes of solid manure is produced by US farm animals per year. The total waste from farm animals is 130 times what is produced by the human population (around 5 tonnes per person). The report calculated that large livestock operations are the waste equivalent of towns or even cities. Two hundred dairy cows can produce as much nitrogen in their manure as a town of 10,000 people. A pig operation producing 2.5 million pigs a year would have a waste output greater than the urban area of Los Angeles[13].

The manure disposal problem in United States factory farming has been summed up by Ken Midkiff of the Missouri Sierra Club thus:

> The problem is that nature never intended for 80,000 hogs to shit in the same place[107].

Table 11. Manure and nutrient output of farm animals in the USA per year. Source: US Senate Committee, 1997[13].
Note. In terms of animal weights, a 500 kg dairy cow is approximately equal to 10 growing pigs of average 50 kg weight, 5 pigs of 100 kg slaughter weight or 250 laying hens.

	solid manure (tonnes/animal)	*Nitrogen (kg/animal)*	*Phosphate (kg/animal)*
pig (sow)	3.1	17.7	11.3
pig (finishing)	1.9	13.2	8.2
dairy cow	20	108.4	54.4
beef cattle	12	66.7	33.1
laying hen (1000 birds)	10	370.1	304.8
broiler chicken (1000 birds)	9	265.4	265.4
turkey (1000 birds)	36	635.0	635.0

Table 12. Total farm animal solid manure production in USA[13]

animal	*solid manure (tonnes/year)*
cattle	1.2 billion
pigs	117 million
chickens	14 million
turkeys	5 million

Large-scale air and water pollution incidents affect the major US factory farming areas. In Minnesota, 34% of the river mileage and 30% of lakes are officially designated as "impaired" by feedlots. In 1997 a spill of 380,000 litres of animal waste into Beaver Creek killed 690,000 fish. Heavy metals such as zinc and copper are added to the feed of pigs and poultry to improve their growth and these metals can end up contaminating the soil. In North Carolina, 17% of soil samples in the major poultry-producing counties contained high levels of zinc in 1995[26]. In the same year an 8-acre lagoon containing pig waste burst, spilling 95 million litres of waste into the New River. A total of 10 million fish were estimated to have been killed in the state by spills in 1995[107,26]. Outbreaks of the toxic algae *Pfiesteria piscicida* killed an estimated 450,000 fish in 1997. Pig operations contributed 73% of the North Carolina's annual emissions of 81,000 tonnes of ammonia gas from agriculture[26].

The US Environmental Protection Agency has identified the poultry industry on the Atlantic coast of Maryland, Virginia and Delaware as the primary source of excess amounts of nitrogen and phosphorus in the Chesapeake and other coastal bays. The region produces 600 million chickens and 750,000 tons of manure a year, according to a 1999 *Washington Post* report[108], more than a city of 4 million people. Maize is brought from the mid-West by rail to feed the chickens. The *Post* article explains: "The rail cars return, but the nutrients stay behind, deposited on fields as manure and discharged by slaughterhouses". Sussex Country, Delaware, has to absorb the manure of 232 million chickens a year, while it is estimated that the crops growing there can only make use of manure from 64 million chickens[108].

4.3 Water and soil damage in Europe

With the advent of EU Directives on water, air and soil quality, control of farm pollution is becoming a priority. Unfortunately, the solution is sometimes seen in terms of better management of the existing intensive farming system, rather than a real change in the approach to animal farming. A statement from MAFF in a recent report *Tackling Nitrate from Agriculture: Strategy from Science*[109] illustrates this point when it tells us:

> Agricultural land is the main source of nitrate in most rivers and groundwaters[109]

but continues:

> Nitrogen fertilisation is a vital component of productive grassland and arable crop management, and plays a crucial role in helping to sustain profitable and competitive farm enterprises….Similarly, increases in nitrogen use have underpinned higher livestock stocking densities.[109]

In a more critical spirit, recent reports from the UK's Environment Agency and the European Environment Agency have described the damaging effect of animal farming on rivers and lakes. The Environment Agency's 1998 report on *The State of the Environment of England and Wales*[110] lists the following impacts of farming on fresh waters:

- surface run-off and groundwater pollution by excess fertilisers, pesticides and slurry
- emissions of ammonia from livestock, contributing to acidification and global warming
- draining of wetlands and extending field margins to river banks, with loss of habitats and biodiversity
- overgrazing and changes in land use leading to soil and bank erosion and siltation of rivers.

The trend to increased production of crops such as maize and oilseed rape, which are used for animal feed, is singled out as a probable contribution to increased nitrogen use and soil erosion. On groundwater pollution by nitrates, the Agency tells us:

> There is extensive pollution of the unconfined parts of the major UK aquifers. In many boreholes [nitrate] concentrations are at, or approaching, the maximum permissible concentrations for drinking water[110].

The report explains that groundwater pollution is especially serious because of its long-term nature - water may take up to 50 years to pass though an aquifer, which means that pollution can take a long time to become evident. Currently both rivers and aquifers show nitrate levels either stable or increasing. Nitrate in surface and ground waters comes largely from agricultural sources[110].

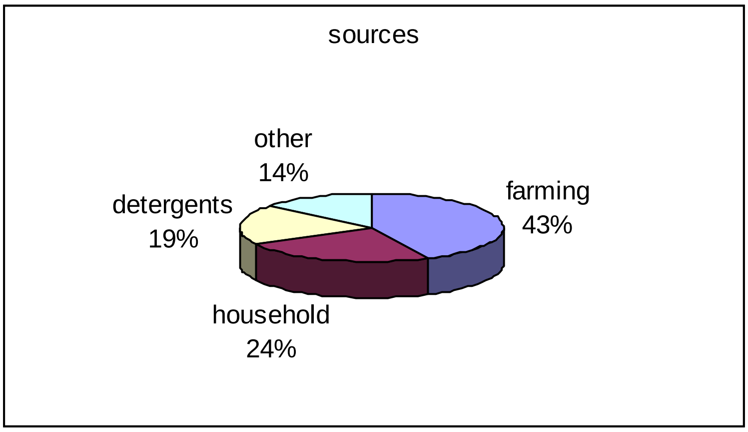

Figure 2. Main sources of phosphorus inputs to rivers and lakes in the UK. Adapted from Environment Agency, *Aquatic Eutrophication in England and Wales*, 1998[111].

A separate Environment Agency study of the eutrophication (nutrient enrichment) of waters in England and Wales[111] tells us that livestock contribute 29% and fertiliser another 14% of the phosphorus input to surface waters, together making up 43% of the total. Farming is thus the largest single source, with human and household waste coming second with 24% (Figure 2). The report explains that farms routinely produce a surplus of phosphorus, and if even small amounts get into watercourses they can have large effects on aquatic life[111].

As a result of pollution, 33 out of 41 lakes designated as Sites of Special Scientific Interest (SSSIs) are affected by eutrophication. Over 5% of SSSIs suffer from acidification. Seven freshwater habitats, including rivers, lakes, standing waters, fens and grazing marshes, are threatened by agriculture and suffer from nutrient enrichment[110]. Between 1989 and 1997 some 3000 different freshwater bodies have been affected by algal blooms, mostly the potentially toxic blue-green algae (cyanobacteria). By 1998 the UK government had officially identified 80 rivers and lakes as affected by eutrophication. Estuaries and coastal waters are also affected; in 1998 five estuaries were found to have excessive algal growth[111]. In the summer of 1999 a toxic ‘Red Tide’ algal bloom, which causes paralytic shellfish poisoning, was reported in the Fal Estuary[112]. Both eutrophication and acidification are processes that change or threaten the balance of species in the affected ecosystem.

The European Environment Agency (EEA) agrees that serious damage has been done by agricultural pollution. The EEA’s ‘Second Assessment’[87] of 1998 tells us that:

> With the increase of livestock production, animal manure production and the emission of reduced nitrogen compounds, eutrophication has become a major problem in north-west Europe and is increasing in significance in southern Europe[87].

Europe's environment

The European Environment Agency in its Second Assessment of 1998 recorded an inadequate (+/-) or negative (-) 'progress score' to the following six of twelve key environmental problems, all of which are related directly or indirectly to Europe's intensive livestock industry[87]:

climate change	-
acidification	+/-
biodiversity	-
inland waters	+/-
marine and coastal environment	-
soil degradation	-

As we have shown, there is now official recognition that factory farming has caused serious pollution of water and damage to soil in Europe. Compassion in World Farming Trust believes that the evidence from the Environment Agency and the European Environment Agency highlights the need for the restructuring of the European animal farming industry to reduce animal numbers and stocking densities.

4.4 Gas emission and air pollution

> Livestock buildings are a major anthropogenic source of atmospheric polllutants, such as ammonia, nitrous oxide, methane and carbon dioxide, which contribute to soil acidification and global warming. *British Poultry Science*, 1997[113]

The 'greenhouse effect' is a normal process in which gases in our atmosphere absorb heat radiated from the earth and re-radiate it, preventing the earth from losing all its heat back into space. Although it is still unclear how much climate change (global warming) is due to emissions of human-generated greenhouse gases increasing the natural greenhouse effect, it is certain that we are generating a large quantitiy of greenhouse gases from intensive animal farming. A contributor to a 1997 publication on *Climate Change Mitigation and European Land Use Policies* has emphasised this point:

> Beef is a greenhouse-gas intensive food…Understanding the greenhouse-gas implications of different livestock-production modes is essential to an effective greenhouse-gas minimising strategy[114].

Animal production involves for example, production of carbon dioxide (CO_2) from the use of fossil fuel energy, nitrous oxide (N_2O) emissions from the use of inorganic fertiliser and methane (CH_4) emission from cattle digestion and manure.

We have seen that fossil fuel use, is a major input to animal production and especially animal feed production. The burning of fossil fuels emits carbon dioxide. More harmlessly, all farm animals produce carbon dioxide by normal respiration. The amounts from one animal per year are about 4000 kg for cattle, 400 kg for sheep and 450 kg for pigs. This compares with about 300 kg for a human being and 5500 kg for a typical passenger car[115]. These emissions are not generally considered a problem, since they do not involve burning fossil fuels. However, carbon dioxide can be a health hazard in high concentrations. A researcher from the Wageningen Agricultural University reports that in waste storage pits the concentration of carbon dioxide, ammonia, hydrogen sulphide and methane can become so high that the oxygen level drops to almost zero, creating a real danger of suffocation for any worker who gets too close[91].

Methane is a much more potent greenhouse gas than carbon dioxide, although its concentration in the atmosphere is relatively small. It is increasing by almost 1 percent per year. Farm animals and manure management contribute about 87 million tonnes a year, about 16% of all methane production worldwide. Most of this comes from digestive fermentation by beef and dairy cattle and the rest from stored liquid manure[1]. A researcher on climate change has commented:

> Worldwide, livestock are likely to be the greatest anthropogenic contribution to methane emissions, which, as a potent greenhouse gas, contributes to the risk of global warming and beef cattle contribute at least half of livestock-related methane emissions[114].

Although methane emissions from animals' digestion and manure can be shown to be greater for animals reared extensively on lower quality foods, this cannot be seen as an argument in favour of intensive systems. The total greenhouse-gas emissions are higher from intensive systems because of emissions associated with the use of inorganic fertiliser and fossil fuels.

Nitrous oxide is believed to contribute about 6% to the man-made greenhouse effect and it also contributes to the depletion of the ozone layer in the stratosphere. Inorganic nitrogen fertiliser use is one of the main sources of nitrous oxide. Sir John Houghton's 1994 report on climate change and the IPCC emission scenarios estimated that agriculture contributes 80% of the current annual increase in nitrous oxide in the atmosphere[116]. Intensive wheat production can lead to high emissions of both nitrous and nitric oxide (NO)[117]. Oxides of nitrogen have an additional damaging effect because they are one of the main causes of acid rain.

The Silsoe Research Institute made an inventory in 1995 of UK farming's emissions of methane and nitrous oxide. It was calculated that 95% of the 850,000 tonnes of methane came from fermentation in cattle and sheep and 5% from slurry and manure. Of the 18,000 tonnes of nitrous oxide, one third came from stored manure and one third from mineral fertiliser after application to soil[118].

Ammonia gas is a major route for escape of nitrogen from farming into the rest of the environment. Ammonia emissions are strongly associated with the confinement of farm animals. In the UK around 350 million tonnes of ammonia are released into the air per year. ADAS estimates that 80% of the total comes from farming and 39% of this comes from farm animal housing. Brian Pain of the Institute of Grassland Research says that "half of ammonia emissions come from cattle farms"[119]. Pain estimates that for each dairy cow kept in slurry-based systems, 25kg of nitrogen a year is lost as ammonia gas. The Silsoe Research Institute in its 1996-1998 report estimates that the nitrogen lost as ammonia gas from stored farmyard manure can be as high as 40%[118].

Emissions of ammonia from poultry and pig farming are also high. MAFF estimates that 16-18 kg of ammonia per year is emitted for every 500kg weight of housed pigs[119]. A major study published in 1998 from the Silsoe Research Institute compared ammonia emissions from animal housing in Northern Europe[120,121]. The highest rates of emission were found to come from broiler chicken and laying hen houses. In the UK, The Netherlands and Denmark taken together, the average emission per hour was around 4000 mg for hens kept in battery cages, 9000 mg for hens kept in 'perchery' systems and 5000 mg for broilers, per 500 kg of birds[120,121]. A shed containing 100,000 broilers of about 2kg slaughter weight each would therefore emit 2 kg of ammonia per hour. Some poultry units emitted over twice the average quantity of ammonia. In that case a 100,000 broiler unit would emit 4 kg of ammonia per hour.

Agriculture and pollution

An ADAS conference of European agricultural scientists on *Agriculture and the Environment* quantified agriculture's contribution to the following environmental pollutants: (Source: Carter *et al.*, 1999[122])

pollutant	*environmental impact*	% from agriculture
ammonia	acid deposition, nitrate leaching,eutrophication	80-90
nitrous oxide	climate change and damage to ozone layer	30
nitric oxide	acid deposition	2-6
methane	greenhouse gas	15
nitrate	eutrophication of fresh waters and salt waters, groundwater contamination, acidification	50-60

Factory farming is either a major source or a significant source of the polluting gases carbon dioxide, methane, nitrous oxide, nitric oxide and ammonia which are variously associated with global warming, ozone depletion and acid rain. Compassion in World Farming Trust believes that these facts alone are sufficient reasons for the re-assessment of animal farming practices worldwide.

4.5 Local pollution nuisance from intensive farms

> [N]umerous reviews ..demonstrate the poor quality of air hygiene attributable to the heavy concentration of livestock in enclosed spaces.
> *British Poultry Science*, 1997[113]

In spite of the concern expressed over a long period by environmental experts, there is evidence that some livestock farmers may not be aware of their industry's potential for environmental damage. A 1994 US report[123] tells us:

> A survey of Kansas pork producers found that less than half…were concerned about nitrates in swine manure as a potential environmental hazard and only 27% showed a concern about the phosphorus content of swine manure[123].

In the UK, a 1997 study of the Environmental Impact Assessments submitted under planning rules for intensive livestock developments found only 10% of them to be adequate compared to other planning applications; few farmers used soil or ecological consultants or showed an understanding of surface and ground water problems[124].

Statutory controls on farm pollution have been slow to arrive in the UK. Until recently farmers in Nitrate Sensitive Areas have been compensated for voluntary reduction of their nitrate use and it is only with the implementation of the EU Nitrate Directive in December 1998 that compulsory limitation in Nitrate Vulnerable Zones (NVZs) has been introduced[106]. In recognition of the pollution potential of factory farms, the 1996 EU Directive on Integrated Pollution Prevention and Control (IPPC), includes large pig and poultry units as 'industries' to be regulated. The Directive requires the regulation of waste production by poultry units with over 40,000 birds and pig units with over 2000 pigs or over 750 sows[125] and is due to be implemented in Member States by the end of October 1999. The UK's Pollution Prevention and Control (PPC) Act 1999 comes into force on 31st October 1999, to be phased in over 8 years.

At the local level, public opposition to what is seen as the environmental nuisance of large scale intensive farming is making it more difficult to obtain planning permission for new units[126]. Some of the local environmental issues are summarised by Weston and Prenton-Jones from Oxford Brookes University:

> [Livestock operations] take place in open countryside but often close to local settlements; intensive livestock buildings are relatively large; they generate traffic on local roads which were not designed for modern heavy vehicles; they normally require the disposal of large amounts of organic waste through slurry spreading on adjacent land; there is always the potential for groundwater pollution, wildlife disruption, landscape and visual intrusion, as well as the more obvious traffic, odour and noise impacts[124].

Intensive animal farming has high inputs and therefore high demand for waste disposal concentrated in a small area. In a small country like the UK the potential for local nuisance is large, and planning applications are frequently opposed or fail because local residents object to smells or the visual impact of the farm development.

The total amount of waste that has to be removed from a typical broiler unit has been calculated by a consultant on farm planning applications[127]. The daily production of wastes is approximately equal to the amount of feed used. We have already seen that animals need large amounts of feed to achieve the high growth rate expected of them. Figures on broiler chicken metabolism from ADAS Gleathorpe experimental farm show that in 6 weeks a broiler chick needs 3.6 kg of feed and 6kg of water to achieve a weight gain of 1.7kg in the same period. The ADAS data were used to calculate total quantities of material to be disposed of or transported from a broiler chicken unit holding 100,000 birds at a time. Quantities are given for a single 8-week 'crop cycle' of 100,000 birds and for a whole year (Table 13)[127].

The total feed input is estimated to be over 3000 tonnes per year and the water input is over 5000 tonnes per year. Total solid and liquid wastes are over 4000 tonnes per year. Total wastes to air are another 7000 tonnes per year. The total solid and liquid weight to be removed is over 5000 tonnes per year, including the weight of the reared chickens[127].

The organic waste to be disposed of from a farm includes dead animals, as a proportion of the animals die during production. A normal commercial death-rate for broiler chickens is 5-6%. For a large broiler house of 100,000 birds this death rate would be 5000 birds per cycle, which would require disposal of more than 32 thousand dead birds a year. Dead chickens are sometimes burned on site, creating additional smells, or may sometimes be left to decay and contribute to litter and dust in the broiler house[127].

Table 13. Total outputs from broiler unit containing 100,000 birds, in tonnes, for one 8-week crop and for one year. Source: Howard, 1998[127].

Type of output	*single crop (tonnes)*	*per year (tonnes)*
weight of birds	267.8	1393
dry matter	111.3	579
nitrogen excreted	13.6	71
water voided	662.7	3446
excreta	144.7	752
dead birds removed	5.1	26
water respired	334.9	1741
carbon dioxide respired	395.8	2058
total wastes to air	1378.0	7166

Pigs that die on farm before slaughter are one of the principal "by-products" of the industry, according to a US report in *Journal of Animal Science*. Typically these would amount to 15% of pigs between birth and weaning and an additional 5% between weaning and slaughter[25]. In the UK and Europe, the death rate during production is similarly around 15-20%, according to the EC's Scientific Veterinary Committee[23]. Given that the UK produced 15.6 million pigs for slaughter in 1998[15], around 3 million dead piglets and young pigs need to be disposed of annually. Dead animals are sometimes dumped illegally in public places in order to avoid disposal costs. In the first 3 months of 1999, North Yorkshire Trading Standards Department reported 300 animal carcases dumped illegally by farmers. In one incident, 39 dead cows and 14 dead sheep were dumped near a roadside[128].

The concentration of airborne pollutants emitted in animal sheds may be high enough to be damaging to the health of the animals or farm workers. The types of pollutants that are regulated by exposure limits for animals and people in livestock buildings include ammonia, carbon dioxide, carbon monoxide, formaldehyde, hydrogen sulphide and inhalable and respirable dust. A collection of pollutants known as aerial endotoxins is composed of fragments of bacteria, insect parts, faeces, dust from skin, feather and feed, and irritant gases, such as ammonia. Ammonia causes inflammation of the mucous membranes of the eyes and the respiratory tract. Endotoxins have been implicated in respiratory diseases and toxin fever in some poultry and pig workers. The housed animals are exposed continually to these pollutants which are often high enough to be potentially damaging to their health[113].

In 1998 an international survey reported the concentration of airborne pollutants in livestock buildings in Northern Europe[120,121,129,130]. The levels of ammonia and inhalable dust found in laying hen and broiler houses were close to or over the limits for continuous exposure for animals or for 8-hour occupational exposure for stockmen. Table 14 shows the average levels of ammonia, inhalable dust and inhalable endotoxins found in 33 broiler houses in The UK, The Netherlands, Germany and Denmark[120]. The last two rows give the guideline limits of the concentrations of these pollutants that are permissible for animals and the statutory limits for stockmen[131].

Table 14. Concentrations of ammonia (in parts per million) and inhalable dust and inhalable endotoxin (in milligrams per square metre) found in survey of 33 broiler houses in Northern Europe. Sources: Wathes 1999[120], Silsoe Research Institute, 1997[131].

	Ammonia	Inhalable dust	Inhalable endotoxins
UK (av)	27.1 ppm	9.9 (mg/m^3)	128 (mg/m^3)
Netherlands (av)	11.2 ppm	10.4 (mg/m^3)	381 (mg/m^3)
Germany (av)	20.8 ppm	4.5 (mg/m^3)	6000 (mg/m^3)
Denmark (av)	8.0 ppm	3.8 (mg/m^3)	70 (mg/m^3)
Limit (animal) [1]	20 ppm	3.4 (mg/m^3)	
Limit (human) [2]	25 ppm	10.0 (mg/m^3)	

[1] Recommended limit for continuous exposure for animals
[2] Statutory limit for long-term exposure (8-hour) for stockmen (1997 UK Health and Safety Executive)

The European study included UK data from a Silsoe Research Institute survey of pollutants emitted from 12 broiler and laying hen houses with mechanical ventilation systems[113]. The survey concluded:

> These findings support the general consensus that air quality in, and emission rates of, aerial pollutants from poultry houses are unsatisfactory according to a variety of criteria[113].

The 'criteria' include excessive concentrations of endotoxins and dust. Concentrations of dust in the UK poultry houses were up to 10 mg per square metre, which is close to the regulation limit for occupational exposure for humans and "greatly exceeded" the guideline limit for animals. The ammonia concentration was up to 24.2 parts per million and may have been high enough to be damaging to the birds' health. The levels of endotoxins were considered high enough to induce toxin fever in humans given prolonged occupational exposure[113].

Over 100 chemical species of odorants have been identified in animal housing, which are likely to be carried on dust and smelled up to 2km away. The rate of emission of dust found in the Silsoe Research Institute study was 8g per hour per 500kg weight of animals. This would amount to 3.2 kg of dust emitted per hour from a broiler house of 100,000 birds at their slaughter weight[113].

Smells from factory farms are a major cause of complaints from members of the public. Farm buildings smell because of the decay of organic matter such as faeces, urine, skin, hair, feed and sometimes bedding[132]. A 1994 report from the Institute of Grassland and Environmental Research estimated that there were around 4,000 complaints of smells from farms per year, mainly arising from manure spreading, livestock buildings and waste stores. Feed processing accounted for 10% of complaints. Pig farms headed the list of complaints (57%), followed by poultry farms (22%) and cattle farms (17%)[132].

A 1999 article in the industry publication *World Poultry* warns:

> The air of a poultry house seethes with a health-threatening mixture of gases, dusts and microorganisms that arise from the birds themselves, their feed, manure and the litter…. The typical poultry farm is a large source of aerial pollutants emitted from the ventilation exhausts"[120].

Compassion in World Farming Trust believes that reform of UK planning law is essential. All applications for planning permission for new intensive livestock farms or units should be subject to a detailed assessment of the impact of the proposed development on animal welfare and the environment, including all emissions.

5. The global perspective

In this report we have concentrated on the environmental impact of intensive animal farming in the UK and Europe. However, factory farming is spreading worldwide and we need to look at it in a global context. A crucial fact is that the global human population's demand for cereals and meat is expected to rise by at least 50% by 2020, as predicted by the FAO and World Bank below[1]:

	human population	*demand for cereals*	*demand for meat*
1996	5.5 billion	1.7 billion tonnes	206 billion tonnes
2020	8 billion	2.5-2.8 billion tonnes	275-310 billion tonnes

If this scenario is correct and intensive animal farming continues to grow, the inevitable result will be more intensive land use and water use for animal feed, with equally inevitable environmental degradation. Industrial animal farming is already putting natural resources under stress and causing severe localised pollution in many developing countries.

Animal farming is the most environmentally costly way of feeding the world. We have seen that the production of animal protein is a highly inefficient use of land and water resources. Farm animals convert plant protein to animal protein with a low efficiency - typically around 30 - 40 % and only 8% in the case of beef production. Four kg of grain fed to a pig produces one kg of pork[133]. An estimate from Cornell University is that the water requirement for beef production is over 50 times as much as for rice production and 100 times as much as for wheat production, kilogram for kilogram[82]. The United States Union of Concerned Scientists has concluded that halving the average US household's meat consumption would reduce food-related land use by 30% and water pollution by 24%[134]. Compassion in World Farming Trust's recent book, *The Meat Business*, argues that global factory farming could lead to environmental and social devastation[135].

In the next two decades the problem of how to feed at least 8 billion people while protecting our natural resources of land, water, air and wild species will become increasingly urgent. The spread of intensive animal farming throughout the world cannot be seen as a sustainable solution. Compassion in World Farming Trust believes that the FAO should take the lead in rejecting the spread of intensive animal farming and should promote animal husbandry methods that are appropriate to local conditions and respect biodiversity, animal welfare and the environment.

Hong Kong's pig farms

Factory farming of pigs in Hong Kong follows Western methods. There is a particularly high density of pigs in the North West Territories and *Pig Progress*[135] reports that "livestock waste still accounts for a significant proportion of the pollution load in the watercourses and greatly exceeds their absorptive capacity". Indigenous breeds have been abandoned in favour of imported Western breeds. Hong Kong imports all its animal feed. The average pig farm now has around 800 pigs, kept at a stocking density of 1 fattening pig (up to 110 kg) to a square metre. A typical farm includes 100 sows, confined individually in sow stalls and farrowing crates. Weaning pigs are kept in cages and growing pigs in concrete pens. Waste disposal is usually done by hosing down the pig pens and treating the liquid manure. The sludge is left to dry by evaporation and drainage. Treated water is released into nearby streams, in spite of doubt about the quality. Pig slaughterhouses cause serious environmental nuisances associated with the transportation, slaughtering and processing of the by-products of the pigs[136].

6.0 Conclusions and recommendations

6.1 Factory farming's environmental legacy

The intensification of animal farming over the last 30 years has played a fundamental role in the well-documented damage that agriculture causes to the environment and to biodiversity. The FAO, among several other official bodies, concludes that "livestock production has become an important factor in environmental degradation"[7].

Factory farming damages the environment both directly and indirectly. The direct effects stem from the pollution caused by the confinement of large numbers of animals at high stocking densities, feeding and excreting in relatively small areas of land. The indirect effects come from the need to produce the feedstuffs for our billions of confined animals world-wide. In order to produce feed for farm animals by intensive farming methods we have polluted water and air, damaged our long-term soil fertility and water resources and caused serious declines in many wild plant and animal species.

- Industrially farmed animals are concentrated at unnaturally high stocking densities. They are confined, often indoors, on agricultural operations that are too small to grow their feed or absorb their manure.

- Highly productive factory farmed animals need large amounts of protein-rich and energy-rich feed to be provided for them. A dairy cow expected to produce 35 litres of milk per day may eat 4700 kg of forage and 1600 kg of concentrate feed in a year[50]. A broiler chicken needs 3.6 kg of feed and 6.0 kg of water to increase its weight by 1.7 kg in its 6 week-life[127]. A feedlot beef animal needs 1400 kg of feed in the 'finishing' period[37].

- The animal feed industry is a major reason for the intensification of arable farming world-wide. Factory farming depends on a plentiful supply of affordable feed, produced using fertilisers, herbicides, insecticides and fungicides. Application of nitrogen fertiliser to crops has increased 6-fold in the UK since the 1950s[69], and nitrogen use has increased nearly 7 fold worldwide since 1960[61]. The area of UK fodder crops and grassland treated with herbicide has increased by 40% during the 1990s[67].

- Large amounts of cropland are given over to producing food not for people but for confined animals. 95% of world soyabean production is used for animal feed[55]. In the UK, 39% of our wheat, 51% of our barley and 75% of our total agricultural land is used to feed animals[15]. Worldwide one third of grain production is used for animal feed[54].

- As well as using a large proportion of its own land, Europe imports 70% of its protein for animal feed[21]. A European Parliament report has stated: "Europe can feed its people but not its [farm] animals"[21]. The UK's total imports of all animal feed are equivalent to the use of 1.75 million hectares outside the EU[49], or an additional 35% of UK land under tillage. Much of the feedstuffs come from countries suffering from poverty or environmental degradation.

- Worldwide, producing feed for animals consumes scarce resources of water and fuel. 87% of the fresh water consumed worldwide is used for agriculture[82], while the UN predicts that 40 countries will suffer from extreme or absolute water shortages in the next 20 years[83]. To produce 1 kg of beef uses 100 times more water than to produce 1 kg of wheat and 50 times more water than to produce 1 kg of rice[82]. Feed production accounts for 70% of the total fossil fuel use in animal farming[81], for vehicles and machinery used for growing and harvesting, for fertiliser and pesticide production, for water pumping, feed processing and transport.

- Animal farming is a major source of the greenhouse gases methane and nitrous oxide. An estimated 16% of all methane production[1] and 80% of the annual increase in nitrous oxide[116] comes from agriculture. These emissions are mainly associated with the animals' digestion, manure and the use of mineral nitrogen fertiliser, much of it used to grow animal feed.

- Fertilisers and pesticides have seriously damaged biodiversity in the UK over the last 50 years. Birds are recognised as key environmental indicators. The British Trust for Ornithology has placed 20 species of birds on a 'High Alert' list because of population declines of over 50% in the last 25 years[72]. The Royal Society for the Protection of Birds lists grassland improvement, artificial fertilisers, high density of animals, decline of mixed farming, disposal of manure and silage effluent as probable causes[3]. All of these are associated with intensification of animal farming.

- Over-use of nitrate fertiliser – much of it used to grow animal feed – interferes with biological nitrogen fixation and damages soil fertility. A 10-year crop study published in *Nature* found that the long-term fertility of the soil is reduced and that 60% more nitrate leaching occurs when crops are intensively farmed compared to organic methods[61,94].

- The use of fertiliser and high-protein feed means that intensive farms often operate on a permanent excess of plant nutrients (nitrogen and phosphate). A dairy cow produces 57 litres of excreta a day[99], including

80% of the nitrogen[90] and 40% of the phosphorus[50] in her feed. Excess nutrients act as pollutants. Nitrogen and phosphate are washed into surface water by rains and excess nutrients leach from the soil into groundwater. The Environment Agency reported in 1998 "extensive pollution of the unconfined parts of the major UK aquifers" by nitrates[110].

- Nitrates and phosphates which contaminate the non-agricultural environment cause eutrophication (nutrient enrichment) of freshwater and seawater, changing the balance of species in the ecosystem. According to the Environment Agency 43% of the phosphate load in freshwater comes from farming[111]. Eutrophication can cause algal blooms which remove oxygen from the water and kill fish and other aquatic life. Over half of algal blooms can be toxic[95]. Thirty three out of 41 lakes designated as SSSIs are affected by eutrophication[110]. At least 5 British estuaries have excessive algal growth[111]. The European Environment Agency stated in 1998 that eutrophication "has become a major problem in north-west Europe"[87].

- Manure storage, application to land and disposal is a cause of pollution in areas of intensive animal farming worldwide. In the Netherlands by 1990 the concentration of nitrate in groundwater was over twice the EU limit for drinking water[50]. In the US, a Senate Committee has estimated that 1.4 billion tonnes of solid manure is produced by farmed animals per year, 130 times the waste produced by the human population[13]. Manure from US pig farms is implicated in outbreaks of the toxic algae *Pfiesteria piscicida* which has killed millions of fish on the North Carolina coast in recent years[26,96]. 34% of Minnesota river miles and 30% of Minnesota lakes have been designated "impaired" by feedlot effluent[26]. In Hong Kong, pig farm waste contributes "a significant proportion of the pollution load" in watercourses[136].

- Ammonia gas is an air-pollutant emitted from manure and slurry. As much as 40% of the nitrogen in manure may be released into the environment in this way[118]. Ammonia also contributes to acid rain. Five percent of SSSIs suffer from acidification, according to the Environment Agency[110]. The emission of ammonia from a typical broiler house containing 100,000 birds is on average 2 kg per hour, according to major Northern European study, and may be as much as 4 kg an hour[120,121].

- Intensive poultry sheds are a "large source of aerial pollutants", according to *World Poultry*[120]. The concentration of airborne endotoxins (dust containing residues of bacteria, insects, faeces, feed, skin and feathers and gases) in intensive poultry sheds is likely to be damaging to the health of farm workers and the animals and can be smelled over a radius of 2 km. A large broiler house may emit 3.2 kg of endotoxins per hour[113]. A study of airborne pollutants in poultry housing across Northern Europe found that average concentrations of ammonia, dust and endotoxins were close to or above safety limits[120,121, 129,130].

6.2 Towards environmentally-friendly animal farming

- Farming methods that ignore the welfare needs of farm animals are also likely to be environmentally damaging. This report has shown in detail how the factory farming of animals and environmental damage go hand in hand world-wide. At the same time we are seeing a major change in public opinion in many Western countries. In the UK the public's concerns about the environment and food safety have led to a consumer backlash against intensive farming and a boom in 'organic' and animal-friendly food. Consumers are increasingly demanding to know where their food comes from and how it was produced. According to NOP surveys, 92% of the British public would be willing to pay more for eggs produced in non-cage systems[137] and 74% believe that British supermarkets should only sell pigmeat produced without the use of sow stalls and tethers[138].

- Compassion in World Farming Trust believes that environmentally friendly farming and higher standards of animal welfare are closely linked. In the context of the UK and Europe, the way forward must be the encouragement of extensive animal farming and of mixed farming together with commitment from both government and the farming industry to make environmental protection and animal welfare a priority. This requires the end of subsidies that encourage high stocking densities and overproduction and their replacement with subsidies for environmentally friendly methods of farming. In the context of world trade, the values of environmental protection and animal welfare must be given appropriate weight alongside the values of free trade.

- To make progress towards the goal of high animal welfare within the context of environmentally-friendly animal husbandry, Compassion in World Farming Trust believes there are several immediate priorities:

    - Reform of the CAP to link financial support for agriculture to extensification and good animal welfare
    - The recognition of environmental and animal welfare policy objectives within the GATT/WTO
    - Reform of UK planning law to incorporate detailed animal welfare and environmental impact assessments into all applications for intensive livestock farms
    - The active promotion by the FAO of agricultural practices that are friendly to farm animals as well as to the environment
    - Mandatory labelling of animal products according to method of production, to allow consumers the choice to support good standards of animal welfare and environmental protection

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Glossary and abbreviations:

ADAS	ADAS Consulting Ltd (previously the Agricultural Development Advisory Service of MAFF)
algae	Microorganisms (often unicellular) living in water, which carry out photosynthesis like green plants. An ‘algal bloom’ is an exceptional growth of algae in lakes, rivers or seas, often due to nutrient enrichment of the water. See Box on p 28
Biological Oxygen Demand (BOD)	A measure of the amount of organic pollution in water (the amount of oxygen taken up by microorganisms in the organic material). Also called Biochemical Oxygen Demand.
broiler chicken	Chicken bred for meat
CAP	Common Agricultural Policy of the European Union
EC, EU	European Commission, European Union
EA, EEA	Environment Agency, European Environment Agency
Eurostat	Statistical Office of the European Union
eutrophication	The enrichment of fresh water or seawater by excess plant nutrients. See box on p 28
FAO	Food and Agriculture Organisation of the United Nations
fertiliser	Material which is a source of plant nutrients, usually nitrate and/or phosphate. Fertilisers may be manufactured inorganic compounds (‘artificial fertilisers’) or organic material such as animal manure.
GATT, WTO	General Agreement on Tariffs and Trade, World Trade Organisation
hectare (ha)	1 hectare = 10,000 square metres = 2.47 acres 100 hectares = 1 square kilometre
nitrate	Nitrogen (N) compound that plants use for growth, particularly in the process of making proteins
MAFF	Ministry of Agriculture, Fisheries and Food
phosphate	Phosphorus (P) compound that plants need for growth and biochemical processes
photosynthesis	the synthesis of carbohydrates from carbon dioxide and water by plants, using energy from sunlight
protein	the main constituent of living material, essential for the structure of cells and tissues and for biological functions. Protein molecules consist of amino acids.
pullet	young (immature) hen
silage	conserved grass or other forage crop – see box on p 30
slurry	liquid animal excreta – see box on p 30
tonne	1 tonne (metric ton) = 1000 kilograms = 0.98 ton
transpiration	evaporation of water through pores (stomata) of plant leaves and stem
USDA	United States Department of Agriculture

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