Department for Environment, Food and Rural Affairs – January 2008

The Contribution That Organic Farming Makes in Supplying Public Goods [*]

Introduction

1. According to Defra[1], organic farming tends to deliver greater biodiversity, less pollution, less carbon dioxide emissions, better animal welfare and more local economic activity.[2] This view of the public goods benefits of organic is supported by the Government advisors on sustainability, the Sustainable Development Commission, who have described organic farming as the 'gold standard' for sustainable food.[3] This paper provides a full summary of the public goods delivered by organic farming in the UK.

Greenhouse Gases

2. In the words of Defra's previous Secretary of State, organic farming "in many, but not all, cases, produces fewer greenhouse gases".[4] Unlike other industries, farming emissions are not mainly from energy use (CO_2) but from Nitrous Oxide (55% in CO_{2e} forms), and methane (37%) with just 8% coming from CO_2.[5]

3. Very few greenhouse gas life cycle assessments have been done on organic farming. Two recent studies have shown that organic farming produces fewer greenhouse gases per tonne of food than conventional farming. A nine-year study of four arable farming systems by Michigan University concluded that organic farming has a global warming potential of 43% that of conventional on a per unit yield basis.[6] A recent Australian study supports this figure, showing organic farming in Australia to have less than half the greenhouse gas intensity than conventional farming.[7]

4. A reliable UK study has not yet been published: the first attempt by Williams *et al* (2006) used an unrepresentative model of UK organic farming that had the effect of increasing the land use by 50% and thus distorted the greenhouse gas figures. However, as the then Secretary of State said, there is reason to believe that the global warming potential of UK organic farming would be lower than that of conventional, in line with the findings from other countries.

5. Organic farming prohibits the use of inorganic nitrogen fertiliser, the production of which is responsible for 1.2% of the UK's total GHG emissions.[8] 6.7t CO2e is emitted in the form of NO3 and CO2 during the manufacture of each tonne of fertiliser,[9] and further significant emissions occur from both the transport and application stages. It is hard to see how UK NO_3 emissions, and in particular NO_3 emissions from farming, could be cut by the required 60-80% by 2020 without moving completely from inorganic nitrogen fertiliser to

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fertility provided by nitrogen fixed by legumes and the sun, as is required in organic farming.

6. Methane, responsible for over a third of farming's greenhouse gas emissions, arises from animal wastes, but mainly from direct emissions from cattle and sheep. In some cases, because some organic animals take longer to reach maturity, emissions per unit of meat will be higher. In contrast, because organic dairy cows have longer productive, milk-producing lives, and a smaller number of replacement animals are needed, lower methane production may offset lower yields per animal. Extensive grazing systems, required under organic standards, and the greater use of straw-based bedding systems, will lead to less methane production from animal wastes from organic livestock.[10] There are other benefits of encouraging the wider adoption of the extensive grazing followed by organic farming. Many areas of greatest wildlife importance require grazing, ideally by both cattle and sheep, and undergrazing is emerging as a threat to these areas due to a shortage of grazing animals available.[11] Overall, methane emissions will only be significantly reduced by reducing the number of methane-producing livestock, and encouraging the adoption of diets containing less but better quality meat.

7. Recent research by the National Soils Resources Institute show that UK soils are losing 13mt C per year.[12] This figure is not currently included in the UK's greenhouse gas inventory, but amounts to around 7% of our annual emissions. Unlike conventional agriculture, organic farming is dependent on high soil organic matter levels for fertility and health of crops. The system therefore involves many practices that protect and build up soil carbon levels and studies from around the world have shown it to have a significant capacity to sequester, or, at the very least, stabilise, carbon in the soil. [13] [14] [15] In its written position on organic farming, the FAO states: "Organic agriculture contributes to mitigating the greenhouse effect and global warming through its ability to sequester carbon in the soil. Many management practices used by organic agriculture (e.g. minimum tillage [during leys], returning crop residues to the soil, the use of cover crops and rotations, and the greater integration of nitrogen-fixing legumes), increase the return of carbon to the soil, raising productivity and favouring carbon storage".[16] During the compilation of a 1980 report on organic farming, the United States Department of Agriculture (USDA) found little evidence of soil erosion on organic farms and noted that many of the practices were those highly recommended by the USDA for soil management.

Energy

8. Reliance on inorganic nitrogen fertilisers means that non-organic systems of agriculture are effectively producing food from fossil fuel. The practice of bringing chemical fertiliser and other industrially manufactured inputs, such as pesticides and veterinary drugs, onto the farm accounts for 72% of the energy use on non-organic farms. In contrast, organic farming is a largely local production system, using natural processes on the farm. Solar power is used to fix nitrogen into the soil, manure is added from the livestock within the

mixed system, rotations and natural predator populations are used for pest control, and the extensive system and focus on animal welfare reduces the need for drug treatment. Not surprisingly, there are many reliable life cycle assessments from the UK and abroad that have found organic farming to be more energy efficient that it's non-organic counterpart.[17] [18] [19]

9. The table below shows the results of two recent Defra studies on the production of various common foodstuffs within the UK. [20] [21]

Sector	**Organic energy use/t vs non-organic**
Milling wheat	29% less
Oilseed rape	25 % less
Potatoes	1.5% more
Carrots	25% less
Cabbage	72% less
Onion	16% less
Calabrese	49% less
Leeks	58% less
Beef	35% less
Sheep	20% less
Pigmeat	13% less
Milk	38% less
Poultrymeat	32% more
Eggs	14% more
Tomatoes (long season glasshouse)	30% more

10. The research shows organic production to be significantly more energy efficient per tonne of food produced in eleven out of the fifteen sectors examined. With potato refrigeration as a major energy input for potatoes in both farming systems, energy use in this sector was roughly equal, while heated glasshouse and poultry products were the only sectors in which non-organic farming was more efficient. Out of season glasshouse production require similar levels of heating but produce lower yields in organic systems and solutions could be a move towards more seasonal consumption or the use of renewable energy to provide heating. The efficiency of the feed conversion within the conventional poultry sector is due to the very intensive system, but factory farming is considered by many (including some multiple retailers) to be an option that is increasingly unacceptable to the public on animal welfare grounds. The solution would be for consumers to enjoy fewer, but better quality, poultry products, which, when combined with more seasonal consumption of 'hothouse' crops, would mean that organic production of a typical UK diet would use 29% less energy than conventional production of the same foods.

Biodiversity

11. It is now widely accepted that organic farming methods are more favourable for wildlife than non-organic farming. [22] The Government's statutory advisors on wildlife conservation (English Nature, now Natural England) have stated that they would like to see more farmers taking up this option to farm in an environmentally sensitive way, terming organic farming as "a well defined modern system of agriculture that is broadly beneficial to the environment and to wildlife". This statement is well supported by the solid body of scientific research that has been undertaken in recent years:

- A scientific literature review of 76 studies by English Nature and RSPB found that there are more birds, butterflies, beetles, bats and wild flowers on organic farms than on non-organic farms. [23]
- A literature review of 66 published comparative studies concluded that on average wildlife is 50% more abundant on organic farms and there are 30% more species than on non-organic farms.[24]
- A large-scale survey by BTO/CEH/WCRU of most lowland mixed crop and livestock organic farms in England (August 2005) found that the organic farms have almost twice as many numbers and species of plants, about a third more birds and a third more bats in organic farms. [25]

12. The main benefits of organic farming for biodiversity are: its non-use of fertilisers, herbicides and synthetic wormers; minimal use of pesticides; lower livestock stocking densities; encouragement of natural predators for controlling pests (and thus maintenance of hedges, field margins and other uncropped areas); higher soil biological activity; and the use of mixed crop and livestock systems rather than monocultures. It is the absence of these beneficial factors on most non-organic farms that has accounted for most of the decline in farmland wildlife in Britain's farmed countryside in recent decades.

Animal Welfare

13. Defra have listed high standards of animal welfare among the acknowledged benefits of organic farming.[26] This is supported by the Scottish Executive Environment and Rural Affairs Department's report on the subject, which concluded that "organic standards provide a collective framework for production systems that are likely to create conditions where high animal welfare status can be achieved."[27] Further independent, peer-reviewed research has demonstrated that, overall, organic standards deliver higher standards of animal welfare on organic farms compared to non-organic systems.[28] These findings were confirmed by Compassion in World Farming (CIWF)[29], whose investigation into farm assurance schemes and animal welfare found that the organic farming standards set by the Soil Association far exceeded, in welfare terms, those of any other scheme. The report concluded that, "the organic standards laid down by EU law and refined by certifying bodies like the Soil Association stipulate a range of measures which between them should result in good animal welfare."

Water

14. Through the avoidance of pesticides and strict manure management, organic farming minimises pollution of watercourses. The better soil structure maintained by organic practices is also more able to cope with water problems arising from climate change, reducing the risk of flooding and showing more resistance to drought.

15. The removal of agricultural pesticides from UK water sources has been estimated to cost £120 million each year[30] and a recent study by the Environment Agency[31] revealed that pesticides were found in over a quarter of groundwater monitoring sites, some at levels exceeding the drinking water limit. Organic farming does not contribute to this burden.

16. A Defra study[32] found that organic production reduces nitrate leaching to an extent similar to that achieved by the use of Nitrate Vulnerable Zones (NVZs). Indeed, organic standards already incorporate most of the requirements of NVZs, for example through limiting the application of nitrate application to 170kg manure/ha/yr over the holding and maintaining low stocking densities. The lower level of leaching is also due to the significantly lower nitrogen surpluses on organic farms than conventional, as shown by Stolz *et al*'s 1999 review of all the published studies in Europe.[33]

17. The water absorption of agricultural land is an important factor in the risk and severity of flooding and drought. Measurements taken by the Rodale Institute showed that water infiltration rates were twice as high in the organic system than the non-organic system.[34] This means that organic soils are more able to absorb water in periods of extreme rainfall, leading to less run-off and reducing the risk of flooding downstream. Organic soils also retain moisture for longer due to the higher level of organic matter and the longer root systems of the crops. For this reason, organic farming produces higher yields than non-organic farming in drought years, as demonstrated by the soy and maize crops in the Rodale Institute's 21-year trial,[35] and organic crops withstand drought for longer, shown by trials in Ethiopia.[36] Australian research has also found that organic farming uses less water than conventional systems.[37] This resilience reduces the need for irrigation, putting less pressure on water resources, and the non-use of inorganic nitrogen fertiliser avoids the enormous use of water involved in fertiliser manufacturing, estimated at 37 cubic metres per tonne of fertiliser produced.

Organic food and nutrition

18. There is a growing body of evidence that, on average, organic fruit and vegetables contain higher levels of primary and secondary nutrients than non-organic food.

19. An independent review of the evidence in 2001 found that in general organic crops had significantly higher levels of all 21 nutrients analysed compared with conventional produce; including vitamin C (27% more),

magnesium (29% more), iron (21% more) and phosphorous (14% more)[38]. The Soil Association also conducted a systematic review of the evidence in 2001. It was found that, on average, vitamin C and dry matter content was greater in organic food, and that levels of minerals and phytonutrients were also generally higher but that further research was needed due to the limited number and heterogeneous nature of studies.[39]

20. A significant new body of research is confirming these preliminary conclusions, including the following studies published in 2007:

- A University of California Davies study concluded that organically grown kiwis had significantly higher levels of vitamin C (14%) and polyphenols (17 %).[40]
- A new Polish study found that organic apple puree contained more phenols, flavonoids and vitamin C in comparison to conventional apple preserves.[41]
- A further Polish study found that organic tomatoes contained more dry matter, vitamin C, B-carotene and flavonoids, while conventional tomatoes were richer in lycopene and organic acids[42]. Previous research has found organic tomatoes have higher levels of vitamin C, vitamin A and lycopene.
- In the same proceedings, a French study reported finding that organic peaches have a higher polyphenol content.
- A University of California Davies study found 79 – 97% higher levels of flavonoids in organic tomatoes; the researchers stated that these antioxidants have been linked to reduced rates of cardiovascular disease, some forms of cancer and dementia.[43]

21. It is now widely accepted that organic milk has higher levels of Vitamin E, beta-carotene (Vitamin A precursor) and short-chain omega-3 fatty acids than conventional milk.[44] Following representations by scientists asking the Food Standards Agency to recognise the mounting body of evidence that organic milk has a different nutrient profile than non-organic milk, advice to this effect is now included on the FSA's website.

22. Secondary metabolites or polyphenols – a category to which vitamins belong - are produced by plants as a protective mechanism in response to external stress and disease. These polyphenols are antioxidants that have an important role to play in cancer prevention. Researchers have suggested that non-organic growing practices utilise levels of pesticides that can result in a disruption to phenolic metabolites in the plant that have a protective role in plant defence mechanisms[45]. Higher levels of minerals in organic produce may be explained by the improved bioavailability of minerals in organic farm systems. Organic farming is based around the maximisation of soil biology to optimise nutrition pathways from soil to crops.

23. The Food Standards Agency advises that: "*Eating organic food is one way to reduce consumption of pesticide residues and additives*." US studies have shown that children fed an organic diet significantly reduced their exposure to some groups of pesticides. Latest results from the Pesticides Residues Committee show 74% of fruit and vegetables destined for schools contained

pesticides, almost all below the Government's permitted Maximum Residue Level, with 50% containing multiple residues. The British Medical Association advises that, due to the manner in which pesticide residues are stored in fatty tissues, they may remain in the body for several years, and there is concern regarding possible neurobehavioral and neurotoxic effects, mutagenicity, teratogenicity, carcinogenicity, and allergic and other immuno-regulatory disorders.[46]

24. The risk of mycotoxins in general is less with organic products. There have now been thirteen comparative studies, of which 9 found a lower risk/levels[47], three found no difference[48] and only 1 found higher risk/levels in organic.[49]

Employment and other local economic benefits

25. Organic farming can make a significant contribution to local economies, helping to regenerate agriculture as a significant employer by providing more jobs and more direct marketing initiatives. Results from the most comprehensive survey comparing employment on organic farms to that on non-organic farms shows that organic farming delivers 32% more jobs per farm on average across the UK.[50] The independent research also reveals that organic farmers are:

- Younger – the average age of organic farmers surveyed was 49, seven years younger than their non-organic counterparts, who average 56 years old.
- More optimistic about the future of farming - 64% expect their family to take on the farm compared to 51% for non-organic farmers. [51]
- More entrepreneurial - three times as many organic farms are involved in direct or local marketing schemes than non-organic farmers.[52]

26. Notwithstanding such benefits as on-farm processing and retailing, the survey confirms that it is the actual system of husbandry required by organic farming that generates the majority (81%) of the additional jobs.[53]

27. These findings for organic farming run counter to the trends for UK agriculture generally which have seen the number of farm workers drop by nearly 80% over the last 50 years.[54]

Can these public goods actually be delivered on a significant scale?

28. For many of these public goods, delivery is disproportionately when larger areas of land are farmed organically. This is particularly clear for some biodiversity benefits. For example, most organic farms are below the territory size for some larger threatened species such as birds of prey, and while adult grey partridges disperse over a wide area when population levels are low, they breed most successfully on organic farmland. Researchers believe that the potential of organic farms to support wild animals is actually far greater,

and that the biodiversity benefits are held back because organic farms are currently mostly "isolated units" in an intensively managed landscape. [55] The benefits of large-scale organic conversion are self-evident for issues like the pesticide burden on water catchment[56] and if organic farming, currently practised on 4% of UK farmland, was adopted by all UK farmers, it would produce an additional 93,000 on-farm jobs.[57]

29. The criticism most often levelled at the large-scale viability of organic farming is that it does not produce sufficiently high yields to feed the world's growing population. Certainly, when an industrialised high-input arable system in Europe is converted to organic, a drop of around 40% in yield can be expected, while vegetable yields would not be significantly affected.[58] Comparative yields differ enormously between crops and regions and there is a growing body of evidence to suggest that a global switch to organic agriculture could match, and possibly exceed, current levels of production. In the US, a region with medium growth conditions and more moderate use of synthetic inputs, numerous studies have shown that organic productivity is over 90% of conventional, and exceeds it in drought years.[59] [60] [61] The biggest[62] benefit of organic agriculture, however, comes in the Southern Hemisphere, where dramatic yield increases have been reported. A review of over 200 food production projects found that simple organic-type techniques resulted in yield increases of 46 – 150%;[63] another study reported that composted plots in Ethiopia yields 3 – 5 times as much as chemically treated plots and showed increases in Brazil between 20 –250%[64]; and the average increase in yield for subsistence agriculture has been estimated at 80%.[65]

30. Researchers in Denmark found that there would not be any serious negative effect on food security for sub-Saharan Africa if 50% of agricultural land in the food exporting regions of Europe and North America were converted to organic by 2020. A similar conversion to organic farming in sub-Saharan Africa would ease hunger problems in the region and reduce their need to import food.[66]

31. Recent models (Badgley, *et al*., 2007[67]; Halberg, *et al*., 2006)[68] of a global food supply grown organically indicates that organic agriculture could produce enough food on a global *per capita* basis for the current world population: between 2,640 and 4,380 kcal/person/day, depending on the assumptions used. The lower value effectively provides the adult 2,650 kcal daily caloric requirement, while the higher value is based on expectations of a 57 percent increase in food availability, especially in developing countries, giving it the potential of supporting a far larger human population. These results considered the average organic yield ratio of different food categories with no further increase in the current agricultural land base and suggest that organic agriculture has the potential to secure a global food supply with reduced environmental impacts. In response to the findings, the Assistant Director-General of the UN Food and Agriculture Organisation has stated that, considering that the impact of climate change will target the world's poor and most vulnerable, "a shift to organic agriculture could be beneficial".[69]

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[1] Defra (2002) *Action plan to develop organic food and farming in England*

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[5] Soil Association calculation. Using 2002 data for UK agricultural (i) CO2 emissions of 1.2MtC from "Review of the UK Climate Change Programme – consultation paper, Defra, 2004; (ii) methane emissions of 890,000 t and N2O emissions of 89,500 t from "UK Greenhouse Gas Inventory 1990-2003 – Background for Agriculture", 2005 (http://www.naei.org.uk/reports.php). Using conversion factors of 21 for methane and 310 for N2O, gives 5.1MtC-equivalent for methane and 7.6MtC-equivalent for N2O emissions. Total = 13.9 MtC. 1.2 MtC of CO2 = 8.6%; 5.1MtC of methane = 37%; and 7.6MtC of N2O = 55% of total UK agricultural GHG emissions

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[8] 1,130,000 t N x 6.7 = 7.6 mt CO2 equivalent (using 6.7 kg CO2/kg N from Sheffield Hallam University, ie. 6.7 t CO2/t N). Total UK carbon emissions were 178 million t of C in 2005 [x 44/12 = 652.7mt CO2] (Source: UK Climate Change programme review, 2005). So, 7.6 mt ÷ 653 mt x 100 = 1.2% of total UK GHG emissions.

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