SUSTAINABLE FOOD AND DRINK – LOOKING AFTER THE EARTH

Climate Friendly
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Working for a low carbon future

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Sustainable Food and Drink - Looking after the Earth

A discussion document compiled for Climate Friendly Bradford on Avon by
the CFB Sustainable Food and Drink Group

"So that's the rule to remember, the whole quilt is more important than any single square."
(*A Fine Balance* by Rohinton Mistry)

Our day to day choices can help:

- ensure that we have a nutritionally balanced and varied dietary intake to promote our health, enjoyment and well being
- safeguard the environment and wildlife
- ensure fair trading for farmers and producers in the UK and elsewhere, including in the world's poorest countries, in order to keep farmers farming, people fed and to ensure that we do not lose the skills needed to keep our food supply secure
- keep soils, and marine and fresh water, healthy and able to produce food for us and future generations
- reduce waste
- reduce demand for energy, including transport fuel
- reduce emissions that contribute to climate change
- help mitigate climate change

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GHG: Greenhouse gases - mainly carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) (ref 418)
CO2e: "Carbon dioxide equivalent" is a term for describing different GHGs in a common unit. For any quantity and type of GHG, CO2e signifies the amount of CO2 which would have the equivalent global warming impact.
Agroecology: "The adaptation of agriculture to natural conditions and cycles, as well as to local needs." (IAASTD, ref 352)
I hectare (ha) = 2.471 acres

1) Introduction

The food that we eat should be enjoyable and provide us with the essential nutrients that we need for optimal health. People have a wide variety of preferences and values, and sometimes health reasons, affecting what they choose to eat. It is probable that most foodstuffs can be produced in an environmentally friendly way, however at the present time about 30% of UK greenhouse gas emissions (GHG) is related to the food chain and additionally serious environmental damage is occurring globally, for example: impoverishment and erosion of soils, loss of biodiversity, damage to marine and freshwater ecosystems, destruction of rainforests and many other important habitats. About 10% of these UK emissions relates to global land use change (including forest) counted proportionally for the UK.

The food chain is by far the biggest business in the world and the UN Food and Agriculture Organisation (FAO) states that "Taken together agriculture, forestry and land use change account for about one fifth of

global GHG emissions…The share of the food system as a whole in total GHG emissions is even greater - associated with manufacture of agrochemicals, fossil energy use in farm operations, post-production transport, processing and retailing." (FAO, 2013, ref 236). The food and drink supply chain is the UK's largest manufacturing sector (ref 410).

2) Away from Ideology

It is unfortunate that the debate about how to reduce our emissions from the food we eat has become so centred around the inclusive diet of those who eat meat, or the vegetarian or vegan option. It is possible that this is dominating and clouding the issues and that other very important aspects of our food choices, and other sources of emissions in the food chain, are being given insufficient attention. How the food we eat is produced may be more important than what we eat, as long as we are eating a nutritionally balanced diet. The energy consumption of food and drink *en route* to our table and the waste at different stages of its 'lifecycle' are also critical.

3) The Answer Lies in the Soil

It is vital that our food is produced in a way that ensures that soils are, and remain, healthy and fertile. The importance of putting the heart back into our soils, so that we have living soils capable of producing nutritionally rich foods and a restored natural capacity for acting as a major carbon sink, is one of the main findings of this literature search and much else flows from this.

The United Nation's (UN) **International Year of Soils** 2015 highlighted concerns about the state of soils globally, and the ability of soils to provide healthy food for us and for future generations (ref 19, 20, 21). Intensive modern farming methods have reduced organic matter in soils and led to damage to the complex and vitally important microbial and fungal activity, and structure, within soils, such as the thread-like filaments of mycorrhizal fungi which form symbiotic links with plant roots. Certain of these greatly enhance the plant uptake of soil nutrients, such as phosphorus, zinc, copper and magnesium, as they vastly "increase the absorbing surface of the plant root hairs" (Harvey 2016, ref 269). The decaying of plant and animal materials and the very complex activity involving plant roots, micro-organisms and other "inhabitants" of healthy soils are essential for nutrient uptake, sustainable fertility and the ability of soils to take up and store very substantial amounts of carbon dioxide from the atmosphere (refs 225, 430, 195); and are also at the base of the food chain for wildlife. Modern production methods have led in many places across the world to thinning of top soils and soil compaction. Serious erosion is an increasing problem with 2.2 million tonnes of precious topsoil being lost in the UK alone every year. Soils that are depleted, and not retaining nutrients, result in crops that are more disease prone, leading to a vicious spiral of increasing use of chemical inputs to compensate and to tackle pests and disease.

The UN is concerned about the emergence of "hidden hunger": malnutrition due to the decreasing levels of micro-nutrients (vitamins and minerals) in foods. Graham Harvey's book *Grass-fed Nation: Getting back the food we deserve* cites some of the data examined by David Thomas in 2003 (ref 429) from Medical Research Council studies by R.A, McCance and E.M. Widdowson on the changes of nutrient content of many everyday foods between 1940 and 1991 (*The Composition of Foods*). During this period the mineral content in vegetables had, on average, declined by: 24% of their magnesium content, 46% of calcium content and 76% of copper content. Carrots had lost 75% magnesium, 48% calcium, 46% iron and 76% copper. Potatoes had lost 30% magnesium, 35% calcium, 45% iron and 47% copper. "According to Thomas, you'd have needed to eat ten tomatoes in 1991 to get the amount of copper a single tomato would have supplied in 1940." In seventeen varieties of fruit magnesium, calcium, zinc, iron and copper content were between 16% and 27% lower in 1991 than in 1940. "Even meat showed a fall in mineral levels. In a range of ten popular cuts the iron content fell by 54 per cent and the copper content by 24 per cent" (Harvey, 2016, ref 269, pp. 221-2).

Well-managed soils containing plenty of organic matter are capable of retaining more nutrients; they are

also capable of absorbing more water, making them more resilient to drought, reducing run-off and associated flooding resulting from heavy rain and enabling the provision of clean groundwater. Importantly, such soils are also capable of taking up large quantities of greenhouse gases, such as carbon dioxide and methane.

All dietary preferences have their pros and cons, however documents prior to 2013 (*National Trust*, ref 34), and most analyses of the GHG emissions associated with the food we eat, still do not take into account the role that livestock grazing has in wider "eco-systems services", including the possibility of enhancing the ability of soil to act as a natural, biological carbon capture system, or "carbon sink", for greenhouse gases (see also section 20 on methane).

4) Eating the Food That Grows Well Around Us

Many of us will be aware that what grows well in one part of the garden, may not flourish in another. Soil type, aspect, shade, exposure to wind, altitude, latitude, longitude, climate and seasonal weather are among the many factors which will affect how easy or hard it is to produce various ornamental plants and foods successfully; and so it is with our farming and food production and where different crops or livestock thrive best with the lowest level of extra inputs. These local factors, and also transport connectivity, proximity of processing facilities and outlets and so on will influence what contributes to a low carbon diet in a locality.

Eating food that can be produced in this country helps to reduce our dependence on the land of others. It also keeps the countryside in production, retaining the knowledge and skills of farmers and producers; enables us to enjoy some of the delicious food that is grown around us; provides employment and opportunities for young people; improves the traceability of food and the accountability through the food chain; reconnects us with where our food comes from and improves the trade deficit.

Fruit and vegetables:

Plenty of fruit and vegetables is considered to be a key component of any healthy diet. As with all food, there are many different approaches to production, some of which are more environmentally friendly than others. Factors which will influence what effect production has on the environment and GHG emissions include, for example, the organic content of the soil (and added to the soil), artificial fertilisers, pesticides, herbicides and fungicides, hydroponic production (much of our soft fruit is now produced in this way without being grown in soil), irrigation, fossil fuels used in production, processing, transport (distance and means eg air, shipping, road transport), storage and preparation for consumption. Some fruit and veg can have a remarkably high carbon footprint, or it can be very low, depending on factors such as how and where it is produced and what inputs are needed. Agrichemicals have a significant GHG footprint, both in manufacture and application. Energy for heated greenhouses leads to a large increase in carbon footprint, although there are now some heated with renewable energy sources. Air freight has very high CO2 emissions compared with shipping. Also, in terms of relative nutrient content the GHGs associated with transporting a container of lettuces, for example, may be higher than for some foods with a denser nutrient content. Irrigation and water footprint can also be a significant factor: many fruit and vegetables are presently imported to the UK from regions with low water productivity and therefore these goods compete with domestic and industrial users for local supplies in those countries: an example may be tomatoes from Spain (whereas many Dutch tomatoes, for example, may have a high GHG footprint due to the use of heated greenhouses.)

Hydroponics is a system which is used to grow large quantities of the fruit and vegetables in our shops these days, particularly soft fruits and salad vegetables. This involves the plants being grown with their roots in mineral nutrient solutions in a water solvent, without contact with the soil, or the roots may be in an inert medium, such as perlite or gravel. The nutrients may be of inorganic origin or organic such as fish waste or duck manure. For more information on this look up 'hydroponics' on Wikipedia. The greenhouses/polytunnels used for hydroponic production often cover many acres of farmland, without using

the soil, and could perhaps be preferably situated on brown field sites.

Although there are many less local vegetable growers in our area than there were some decades ago, in very recent years there does seem to be some resurgence, as consumers develop more interest in where their food comes from and how it is produced. Happily, those in our immediate area are completely committed to ensuring good soil health and putting environmental sustainability at the heart of their business. This small-scale vegetable and fruit production can enable a significant amount of food to be produced on a small area of land. Some of our local growers are also practising integrated production by variously combining their fruit and veg production with nut, honey, free range eggs and pork production: finding that these confer natural economies and benefits, such as free fertilisation by the bees, and, in a different way by the pigs. The pigs also contribute free weeding and digging. Free range hens assist pest control, and "recycling" of some of the waste vegetation. This integrated production also creates havens for biodiversity.

Permaculture is an integrated ecological concept of food production which is often able to produce very large quantities of food even from small areas and includes using the vertical dimension for food growing along with ground level production and good soil management.

In *Your Kitchen Garden* (1975) George Seddon indicated that 335sq m is required for a family of four, with hearty appetites, to be self-supporting in most vegetables, or 445sq m if main crop potatoes is included (ref 267). It would be interesting to consider, if we ate mainly locally produced vegetables, what acreage of land would be needed to grow vegetables for the 18,292 residents (2016 figures) of Bradford on Avon Community Area.

Competition from cheaper imports, the desire for year-round availability with loss of awareness of seasonal production, and the taste for exotic fruit and vegetables, have all contributed to the reduction in consumption of UK produced fruit and vegetables to the point where in 2015 Defra statistics show that we are only 18% self-sufficient in fruit and 57% in vegetables (ref 252). Lower labour costs in some other countries is a major factor in certain imported foods being available at the cheaper prices that the British consumer, supply chains, corporate outlets and government all demand. Clearly food producers and their workforce need an income commensurate with the country they live in (like everyone else); this is challenging if the consumer and the large retailers are demanding lower prices and there is strong competition from imports. Valuing healthy food and making a link with where our food comes from, is probably central to people giving good food a higher priority in the household budget. This is possible for many; there are many others where good food should be a basic right, but it cannot be a reality without redistribution of wealth within the country. Nevertheless, education, knowledge and skills have a role to play in enabling people to feed themselves a healthy diet on well-produced food on a tight budget.

Tubers and root crops, such as potatoes, carrots, parsnips, beetroot etc are regarded as having a relatively low carbon footprint, however they may have other environmental impacts, such as soil run-off. They are usually a reasonably economical choice and many are good, warm and hearty, locally-grown options during the winter months. The potato is so versatile that it is surprising that it has been so extensively displaced by pasta and rice and other imported alternatives.

Joanna Blythman is a fine investigative journalist and food writer, who Hugh Fearnley-Whittingstall has described as having “one of the sanest food heads in the Western World”. Her book ‘*What to Eat’* (2012, ref 128) gives a detailed description of our different fruit and veg and all other food groups with nutritional information about each, how to use and also the different production methods used and environmental impacts. Her excellent short introductory section includes: “*The 20 principles of eating, made simple*” which is based around healthy eating, and also puts environmental issues at its heart; and “*10 ways to save money on food without compromising your principles*". She advises against becoming an ideological eater: “Instead, just try to head in the right general direction, but don’t make a fetish of it. Be led by your stomach as well as your head. Eating well can seem complicated, but, actually, it’s simple.”

Arable crop production and keeping the soil healthy:

Only around a third of the farmland in the UK is suitable for growing crops. This arable land produces some of our most important nutrients. 2015 figures show about half of the croppable area was planted with cereal crops (mainly wheat and barley), then temporary grass, then oilseed crops (such as rape, linseed and borage), then other crops (such as sugar beet, oats, rye, peas and field beans, maize) and then lesser areas for horticultural crops and potatoes. The need for pesticide use varies from year to year. 70% of the total weight of pesticides used are on cereal crops. (ref 85).

On a vegetable plot, allotment or market garden, rotation of different vegetable groups to maintain soil health and fertility is a relatively easy matter once we learn in what order they should follow one another; and incorporation of organic matter into the soil will be recognised as key by many fruit and veg producers: compost when available or animal manure first or second hand perhaps, after being used as mushroom compost, are invaluable.

The great grain fields also need a rotation to keep the soil and the crops healthy and this can be achieved through careful crop rotation, and break crops, such as root crops, green manure crops, and, traditionally, also through temporary grass for grazing as part of the mixed farming model. Healthy soil structure (ref 195) is promoted by root growth, organic matter and a vast active population of digesters, recyclers, and nutrient transporters such as worms, beetles, insects and micro-organisms and other important soil processes. These promote the development of granular and crumb structures within topsoils that give aeration and permeability to the soil, allowing root growth and water and nutrient filtration and retention. Compaction of the soil by heavy vehicles, human or animal traffic can break down soil structure at surface levels and at subsoil level. Soils that are compacted are vulnerable to erosion. Both water and wind erosion are causing worrying levels of topsoil losses in depleted soils across the world (including in the UK). (ref 416).

The turning over, and during periods of the year the laying bare of the soil, makes arable cultivation particularly liable to yield up the soil stores of carbon dioxide into the atmosphere, thereby contributing to greenhouse gases. Modern industrial farming is implicated in extensive damage to soils across the world, with impairment of microbial activity and soil structure, and decreasing crop yields have been reported. There are however ways of minimising this, including: keeping the ground covered as much of the time as possible; minimal tillage and disturbance of the soil; ensuring good levels of organic matter in the soil and minimising the use of agri-chemicals, which damage the micro-organisms within the soil that promote the uptake of carbon dioxide and other gases.

It must have been in the 1980s that John Seymour (1914-2004), who has been described as an ecological pioneer and wrote over 40 books, addressed a packed audience in the upper room at Green Park Station, Bath. On leaving school he had worked on a traditional farm before studying agriculture at Wye College where he learnt about how agrichemicals would transform the future of farming. In 1934, aged 20, he went to Africa where he would remain until after the war. He spent 5 years in South Africa, Namibia and Zambia (as they are now), working and spending some time with the bushmen. During the war he was in Kenya, then Ethiopia, Sri Lanka and Burma. Returning to Britain, he farmed on an almost completely self-sufficient basis from 1954 for 30 years or more. He also travelled extensively to the USA, India and other parts of the world, partly for the BBC. In Bath he spoke passionately about how modern industrialised farming was damaging soils across the world, including in Britain, and that soils are “just washing away, washing away”. He called animal manure “liquid gold” and talked about the madness of separating livestock rearing from arable production - how this “specialisation” in farming was destroying the structure and fertility of arable soils, whilst simultaneously creating disposal problems for slurry from livestock kept away from the land in intensive systems: problems which traditional mixed farming can resolve. It was not until 2015 that the UN flagged up to the world how serious the problem of depleted soils is worldwide.

Tim May, Director of the 2,500 acre Kingsclere Estate in Hampshire, spoke to CFB in 2014, at an event with Graham Harvey. Four generations of Tim’s family have farmed the estate since 1890. However, over the course of about 10 years it had been farmed on the “big arable” model, widely advocated over the latter

part of the 20th century, and had produced continuous cereals. It was becoming more difficult to maintain yields. After a crop failure, on consultation it was found that the topsoils were depleted of organic matter and microbial life, and the structure of the soil was seriously damaged. One of the most striking images of an interesting and engaging short film - '*One Man, his Mutt and his Mud*' (*Pasture Promise*, 2015, ref 408) - is a deep hole scooped out of a field where this damage is clearly visible. Tim, with agreement, although some understandable reservations from his father with regard to business risk, decided on a complete change of course in management of the estate in 2012 to a regenerative agriculture approach. The (enormously expensive) spraying regime of pesticides and herbicides, which was damaging the microscopic and larger insect life within the soils, was discontinued.

Kingsclere Estate was thus returned to mixed farming with animals as well as crops: 50% of the farm has been put down to mixed species grassland (herb rich and red clover leys) for 4 years, as part of the rotation with crops. The rotational grazing of these leys, by a large flock of sheep, as well as cattle, is helping to restore the fertility and structure of the soil. Although they have yet to follow on the grass by an arable rotation, the soil structure and colour is improving. The local wildlife trust is monitoring the wildlife in the soil and on the farm and an early sign of improvement was first more spiders, and then worms! Fertilisers have still been used to help fulfil the nutrient requirements of the damaged soil for the arable crops until they can follow the pasture rotation, however a minimal tillage approach has been adopted, along with robotic "Global Positioning Systems (GPS) and the latest aerial imagery to create detailed maps, enabling us to pinpoint areas where site specific management is required. For example, increasing sowing density or improving the organic matter within the soil. This allows us to enhance the natural potential of the land for the future whilst helping to minimise our reliance on chemical inputs." The film '*Power Grazing'* is an update of the progress that has been made on the farm and shows the improvements in the soil and biodiversity, which is a pleasure to see (*Compassion in World Farming*, 2016, ref 407).

Tim says that they have now started the conversion process for organic registration and will have a once-a-day mobile dairy enterprise on the grassland in 2018 to complement the sheep and beef. They have pigs and poultry running on the pasture on a trial basis.

The farm as a business has, in fact, not suffered as a result of increased diversification, which actually brings improved resilience. The stewardship of the countryside has come to be seen as of much greater importance than previously and is now an integral part of the business. The plans of Tim and his family are to become, increasingly, local food providers.

Meat and dairy:

An attempt has been made in this literature search to look at the environmental effects of meat in some detail, and particularly beef, which has had a very bad press, but historically has been a key source of first class protein, and other essential nutrients, within the UK. It is worth bearing in mind that animal by-products are also very important, such as leather and wool, to name just two, and that non-animal sourced alternatives to these are very often synthetic. (These not only have their own carbon footprint, but also there are major disposal problems when discarded, as many will not biodegrade. The problem of ultimate disposal often ends up in developing countries, rather than our own country.)

It is important to consider that of the 70% of the UK which is suitable for farming - the Utilisable Agricultural Area (UAA) - 65% is grassland which is unsuitable for arable farming (crop production). Over time animals convert grass, which humans cannot eat, into first class protein with the full complement of amino acids that we need. Also, in the areas that are well suited to crop production, arable crops like cereals, need to be rotated to maintain the fertility and structure of the soil. Traditionally, mixed farming provided both permanent pastures, and temporary pasture as part of a rotation with arable crops. Animal grazing brings fertility to soil through their urine and their dung, which both promote the microbial life in the soil and help activate the carbon cycle, increasing the laying down of carbon and other nutrients into the soil.

Graham Harvey, agricultural advisor to *The Archers*, spoke at a well-attended Climate Friendly Bradford

on Avon (CFB) event in 2014 on ‘Grazing to Save the Planet’. A number of CFB members have also read his books *The Carbon Fields* and *We Want Real Food* and have found his explanations of the biological life in soils and grazed pasture very enlightening. He also talked about how dairy products and meat from animals that are mainly grass fed have a healthier nutrient content and a better balance of omega 3 and omega 6. (Harvey, 2008, refs 195, 127, 279, Leifart, 2016, refs 301, 302, Blythman, 2012, ref 128, Sustainable Food Trust, 2016, ref 341).

There are a growing number of farmers in this area who over recent years have converted to raising their livestock on chemical-free pastures of species-rich grasses, which include deep-rooting herbs, without extra feed concentrates. We are increasingly hearing from them that their animals have shown a marked improvement in health: the frequent need for veterinary care for their animals in the past has reduced, so that calling the vet has become a rare event. This is consistent with various publications indicating that there are animal health benefits (and it is suggested consequent human health benefits) from animals raised thus. They are also noticing an improvement in the biodiversity on their farms. One of our local farmers in Winsley said that his family farm was ploughed up for cereals in the middle of the 20th century as a result of the agricultural policies of the time. However, the soil is not fertile enough to grow arable crops without heavy dependence on fossil fuel based artificial fertilisers. The land is now back under permanent mixed species pasture for their beef herd, and no agri-chemicals are required. Within a close vicinity to Bradford on Avon we have sheep, beef, dairy and poultry farmers who, as well as raising their animals and poultry on pasture, produce all, or almost all, of any additional feedstuffs on their farms.

Importantly, GHG emissions associated with food production can vary widely, depending on how that food is produced. However, the international and national statistics on emissions do not always differentiate between high and low emission production systems. In the United States, high levels of grain are fed to cattle and there is also a very high water footprint because of the irrigation of the cereals there. Beef production in some countries in South America and the Caribbean are associated with land use change and clearing of rainforests, with associated very high carbon dioxide emissions. (FAO Rome 2013, ref 236). Production systems such as these impact upon the generalised global statistics for GHGs associated with beef production. However, in Western Europe and the UK the picture is very different. In the UK the majority of beef is mainly grass-fed and our grasslands are naturally rain-fed (ref 143). Grass cannot be consumed by humans however grasslands can be converted to high quality food through livestock grazing. An All Party Parliamentary Group took a very serious look at '*The Carbon Footprint of the Beef Cattle and Sheep Sector'* in the UK in 2013 and concluded that "the 'eat less red meat to save the planet' message is far too simplistic to be credible at this stage. Because we are not fully able to quantify the carbon footprint of red meat, nor are we able to fully quantify the carbon footprint of the foodstuffs that we would seek to replace red meat with, this argument lacks the scientific grounding to be robust.” (ref 40).

According to National Trust research (2013) on their tenanted farms - in some beef farming systems there may be a net gain: more GHG sequestered than emitted (ref 33). The main GHGs associated with UK ruminants (cows and sheep principally), are methane and nitrous oxide. Different breeds of livestock, different feedstuffs and stocking densities are some of the factors affecting how much methane is produced and this is being actively studied. Animals fed on ryegrass which has been nitrogen fertilised and is fast growing is considered to lead to more methane production than when animals are grazed on slower growing, mixed herb pastures (Harvey 2008, ref 195). Most of the methane emissions associated with UK agriculture is due to ruminants and amounts to around 5.3% of total UK GHG emissions, based on 2014 statistics (DECC, ref 229, pp. 97-99). Methane is a much more potent GHG than carbon dioxide and nitrous oxide is much more powerful again. However, these DECC figures are for carbon dioxide equivalence (CO_2e), so this difference in potency is adjusted for in the figures shown. (Methane production from livestock is discussed in more detail later in this document, see sections 20, 21, 22, see also ref 114.)

The way that GHG intensity is measured at present is generally leading to advocacy for intensive food production systems which are GHG efficient in terms of input in relation to output of food products. However, this is a very partial way of assessing impacts and often does not take into account wider impacts of how food is produced, such as animal welfare, wider eco-systems benefits of livestock grazing, including

potential for increasing GHG sequestration in grassland, water use in water stressed areas and so on. It is now well recognised through research studies that grasslands store huge quantities of carbon dioxide up to depths of at least 1 metre. The carbon stocks are significantly greater under grassland that is cut just once a year and has moderate or light grazing, compared to intensively managed grassland (Ref 322, 284, 224). Disturbance to soil, including through arable cultivation, is known to release large amounts of GHGs from the soil and scientists are saying that permanent pasture definitely should not be ploughed up for this reason. Nevertheless, because assessment of sequestration or release of GHGs to or from soil is very complex, this is still not factored in to the "carbon footprint" of different foods. If sequestration is assumed with grazing, the GHG intensity of grass-fed livestock could move from very high to very low or even GHG negative (ie leading to more sequestration than emissions). (FCRN, 8.3, ref 311; ref 40). See also section 21 - "How GHGs are measured".

The role of livestock in shaping our landscape is significant and the enjoyment of many people in our "green and pleasant land" probably owes much to our pasture land and seeing grazing animals and, for example, lambs in the spring.

Pasture-fed livestock can be produced with very little disturbance to the environment. It is noticeable travelling into Bath through the Avon or Frome valleys, or down the A46 as one nears Bath, how livestock rearing is often associated with smaller field sizes, maintenance of hedges and the retention of mature trees. This combination of trees, hedges and pasture is likely to be very helpful in maximising the GHG take-up by the soils and enabling it to be stored in the deeper levels of soil. Trees are helpful in livestock production, giving both shelter and shade, which is beneficial for the wellbeing of animals and helps productivity. Trees and hedges can be a nuisance to arable farmers, as crops do not grow so well under shade and they may also get in the way of the machinery.

Choosing dairy products from animals that are mainly grass-fed is very important, as dairy cattle are much more likely to be fed concentrates than beef cattle. In 2015 there was widespread media reporting that the supermarket price wars had pushed half of UK dairy farmers (9,960) out of business since 2002, whilst the costs of producing milk had been increasing. (In the 1950s there were nearly 200,000 dairy farmers in the UK - CPRE, ref 423). With constant pressure on farmers to cut prices and become more efficient, over recent years there has been a trend towards the UK dairy herd being kept in sheds with no access to grazing, and there has been a marked rise in US-style mega-dairies. Cows are being bred to produce more and more milk (ref 244). This intensive dairy production, and competition from imports with lower prices (20-25% of our dairy products are now imported), and consumers cutting dairy and beef products, is leading to a debt crisis in farming and forcing out ever increasing numbers of smaller and grass-based system dairy farmers. Patrick Holden, former CEO of the Soil Association, writes about these issues from the perspective of both being an environmentalist and a dairy farmer in Wales (refs 277, 288). Kate Humble, in her TV programme '*Back to the Land'* on 7th March 2017, highlighted the Welsh dairy farmers, where the closures were expected to continue with 1 in 5 dairy farms going out of business in 2017. So, our grasslands, which can produce wonderful, nutrient-rich, traditional foods, are being under-used, whilst increasingly animals are being housed away from the land. At the same time consumers are opting for competing products, often from other, maybe distant, countries.

It is questionable therefore whether the advice, often heard in the UK, to reduce or cut out dairy and meat products to save the environment is most likely to bring about the desired environmental benefits. A better outcome may be achieved for the environment by instead ensuring that we ask for products from animals that are mainly pasture-fed, British, and preferably, local. There are plenty of local outlets for pasture-fed meat and some for dairy products. In supermarkets, ask the question: they need to know what their customers want. Organic dairy herds will be mainly pasture-fed. Jamie Oliver and Jimmy Doherty have flagged up the importance of asking for milk and dairy products that come from pasture-fed herds and the Pasture Promise milk label, which is an assurance to customers that the milk is from herds that have been grazed for at least 180 days a year. It costs a little more, which for the dairy farmer can make the difference between staying in business and being forced out of business (refs 243, 244). In an interview for *Compassion in World Farming*, farmer and founder of the Pasture Promise label, Neil Darwent, said that there are now less than 10,000

farms producing milk in England and Wales compared with 28,000 in 1995. These farms have been an integral part of our rural communities and are the very fabric of our countryside. He says that traditional grazing herds are not inefficient (as we so often hear said) - the conversion of grass, that we can't digest, into nutritious milk is a very efficient process. The global commodity market is now brutally competitive and there is increasing pressure on cows and farmers to deliver more for less. (ref 343).

The majority of UK beef herds are likely to be mainly pasture-fed still (although difficult to find recent data on this) and housed just through the winter months, fed mainly on hay and silage. The farming industry plea to 'Back British Farming' is not without reason: by doing so, as consumers we can also support higher environmental standards in British farming through our food choices. The UK is only about 60% self-sufficient in beef.

A UK beef cow is responsible for less methane emissions and less nitrogen excretion than a dairy cow (in kg/head/year). UK dairy cattle spend less time on grass than beef cattle and also consume more feed concentrates. Animal feedstuffs such as grains, seeds, soy and palm oil products are grown on land that could produce foods directly for human consumption. However, a significant proportion of soy and palm oil is consumed directly by humans or is used for other purposes such as soaps, cosmetics, pet foods, biofuels, industrial purposes and so on. Considerable amounts of animal feeds are the byproducts of other processes, although whether some of these are an appropriate feedstuff for the animals they are fed to is a question raised by Harvey (ref 269). In the UK, the majority of the "concentrate" feedstuffs and grains are in fact fed to pigs and chickens (refs 250, 40).

Worldwide, numbers of livestock have been increasing very significantly, particularly as developing nations are wishing to eat a more Westernised diet, leading to increased emissions globally from livestock. Nevertheless, it cannot be assumed that cutting meat or dairy consumption here will lead to our land being used for more environmentally-friendly food alternative. Reduced demand for meat resulting in lower financial returns to farmers, leads to reduced livestock rearing and conversion to other more profitable commodities, or intensification of production methods, or farmers going out of business. Less land under grassland management and more arable is likely to lead to increased release of soil carbon stores through cultivation of the land: higher fossil fuel emissions from increased fertiliser and pesticide applications and increased consumption of diesel for working the land. In addition, the end products may be more sought after by consumers and give the farmer a better return, however they are not necessarily healthier for people or for the soil.

Eating a well-balanced diet of mainly local food, produced to high environmental standards, and choosing dairy and meat (if eaten) from animals that have been mainly pasture-fed, may be the best way to achieve a more sustainable food system. See also *Two Ways to Tackle livestock's contribution to the climate crisis* (GRAIN, 25 April 2017, ref 212)

"In England and Wales agriculture accounts for less than 1% of recorded water abstractions by volume; the majority in the south and east of England." (ref 84). This is not necessarily mainly associated with livestock.

Game:

Many types of game in the UK have a low carbon cost and in some cases there can be a benefit to the environment from well-managed culling.

Nuts:

Nuts could beneficially be a larger component of many people's protein intake and they have many other benefits. However, it may come as a surprise that most commercially grown nuts are produced with use of agri-chemicals and irrigation may well be used, sometimes in areas of water stress. Wild picking, nut trees in the garden and small scale commercial production are all possibilities. There is more potential for increasing

British nut production, which can be economically viable, especially organic production according to Martin Crawford of the *Agroforestry Research Trust*. (ref 119).

Fats and oils:

The national nutritional guidelines regarding fats and oils, and indeed other foods, are important with regard to the effect that they have on farming and the environment.

Historically, the essential fats in the British diet have been mainly from animal sources: whole milk, cream, buttermilk, butter, lard and perhaps, after Christmas, some valued goose fat. Some of the fat intake was in the meat itself, as well as from fish and nuts. Dripping from roast meats was used for frying foods. The production of these fats did not take up a significant area of arable land and they were produced in conjunction with the protein component of the dietary intake. Today, with the move away from the traditional sources of fat to mainly plant derived sources of oils and fats, a large separate area of, often arable, land use is required.

The health advice that dairy foods and other animal fats are responsible for the increased prevalence of various medical conditions over recent decades has had a significant impact on what we eat, on British farming, and where our food comes from. Much of the ongoing debate has centred around the role of saturated and unsaturated fats in the diet. Alternative fats, oils and milks come from a wide range of sources; some can be produced in the UK such as rapeseed and sunflowers. The majority are principally produced abroad, such as palm oil, soy, olive, corn, almond, cashew, hemp, cottonseed, peanuts, safflower, coconut, rice milk - many of which, even if they provide substantial cash inflows into the countries that produce them, will create their own challenges for local land and water use.

California produces 80% of the worldwide supply of almonds and the industry is reliant on irrigation; however, the state has been affected by severe droughts in recent years. Olive oil has a very good track record through the millennia and is considered to have health benefits. It cannot be produced in the UK. Demand for olive oil in this country has increased greatly over recent years. In some countries olive groves are suffering as a result of climate extremes. Production in some parts of the world may contribute directly to land use pressure which is a threat to precious habitats and biodiversity - such as the impact of palm oil and soy production on rainforests. There is also the matter of an associated reduction in Britain's self-sufficiency in an essential macro-nutrient.

It seems to be becoming **more widely accepted now that both saturated and unsaturated fats are necessary as part of a healthy and balanced diet** and that most fats and oils in fact contain both, in varying proportions. There is however much national and international controversy as to which sources are healthy, how much we need, and which may contribute to health problems. Industrially produced transfats are now recognised to be harmful (De Souza et al, 2015, ref 123). These partially hydrogenated transfats have been banned in a number of countries, although not in the UK. Many major manufacturers have removed transfats from their products, although they are still commonly found in many cakes and biscuits, for example. Some commonly used oils are now considered to be carcinogenic when heated to high temperatures for cooking (BBC news magazine 2015, ref 217) (ref 270). Removing some, or all, of the natural fat content from dairy foods to produce low fat foods leads to reduced flavour and palatability; this is then often compensated for by adding sugar, salt and other additives.

Current dietary advice to replace the saturated fats in dairy produce with unsaturated fats, found in products like margarine and sunflower oil, **has no impact on the risk of developing heart disease**, according to the British Heart Foundation (BHF) which helped fund an analysis of 72 separate studies by researchers from the University of Cambridge. Nevertheless, it recommended that large scale clinical trials are needed before suggesting any major changes in dietary guidelines. (2014, ref 300). So at the present time, Public Health England recommends “some milk and dairy, choosing reduced fat versions or eating smaller amounts of full fat versions or eating less of them.” These guidelines, including the advice on which cooking

oils to use, are not universally endorsed by all experts, in the light of the evidence over recent years. However, although the evidence is not robust, according to the BHF, the guidelines remain unchanged in favour of often highly processed and sometimes denatured alternatives to traditional sources of dietary fat.

Whole foods such as eggs, meat and dairy produce have fallen into a state of disgrace on a number of occasions over recent years and the evidence is sometimes later found to be wanting. These are traditional British foods, that have been amongst the principal sources of nutrients and health through the generations and through the centuries. If a food which has been a part of the traditional diet is thought to be causing an increase in health problems in more recent times, we need to know why. We need to know what has changed: for example, is it the way the food is produced (it may well be that food produced in some ways may be healthy, whilst the same food produced in other ways may have a detrimental impact on health); the way it is consumed; what else has changed outside of the nutritional factors for instance the effects of exercise and other environmental and lifestyle factors.

Dairy and meat from mainly grass-fed animals have a better balance of omega 3 and omega 6 than grain-fed animals. "Within the cell membrane omega-3s and omega-6s are largely interchangeable - evolution has made them this way. In nature omega-3 fats are chiefly found in green plants and grasses, while omega-6s are found mostly in seeds. For man the hunter-gatherer, summer-time diets were higher in omega-3s, with omega-6s becoming more plentiful in the autumn" (Harvey, 2008, ref 195, p.26). Harvey also refers to the high levels of fat soluble vitamins A, D, K and E in milk from dairy cows grazing fresh young grass, with butter made from this milk being a particularly rich source. (ref 195, 127, Leifart, 2016, refs 301,302, Blythman, 2012, ref 128, *Sustainable Food Trust*, 2016, ref 341).

The '**Debating the Role of Livestock'** conference in Bristol in December 2016 is well worth watching online (ref 341) as it is very pertinent to the issues raised in this document. The main speaker is US farmer Joel Salatin, whose regenerative agriculture practices have restored depleted soils at Polyface Farm, and there are contributions from an expert panel: Prof Mark Eisler, Chair in Global Farm Animal Health at the University of Bristol, Dr Tara Garnett, founder and leader of the Food Climate Research Network, Simon Crichton, Head of Food, Farming and Trade at Triodos Bank and Dr Zoe Harcombe, an expert on public health nutrition. Dr Harcombe questions the validity of the conclusions drawn from the research behind our present national dietary guidelines on fats, oils and unprocessed meat. The meeting is chaired by Dmitri Houtart, BBC Rural Affairs and Environment Editor, who comments on the interest raised at the meeting by Dr Harcombe's short presentation.

Defra figures (2010) (ref 305) show that between 1983 and 2008, the consumption of butter fell from 93g per person per week to 40g; margarine fell from 116g to 22g; lard fell from 48g to 3g; vegetable oils rose from 28g to 60g; low fat spreads rose from zero to 11g (with a peak of over 25g between 1989 and 1995); reduced fat spreads rose from zero to 40g; and total fats fell from 303g to 184g. Over the same period again, liquid whole milk in Great Britain fell from 2,159 ml per person per week to 420ml; skimmed milk consumption rose from 69ml to 1,145ml and total milk and cream consumption fell from 2,444ml to 1,957ml. (Fish intake increased. Consumption of fruit increased, but that of vegetables decreased. Consumption of all meat, except chicken, fell over this period, as did total calorie intake.) Nevertheless, levels of obesity and obesity related ill health **have risen significantly**.

An interesting, recent large scale Canadian study found evidence that consumption of whole milk by children is linked to healthier weight and higher Vitamin D body stores, compared with low fat milk (1%), although again, they say further studies are needed. (Vanderhout et al 2016, ref 232). There seems to be an increasing body of evidence emerging however that suggests that whole milk, and whole milk products, are related to better health outcomes than reduced fat milk.

The advertising of manufactured products over the decades, claiming health benefits, has had a significant impact. It is interesting to read the Wikipedia entry on cottonseed, which was an early product to be advertised in this way as manufacturers looked for an alternative use for a by-product of the cotton industry.

Health guidelines can change our ability to use our farmland to best advantage to help feed our own population with key nutrients. They also have wider secondary consequences for the environment. So it is obviously vital that guidelines are updated regularly, with any new research or analyses which give grounds for uncertainties being fully, and openly, acknowledged in public health guidelines.

Honey:

Research reported in the CSI Pollen Update shows that bees, interestingly, seem to be like people, cows and much of the rest of the earth's species and thrive best on a varied diet (ref 209).

Fish:

"Fisheries and aquaculture make only minor contributions to GHG emissions, but are linked to other environmental impacts" (CGIAR CCAFS Food Emissions, ref 4). Over-fishing across the world has seriously diminished some fish stocks and certain methods of fishing cause damage to the marine environment. Bottom trawling is frequently mentioned in this regard. The Eatwell Plate recommends two portions of fish per week, one of which is oily fish, however there is not enough fish globally for everyone to follow these guidelines. (Garnett 2010, ref 321).

'The price of protein: Review of land use and carbon footprints from life cycle assessments of animal food products and their substitutes' (Nijdam et al, 2012, ref 309) discusses the carbon footprints of various fish and other protein sources. See also section 21 below, which raises some questions regarding how GHG are measured.

Hugh Fearnley-Whittingstall in his Fish Fight campaign has highlighted the problems associated with discards of fish, leading to action by the EU. The Marine Conservation Society (MCS) indicates that 71% of Europe's fish stocks are over-fished or depleted. Their Good Fish Guide rates fish on a 1-5 scale with 1 being the most sustainable choice. For more information see the website (ref 249). At the excellent fishmonger at Bradford on Avon Thursday market, the wide variety of fish available are marked with this rating.

It is strange that as an island nation we have had such a limited interest in the range of fish that we cook, with just a few (over-) popular species, when in fact there is a wide variety of excellent seafood caught off our coasts. Mussels are regarded as a sustainable, low GHG choice, and also oysters and cockles. A significant amount of our best fish is exported - langoustines, crab, scallops, mackerel - the French, Spanish and Italians know a good thing when they see it! In medieval England a greater variety of fish was eaten. In monastic fish ponds, even, there were bream, pike, roach, perch, trout and occasionally tench, and later carp. (ref 320).

There are significant environmental problems associated with the farmed salmon industry (ref 417). Also shrimp and prawn farming in many parts of the world is destroying coastal mangrove swamps and their eco-systems, causing pollution and coastal erosion and damaging poor local communities (WWF, ref 240, p.15).

There is a high level of concern now about the vast amount of plastic in the oceans, not only affecting birds and marine life, but also consequently entering the human food chain.

Fishing quotas are leading to a welcome recovery of some fish stocks, and the efforts to clean up some of our rivers have seen fish increasing as the eco-system has improved, showing that conservation measures can achieve significant and vital change. However, fish stocks generally remain very low and there is still much to be done to restore abundance to our oceans and rivers (as with our soils and land based eco-systems). The *Wildlife Trusts* called on the Government in 2016 to create 48 new **Marine Conservation Areas** in addition to the 50 that have already been designated. The Irish Sea is one of the most overfished areas in the UK.

The first partial fishing ban in international waters was agreed by 24 countries in 2016, creating the

world’s largest marine park in the Ross Sea, off Antarctica.

Climate change is leading to acidification of the oceans due to the increased absorption of carbon dioxide. One effect of this may be to impair the ability of some marine creatures to form shells. Temperature rise and ocean current flow changes are also occurring and fish stocks are migrating to different areas of the marine environment, with many species in the northern hemisphere moving north or to deeper cooler water. Some species of seabirds are now suffering as a result and less able to breed successfully. There are likely to be winners and losers.

5) Drink and the Environment

Production of drinks has a very extensive land use footprint globally - tea, coffee, cocoa, juices and other soft drinks and alcohol, to name just a few key players. Relatively few are produced in this country. Plantations for the crops have been deeply associated over time with appropriation of lands and displacement of people, although they also provide employment and foreign currency. For many soft/carbonated drinks and others the production of the associated sugar component is also mega! - a key source being corn syrup (from maize). There are many beverages which have a massive impact on land use, often mainly for the export trade and sometimes competing for land and water resources with feeding the populations of those countries. Like so many food crops, monocropping is also a major consideration, with implications for crop disease, soil depletion and negative impacts on wildlife with the loss of diverse eco-systems. Some production however is on a small scale, integrating production of several crops, with a range of benefits. Fairtrade products importantly ensure a minimum price for small producers when world market prices dip very low, which, although only available on a certain percentage of their output, is vital for livelihoods.

Replacing some of our drinks during the day with tap water would be good for the environment, taking pressure off land use and other resources (including raw materials for packaging, processing and transport), and may well be good for our health also.

Refill *City to Sea* scheme has an App which tells you which businesses and other establishments are happy for you to ask for a free water bottle refill when you are out and about. CFB have signed Bradford on Avon area up to this initiative. The Town Council is very positive about the scheme and was the first of nineteen Refill stations to be signed up. To be on the App as a Refill station, contact Climate Friendly Bradford on Avon. Members of St Laurence School Sustainability Group have been very involved in this project and have run a competition for the best sticker design to go on people's refillable bottles. 5 million single use plastic bottles are recycled in Wiltshire alone, each month. Additionally, many end up in the general waste collection, adding to landfill, and there are distressing numbers littering our roadsides and other public spaces, despoiling our beautiful environment. There is a far reaching environmental cost to producing, transporting and disposal of these bottles and their legacy lasts for years - all for a single drink! So.. remember to take your refillable bottle when you go out!

Within a stone's throw of Bradford on Avon there are vineyards and orchards (producing apple juice) certified as being managed to high ecological standards.

6) Food, Ethics and the Environment

The ethical objections to meat eating need to be considered because of the precedence they have taken in the debate about reducing GHG emissions. How robust is the ethical argument? Does it acknowledge the facts of life? Cows only produce milk because they have had a calf (usually on a yearly basis): half the calves will be bull calves, and not all the heifer calves will be needed for replacement stock in the milking herd: so veal and beef are natural by-products of the milk industry. Artificial insemination with sexed semen is sometimes used, however it seems that this may be associated with decreased rates of conception (ref 427). If milking herd replacements are not needed, milking cows are crossed with a beef bull breed, so that both the bull and heifer calves will be better suited for raising for beef. About half of our beef is supplied from

culled dairy cows. Pedigree beef, dairy and dual-purpose breeds are important for retaining the genetic diversity and specific traits of the different breeds. This is also true of all other livestock and poultry, of course. Different breeds will have different qualities and also be well adapted to different situations, in the same way that seeds are. It is much easier to maintain this diversity and retain heritage animal breeds (and plant species and varieties) if there is a commercial value. With the emphasis on high productivity breeds, there is an over-emphasis on certain breeds, whilst others of our traditional breeds have become rare breeds, very low in numbers. At the Bath and West Show and other agricultural shows, a wide range of the different breeds can be seen, as well as the pride that farmers take in these wonderful animals.

New fossil finds in Morocco "reveal what was on the menu for our oldest-known *Homo sapiens* ancestors 300,000 years ago: Plenty of gazelle meat, with the occasional wildebeest, zebra and other game and perhaps the seasonal ostrich egg, says Teresa Steele, a paleoanthropologist at the University of California" (2017, ref 190). It would be unsurprising if meat and animal products have been part of the human dietary intake before and ever since.

Goat milk and cheese producers in the UK are currently encouraging British consumers to start eating goat meat, as about 30,000 billy goats are culled at birth each year, which could be bred on for meat (ref 59). And of course, fertile eggs hatched to produce the vast national (and global) laying flock, will produce half cock birds, not just laying hens in-the-making.

Clearly, a vegan diet needs to be accompanied by a good level of knowledge of how to achieve an adequate and balanced intake of nutrients, and some artificial supplements are required as a purely plant-based diet is unable to provide quite all of the nutrients essential for human health: presumably this is why historically it has not been adopted by any of the world's major cultures or religions.

Foodsource cites a study of real life diets of over 55,000 people in the UK. In this study, (by Scarborough P. et al, 2014), daily meat consumption is assessed as: - high: more than 100g; medium: 50-100g; low: less than 50g. Vegan and vegetarian diets were found to have lower GHGs than all meat-based diets. A vegan diet was found to have 50% of the GHGs of a meat-eater's diet. A pescetarian diet (fish-based, but no meat) also has lower GHG emissions than all meat-eater diets, however the consumption of fish gives rise to a different set of environmental issues concerning fish stocks and marine eco-systems. The difference between the carbon footprint of vegetarian, fish-eaters and low meat-eaters was not so great. However, the study did not factor in any possible carbon sequestering effects of grazing management (9.2.3, *FCRN*, ref 310). (As mentioned elsewhere in this document, this could change the footprint of pasture-fed animals from very high to very low.)

Personal values and beliefs need to be respected. At the same time, data on the GHG intensity of different foods, including UN data, does not necessarily take into account many wider environmental issues associated with food and drink production. Additionally, there are some possible problems, around how GHG intensity is measured, which are raised in more detail in section 21. It is also open to question whether the global figures can be interpreted as having equal validity and relevance in every country: the figures do not necessarily reflect what foodstuffs grow well in different areas of the world and the need for country-appropriate rotations, for grain production for example.

Grains and pulses (beans, including soy, peas, lentils, chickpeas) have the highest levels of non-animal protein: many are not suitable for cultivation in the UK. Legumes are also the main protein sources for some of the world's poorest people: so perhaps we need to ask some questions about whether we should be turning away from our locally-produced, first class protein and other foods to compete in the world food markets for these products - putting up prices for the most nutritionally vulnerable and using their land to feed us, whilst under-using our own land. If the world population became vegan, that would unduly concentrate the production of many key protein sources in certain parts of the world. Already, some of the countries that we import from are more vulnerable than the UK to the effects of climate change on future food production, which raises the issue of food security for both them and us.

Richard Young did a detailed investigation, based on the most recent UK data, asking '*Are dairy cows and livestock behind the growth of soya in South America?*' He was seeking to answer the following questions:

1. How much soya is used in producing milk and other dairy products and what proportion of total soya use is this?
2. Does producing soya milk use less soya beans than producing milk from cows?
3. Is soya in livestock production the major driver of soya production, as we have been led to believe?

Young was surprised by the outcomes of his inquiry, as many others probably will be, and it is well worth reading, although a little too complex to summarise briefly here (Sustainable Food Trust, Jan 2017, ref 342).

A crop with, unusually, a full complement of the amino acids that we need, is quinoa. Its increasing popularity in "developed" (this term always seems something of a misnomer - depends what one is measuring!) countries has led to reports that it is leading to a deterioration in the dietary sufficiency of the indigenous Indian peoples of the South American Andes, for whom it is a staple food. Recently this crop has been successfully grown in the UK and we have a local producer. So, again, it is worth thinking carefully about the impact of where food comes from.

There will always be international trade, and most people enjoy, and would like, some produce that cannot be produced in this country. However, it is open to question whether we should be outsourcing so much of the production of our key nutrients (and our carbon footprint) as we are doing: proteins - as discussed; carbohydrates - rice and pasta (the type of wheat suitable for making pasta does not grow in this country) taking precedence over potatoes (since the 1970s there has been a 67% drop in fresh potato consumption); fats - palm oil, coconut oil etc; and vitamins and minerals (only 23% of our fruit and veg is now being produced in the UK).

Many fruit, veg and nuts have a very high water footprint and a large proportion are imported to the UK from countries with water stress.

Many people are adopting restrictive diets, cutting out certain foods without always having a good knowledge of balancing nutritional requirements, which is causing concern (refs 386, 387).

Of course, meat eating, vegetarian and vegan diets can all be associated with good or poor health outcomes. It seems that studies done on the relative health benefits are often confounded by other behaviours that may influence the outcome. Whatever we choose to eat, a nutritionally balanced diet (although there is not total consensus on what comprises a nutritionally balanced diet!) and other life-style factors, such as exercise, are considered to make a positive difference (Garnett, 2014, ref 321).

There are a range of novel foods being developed - for example, laboratory-cultured foods (such as, lab burgers). These are being promoted as the way to reduce the impacts of our food production on climate change and obviate the need to use animal products; and we are encouraged to think that we will, as a result, feel guilty in the future if we do eat animal products. Whether the variety and complexity of soil-based nutrients in our foods can really be satisfactorily replicated in the lab is open to question, especially since we still seem to know so little about so much! Over the last century, in spite of an over-production of calories in the world, the scientific and manufacturing industries have not been remarkably successful either in bringing an end to world hunger and malnutrition, or in bringing about good health outcomes for those people who can afford food. (See also section 15.)

Given the present state of our knowledge, it seems as if there is really no moral high ground to be claimed by any particular dietary choice: all food and drink and parts of the food chain system, right up to how we feed ourselves at home and what we waste, impacts to a greater or lesser extent on the environment, on biodiversity and often on working conditions, as well as human rights and justice (see more later). At the same time, there is every reason to think that it is perfectly possible to feed the world, to look after the soils, and to take care of the world's water resources and biodiversity whilst also strengthening social structures and communities everywhere. (See section 26.) In both *enjoying a variety* of foods which provide a well-

balanced nutritional intake and in gradually *thinking more about where and how our food is produced* in order to make informed choices, we may each discover our own way forward, for the wider environmental good.

7) The debate around self-sufficiency and food security issues

The IAASTD (2008, ref 365) gives the following definitions -
Food security: [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. (FAO, The State of Food Insecurity, 2001)
Food sovereignty: is defined as the right of peoples and sovereign states to democratically determine their own agricultural and food policies. (There is no internationally agreed definition.)

Karl Matheson of *The Guardian's* short article on 7th August 2014 '*Should the UK be able to feed itself?*' is followed by an excellent blog, including contributions from the *NFU*, various Green groups and other expert commentators. It is well worth reading to help give insight into the differences between, and issues relating to, self-sufficiency and food security. It emerges that the last time that the UK was self-sufficient was the mid-1700s and that 1984 was the year with the highest self-sufficiency in the last century. It is mentioned that, according to the FAO, Britons eat a third more than we need to, with a substantial rise since 1995. (This obviously applies to some people and not others!) Self-sufficiency is a measure of output, but not necessarily of food security, although a comment by Professor Tim Lang indicates that there is a slow decline in our food production and we are therefore becoming "more sensitive to world food prices and the volatility in financial markets." Peter Melchett, the Policy Director for the *Soil Association*, highlights that an increase in sustainably-produced food could be achieved in the UK, if we stop "allocating ever increasing areas of farmland to grow more maize for anaerobic digestion plants and oilseed rape for fuel" ...and if we increase fruit and vegetable production, invest more into researching sustainable production which does not rely on agri-chemicals, and if demand for food produced in the UK is increased. (GNM, ref 290)

Some trading of food improves food security, and poor harvests in different parts of the world in some years are an important reason why this is the case. However, it can be argued that at the present time the UK could be doing more to produce more of its own food sustainably. Most food across the world is consumed close to where it is produced, although 20% of food is now traded internationally (interestingly, in this context, the UK imports nearly 50% of its food and even its indigenous food is likely to have been bought through a supermarket and therefore unlikely to be local). It is therefore concerning that our MP has said that the present Conservative Government's plans are to "turbo-charge" exports and intensify food production (rather than focusing on increasing self-sufficiency in well-produced food). At the present time, there is no satisfactory renewable fuel available for transport, so increased trading (especially to more distant parts of the world post-Brexit) increases fossil fuel emissions, and also leads to more competition for farmland for biofuels. Until a full solution is found to this scenario, home production and trading as close to home as possible, is surely the wisest course.

8) Feeding the world population

The current world population is 7+ billion; the projected population in 2050 is 9.7 billion (UN 2015). There are currently sufficient calories produced globally to feed 9 - 12 billion people, according to different sources. So, is the drive to intensify food production systems to feed the world appropriate at the present time, especially as the rate of world population growth is now slowing and a third of present worldwide food production is wasted? Further intensification on many of the current models of production will inevitably lead to further increases in environmental damage. Surely now is a time when there is a very positive opportunity to adopt less intensive, more environmentally- and health- friendly methods of food production?

The World Hunger Education Service (2015) concludes that poverty, harmful economic systems, conflict

and climate change are the main causes of world hunger and that there is more than enough food produced globally to feed the world population (ref 100). The UN Food and Agriculture Organisation (FAO) statistics for 2014-16 show that 1 out of every 9 people in the world is hungry. The vast majority of hungry people (780 million) live in developing regions of the world, particularly South Asia and sub-Saharan Africa. Although in some parts of the world significant progress is being made to reduce hunger, in sub-Saharan Africa the number of undernourished people increased substantially between 1990-2 and 2012-14.

The FAO (2016) (ref 237, p.102) says that "since impacts are expected to be worse in low-latitude regions, climate change is likely to exacerbate imbalances between the developed and developing world. Climate change underscores the need to help developing countries deal with food and energy price increases, as well as volatility in food supplies."

Globally, consumers in industrialised countries waste up to 222 million tons of food a year. This is nearly the equivalent of the entire level of food production of sub-Saharan Africa. This becomes even more shocking when one finds out that 90% of the world's agricultural land is in Latin America and sub-Saharan Africa (FAO, 2015, ref 74). "40% of losses in low income countries occur at storage, transport and processing levels. 40% of losses in high income countries occur at retail and consumer levels" (CGIAR CCAFS Food Emissions, ref 4).

In "emergent" countries where poor populations are becoming richer, significant increases in demand for food consumption are taking place. This includes a trend towards increased meat and dairy products, calorie-rich foods and processed foods. Some large countries, especially China, are reaching medium to high consumption levels so rises may be much less rapid than in the past. However, persistent poverty prevents hundreds of millions from meeting their needs. (FAO, ref 61).

It is a matter of great concern that the increasing adoption of the Western-style processed food/ fast food culture across the world is resulting in people who are underweight and undernourished, becoming instead overweight and still malnourished. The extra calories being consumed are not necessarily providing a nutritious, balanced and healthy intake.

Tensions between land use for producing goods for export and foreign cash flow and using land to feed a nation's people raise an important issue. Most governments are keen to export more to improve their trade balance, however one country's export, is another country's import. A group of south Pacific islands have chosen to put health first: - observing how western junk food leads to adverse health impacts, Torba province in Vanuatu plans to protect the health of local people by banning imports in favour of their traditional local, organic diet.

Both obesity and restrictive eating disorders are widespread problems in the developed world. Even a person who appears to be a healthy weight may be malnourished, if nutrient intake is poorly balanced, and this is considered to be a not-infrequently seen problem in the UK. Knowledge and skills education to ensure nutritious, healthy diets is perhaps more necessary now than ever.

9) Distribution of wealth

Distribution of wealth and education are surely key factors in enabling people to eat a nutritious diet and buy food which has been produced to high environmental and ethical standards, both in the UK and across the world.

"**Food utilization:** emphasizes the nutritional aspects of food security. It is commonly understood as the way the body makes the most of nutrients from food. Sufficient energy and nutrient intake includes nutritious and safe diets, a clean environment, access to health care, diversity of diet and intra-household distribution of food. Poor utilisation within a population can impose economic and social costs in countries at all economic levels" (FAO 2015, ref 74, p.22).

Food poverty has risen in the UK over recent years and government statistics showed that treatment for malnutrition in NHS hospitals between 2008/9 and 2012 almost doubled, with the highest number of cases in Somerset. Dependence on food banks has increased greatly over recent years. And this in one of the world's wealthiest nations.

'*The easy way to eradicate poverty'* is an interesting article on the introduction of universal basic income in a Canadian town, starting in 1974. After 4 years the new conservative government there discontinued this scheme without ever analysing the results. The detailed records were discovered in 2009 and analysed over the course of 3 years. The outcomes show wide-ranging benefits: "…the people in Dauphin had not only become richer, but also smarter and healthier. The school performance of children improved substantially. The hospitalisation rate decreased by as much as 8.5%. Domestic violence was also down, as were mental health complaints. And people didn't quit their jobs - the only ones who worked a little less were new mothers and students, who stayed in school a little longer." (*The Guardian*, Bregman, 2017, ref 280).

With the increasing use of robotics and other technologies in many spheres of life in the future, we are given to understand that less people will be required in the workforce. So perhaps now is a very good time to be considering the calls for a universal basic income.

10) Tax Injustice and its Effects

Tax injustice is causing poverty and hunger in the developing world according to Christian Aid. Tackling tax dodging and ending financial secrecy could provide the US$50bn the Food and Agriculture Organization of the United Nations (FAO) estimates is needed every year to eradicate hunger by 2025. Tax 'dodging' affects us all including poor people in the rich world but it is especially disastrous for people in the developing world. (ref 396).

Countries like Zambia are losing vital tax revenue which could pay for better health centres, schools and roads because multinational companies can hide vast profits in the secret global network of tax havens.

The tax lost to Africa alone could pay for healthcare to save the lives of 4 million children and to employ enough teachers to educate every child in Africa.

The gap between the rich and poor is growing and Tax Havens are at the heart of the inequality crisis enabling corporations and wealthy individuals to dodge paying their fair share of tax. The UK has the biggest financial secrecy networks with its Crown Dependencies and Overseas Territories which are Tax Havens all linked to the City of London which many consider to be a Tax Haven. Large Audit companies such as Deloitte, Ernst and Young, KPMG and Pricewaterhouse Coopers play a central role in Tax Havens and are complicit in their role of Tax Dodging. What is required to stop this is to make country by country reports available for each country in which companies operate. To be effective this would have to be made public. Some progress in awareness about Tax Dodging has been made but a recent amendment to make Country by Country reporting public narrowly failed in the UK government. (ref 397).

One hopeful sign is that people in the developing countries are fighting back with help from organisations such as Oxfam, Christian Aid and Action Aid. Young people are motivating others, particularly youth groups, to act to stop Tax Dodging in their own communities and to campaign about the money they are losing through companies operating in their countries hiding away their profits in Tax Havens. Two young women, Wanijura Kanyiha from Kenya who works for Oxfam and Onyinye Okechukni from Nigeria who works for Action Aid, toured the UK speaking to MPs and at Universities about the problems their countries face. Poverty is causing a lack of spending on healthcare, schools, nutrition and infrastructure. These young women were getting the message out to their fellow citizens in Kenya and Nigeria particularly talking to Youth groups and through the use of Social Media emphasizing that this situation must change. They also work with people in other African countries discussing the need for Corporation Tax not to become a race to

the bottom, for example. They realised that campaigning must take place in their homelands as well as in countries like the UK. (ref 398).

There would be far less need for aid if there was Tax Justice.

(This section has been contributed by Hazel Jones, CFB SFADG member and Coordinator of the Bradford on Avon Oxfam Group.)

11) Fairtrade

The Fairtrade movement can be traced back to ethical shops in the USA and the UK in the 1940s and 1950s that sold imported handicrafts at fair prices. In 1973 fairly-traded coffee from Guatemala began to be sold in the Netherlands, where in 1989 the World Fairtrade Organisation of retailers was formed. The 1990s saw expansion into many more food products, and non-profit Fair Trade labelling organizations were set up in European countries and in North America.

In 1997 the worldwide association, Fairtrade Labelling International (FLO), was created, using the Fairtrade Mark that we know today. FLO is responsible for setting international Fairtrade standards, for certifying production and auditing trade according to these standards and for the labelling of products, working with national labelling organisations such as the Fairtrade Foundation in the UK, and producer networks. Currently the UK buys more Fairtrade than any other country by quite a long way, perhaps due to having many more volunteer campaigners.

Fairtrade producers are required to form a cooperative if they are small farmers, or a Joint Board with representatives of all the workers if they are a large plantation or company. They have to meet good environmental standards and produce detailed records for inspection.

The Fairtrade Mark carries a guarantee that the producers have received a minimum price, based on local conditions, that is enough for them to survive years when the world price of that product is low. When the world price is higher they get the higher price. It also brings a premium of a small percentage of sales that they decide cooperatively how to use. This is usually on things like barns or facilities for more on-farm processing, solar or grid electricity, vehicles, even schools and maternity hospitals.

Soon after the Fairtrade Mark was established, a combination of large commercial companies that own plantations created their own mark, Rainforest Alliance. It has similar environmental standards to Fairtrade but no minimum price or wage, no premium, and no cooperative decision-making. Unfortunately, many consumers never learn the difference and confuse the two marks. More recently various ‘direct trade’ schemes have arisen, particularly for coffee, where the importer has a direct link with a particular producer and often claims to give better than Fairtrade terms. This may be very genuine and personal, but hard to assess as there doesn’t seem to be any independent verification.

From about 2000 Fairtrade moved beyond specialist shops into supermarkets, which expanded the Fairtrade market enormously, benefiting very many more producer groups. Demand has proved strong enough for the supermarkets to continue stocking it, and presumably they see it as good for their image and social responsibility. This presents competition and challenge to the pioneering companies offering exclusively Fairtrade products and having close partnerships with producers, and sometimes mentoring them until they are ready to supply supermarkets. It does seem so far that there is room in the market for both.

Fairtrade has moved beyond its North American and European roots to, for example, South Korea and Japan. Since 2005 there have been regional organisations in producer countries that support the farmers and promote Fairtrade locally. Countries such as Brazil, India, Kenya and South Africa now sell Fairtrade products to their wealthier classes as well as producing them for export.

It seems a reasonable hope that Fairtrade will continue, as it does now but on an increasing scale, to reduce global inequality, reduce migration of people who cannot make a living in their own country, and spread education and skills. Farmers who once knew nothing of what happened to their produce after it left the farm gate now know about the rest of the supply chain, become educators and managers within their co-operatives, make crucial decisions about spending the Fairtrade premium including measures to adapt to climate change, and to help children progress through school and college.

Fairtrade supporters dream of a world where there is no unfair trade, where perhaps sub-Saharan Africa, which has the highest number of undernourished people and also the highest population growth, would follow the trend of the rest of the world where increased confidence and prosperity prove to be the best way of slowing population growth. Parents have smaller families when they think their children will grow up and have a future to invest in.

Nevertheless, Fairtrade isn't a solution to all problems and can present dilemmas. It doesn't seem likely to reduce the volume of food being transported around the world, having export and import at its core. It grew out of our love of coffee, tea, sugar, chocolate, tropical fruits and roses at Christmas, and may even encourage some of us to consume more with a clearer conscience. Sugar is one of the most important Fairtrade products, although it may be affected by some countries banning imported cane sugar to protect their own beet sugar growers.

It would be unrealistic to think that Fairtrade producers are more likely to avoid the temptations of junk food than anyone else, once they can afford it. Meat eating would be bound to become more than a very occasional luxury, although some of it might be home grown animals that also provide fertiliser. Some of the benefits that may come with Fairtrade that people most value, such as being able to buy an ambulance or a school bus, can radically change people's lives for the better, saving lives and giving access to education, however such changes may also increase the carbon footprint of the community. Land being grabbed and rainforest cleared for palm oil or soybeans is a scandal, but what would we think if the traditional owners of land cooperatively decided to clear it and grow Fairtrade palm oil or soy?

Actually it shouldn't matter what we think. We're not giving them aid to help them on our terms, but trade to be independent partners. If Fairtrade achieves the outcomes it sets for itself, sufficient numbers of farmers in poorer countries will be well-informed, confident and financially secure enough to do what seems best to them.

(This section has been contributed by Vivienne Kynaston, CFB SFADG member and Chairwoman of the Bradford on Avon Fairtrade Group.)

Fairtrade Fortnight - Feedback from a Nicaraguan coffee producer's presentation

A Fairtrade coffee producer from Nicaragua made a passionate plea for us in the developed world, and young people everywhere, to do all we can to mitigate climate change which is increasingly threatening their environment and livelihoods. Speaking at Bath Spa University during Fairtrade Fortnight 2017, she said that they are experiencing: higher temperatures; increased disease levels in crops; torrential rainfall causing erosion; and much colder temperatures than normal during part of last year were associated with cold ocean currents following an enormous polar ice mass breaking away. Adaptation to climate change is going to be crucial and this producer said they were rearing species of replacement coffee bushes with resistance to coffee rust disease, *under*-planting to increase ground cover and create interconnected root systems to give more stability to the soil, and planting vegetation banks to reduce erosion: this in a smallholding with integrated tree, crop and livestock production. She highlighted that the increasing loss of rainforest and biodiversity in Nicaragua, is partly being driven by clearance for vegetable growing. She particularly mentioned yams for export to Puerto Rico, and carrots. There are large scale forest clearances, and also multiple small clearances of perhaps a hectare at a time, that eat away at the forest margins. This lady lives with her husband and family at over 1,000 metres, however yam cultivation extends right up to the edge of

their land. They have been asked to sell or lease their land for yam growing. They say that they will never do this as they know the trees will be cleared. She wishes that shoppers in Puerto Rico gave a little more thought to where their food comes from and the effects of how it is produced.

12) Competition for Land - here and abroad

The above account emphasises that competition for land sometimes leading to exploitation of, and damage to, important natural environments comes from many directions. Recently there have been reports that Mexico is fighting a spate of illegal logging due to land being cleared to increase avocado production. This follows the sharing on social media of the nutritional benefits of avocados and a resultant large increase in demand.

"Livestock: The world food economy is being increasingly driven by the shift towards animal-based products, such as meat, milk and dairy. As a result, agriculture is being affected, not only through growth of livestock production, but also through linkages to other sectors that supply feeding stuffs, such as crops and fisheries. Globally livestock production is the largest user of agricultural land and therefore leaves a significant imprint on the environment" (UN, ref 74, p.30). This document does not differentiate the area of grazing of traditional grasslands worldwide and the areas of rainforest and other sensitive habitats cleared for further grazing and cereal production for feedstuffs. Worldwide, 2,700 million hectares of pasture land and 100 million hectares of cropland are used to feed livestock (CCAF, ref 3). The total available farmland globally used for arable and permanent crops is 1,500 million hectares (FAO, ref 61).

Perhaps one option to enable reductions in intensification of food production might be to convert arable land, currently used to grow grain for feedstuffs for intensive livestock systems, to grazing or re-afforestation with benefits for GHG sequestration, wider ecosystem services, reductions in agrichemicals and animal welfare. Additional land could also be freed up by reducing the third of all food production which is wasted globally. Further land could be made available through reduction in consumption of foods which are not sources of primary nutrients, such as sugar and corn syrup and replacing some of our drinks each day with tap water. If the traditionally-used animal fats were found not to be the cause of the explosion of certain medical conditions, over recent decades, (the evidence that they are is being called into question by many experts), then less arable land would be needed for growing alternative fats/oils to fulfil our dietary needs.

A technological breakthrough in finding a non-land-based alternative to the (potentially exponential) production of bioenergy crops would, even now, release a vast amount of land globally for non-intensive food production or (re)naturalisation. Maybe some of the countries that would like to eat more meat could replace rice production for export by more home-produced meat and dairy - the increased methane production from livestock production might be mitigated by the reduction of methane from rice production. A reduction in water use might also be achieved. It may be that exactly the same land is not interchangeable in terms of usage, but perhaps some readjustment of production areas for different products is(?) (just a thought!!!). For our own home consumption, replacing rice with potatoes, which can be grown in the UK, would help to restore the place of this crop in UK farming as an important part of the rotation with cereals to maintain soil health. International transport emissions would be reduced. It would also bring down our outsourced methane emissions from rice production. Of course, countries need to grow enough rice for the years when there are poor harvests, so there will be surpluses during the good harvest years, and many do restrict exports when the crop is needed for their own people.

There must be plenty of other opportunities to free up land use. Some of these ways of reducing land use could allow more generally for less intensive, but more valued, food production.

GRAIN, the international NGO, says that we cannot address climate change unless we transition away from industrial meat and dairy consumption and redirect subsidy support to smallholder systems and the local systems which support them. Like the *IAASTD* it indicates that sustainability for developing countries is threatened by the "so-called" free trade and investment deals of developed countries, which do not "allow

communities and countries to grow their local markets in cooperation and mutual support" (ref 412).

"The arable area in the world as a whole expanded between 1961/63 and 1997/99 by 155 million ha (hectares) (or 11 percent), the result of two opposite trends: an increase of 172 million ha in the developing countries and a decline of 18 million ha in the developed ones. This decline in the arable area in the latter group has been accelerating over time....[associated with] sustained yield growth combined with a continuing slowdown in the growth of demand for their agricultural products" (2002, FAO, Section 4:3:2, ref 61).

Studies have shown that 75% of deforestation globally is driven by palm oil, soy, paper pulp and beef (GNM, 2016, ref 379).

Biofuel production for electricity, gas production and fuel, is now a large and increasing competitor for farmland, feeding into an exponential global demand for energy. So although this is seen as a cleaner (although this is open to question, see section 28.3) and renewable form of energy, it may also threaten food security particularly for the world's poorest. This is an escalating issue in terms of land use. There is at present no adequate green alternative to fossil fuels, that does not compete for farmland, to replace petrol and diesel. In the absence of an alternative, it may be reasonable to question the wisdom of seeking major trading partners at ever greater distances. Increasing air travel and air freight are a particular concern in terms of emissions. Should there in fact be a much greater emphasis on minimising all forms of transport and travel? (Also see section on Energy.)

The UN is concerned about "soil sealing" as one of the main causes of soil degradation in the EU often affecting fertile agricultural land. This refers to the covering of soil by hard surfaces, such as: industrial, commercial, retail, housing, roads and other infrastructure developments, which also puts biodiversity at risk, increases flooding risk and water scarcity and contributes to global warming. Since the mid 1950s the total surface area of cities in the EU has increased by 78%, whereas the population has only increased by 33%. To what extent are government and local planning departments taking these serious concerns into account? (Ref 380).

"The total area of rural land lost to urban use [in the UK] between 1945-1990 was 705,000 ha - an area the size of Greater London, Berkshire, Herefordshire and Oxfordshire combined." The loss of thousands of hectares of agricultural land to development has been continuing since 1990. "This loss of rural land may reduce the long-term capacity to produce food in an environmentally sustainable way and compromise the ability of the countryside to produce environmental goods, such as landscapes, natural habitats and tranquil areas." (University of Reading, Land Use and Production, ref 422).

Leisure pursuits and many other human activities, such as resource extraction, may be responsible for land use change from agricultural land or natural habitats. Development for tourism is also causing significant clearances and despoliation of pristine habitats in some parts of the world; and the economic benefits do not necessarily accrue to the local people.

It has been reasonably suggested that it is the combination of all the various land use pressures globally on agricultural land, which together have some responsibility for the erosion of rainforests, savannahs and other sensitive habitats for agricultural purposes.

13) Land Grabs

In 2011 OXFAM started the GROW campaign and with it came concern about such issues as:

- Climate Change - because as temperatures rise crop yields will fall and extreme weather events will get worse and happen more often.
- Food Price Spikes - were also an area of concern because when you spend up to 80% of your income on food as poor people often do, spikes in food costs are especially damaging.
- Small Scale farming - because it was time to unleash the enormous potential of small-scale farmers in

developing countries.

There was also a concern about Land Grabs because all over the world secretive land deals force poor farmers away from the land that is providing their living while Multinational Companies (MNCs) are focussed on obtaining land for their crops for food and other products. (ref 390).

One particular crop, sugar, has driven large scale land acquisitions at the expense of small scale producers and their families. Companies such as Coca Cola, Pepsico and Associated British Foods are included in this.

Oxfam says that MNCs should know how sugar impacts on communities' access to land, and whether their suppliers are respecting land rights. Oxfam said these companies should commit to a zero tolerance of land grabbing throughout their supply chain and should work with governments and expect others to do the same. (ref 391).

There have been some success stories – In 2013 Oxfam America reported that 'Coca Cola leads the way on land rights'. They have committed to 'zero tolerance for land grabbing' and agreed to respect and protect the land rights of rural and indigenous communities and also to influence their suppliers. So have Coca Cola kept their word? According to the most recent *Behind the Brands* score card they have scored 8 on land which is up from 3 in 2013 and is classified as good. Associated British Foods only score 5 but it has moved up from 1 in 2013. (ref 392).

However, the problem of land grabbing has not gone away and a report from Oxfam International published 26/9/16 gives much cause for concern. Millions of people face being displaced from their homes as new data shows land sales covering an area the size of Germany are now under contract. Of these deals 59% are communal lands claimed by indigenous people and small communities. Aggressive eviction of entire communities and even murder has been taking place. Winnie Byanyima who is Oxfam's International Executive Director, said "We're entering a new and even more dangerous stage of the global land rush. The frenzied trade in millions of hectares of forests, coastlines and farmlands has led to murder, evictions and ethnocide. Land contracts are being signed and projects are breaking ground without the full consent of the communities living there. Conditions are ripe for increasing conflict in the years ahead if land rights are not better protected now".

Half of the world's land is inhabited by 2.5 billion women and men belonging to indigenous groups or local communities but they formally own just one fifth of it. Part of the problem is a lack of proof about who actually owns the land - it has just been used by indigenous people for generations and they consider it their land. Vast tracks of sparsely inhabited lands are among the world's most important regions on earth for biodiversity and also for mitigating climate change. Three out of four people who are living in poverty survive on farming, making it a vital asset for more than 900 million women and men worldwide. With growing demands for food and fuel and a demand from foreign investment for land across the developing world, it is under severe pressure.

Lua Miggiano, Oxfam's land rights expert, said in a new report '*Custodians of the land. Defenders of our future*' that Oxfam has revealed fresh data on the global land rush and profiles six cases where lives have been shattered by threats to their land in Honduras, Peru, Sri Lanka, India, Mozambique and Australia. (ref 393).

Palm oil is currently a cause of great concern. The Forest Peoples Programme say 'the rapid growth in palm oil to feed global demands for edible oils and biofuels is causing serious social and environmental problems yet plantations are set to double their extent in the next 20 years'. In partnership with affected peoples and supportive non-governmental organisations the Forest Peoples Programme has been 'documenting these abuses and challenging the palm oil industry to stop grabbing people's lands without their consent and resolve the huge number of existing land conflicts.' RSPO - Round Table on Sustainable Palm Oil was formed in 2004 because they realised there was an urgent need for sustainable palm oil. Palm oil seems to be in so many food products but there are now products such as Nairns of Scotland that use

sustainable palm oil and many Fairtrade products. There is a real need for this practice to grow. (ref 394).

(This section has been contributed by Hazel Jones, CFB SFADG member and Coordinator of the Bradford on Avon Oxfam Group.)

14) The Elephant in the Room (or What the International and National Documents hardly mention):

This elephant is truly huge, charging and bursting out on all sides and doing much damage as it goes. This is not fair on elephants; this is no noble giant and it is not a threatened species dwindling in numbers, quite the reverse. Indeed, it is partly what threatens elephants and other biodiversity across the world. It has powerful drivers: global corporations, shareholders, mega finance and businesses of all sizes. And us. It is the result of what we like to eat and will willingly spend more money on than good, nutritionally rich food: it is the many millions of hectares of land worldwide used to produce the raw ingredients for the foods which are now considered to be responsible for the global health crisis: junk food, processed foods (high in sugar, fat and salt), and sugar to excess, in all its forms, including drinks. It is seriously questionable why this has such a low profile in most of the UN and governmental documents on food production and land use.

Farmers everywhere are more likely to be able to make a living out of what we want and are willing to pay good money for. Unfortunately, it is often good food that we think that we should only have to pay the barest minimum for. Our unwillingness to pay a fair price for good food, and our food choices, force many farmers out of business. It also drives the production of foodstuffs for the fast food market, and some of the damaging intensification practices in farming globally.

All calories are not equal in nutritional terms. This may be due to the foodstuff itself or the nature of the end product after processing, which may be de-natured of its natural nutrients and have a range of less healthy ingredients or artificial additives incorporated. Big companies spend gigantic sums on persuading us to eat and drink their processed products, rather than buying recognisable, fresh, whole ingredients sourced at a fair price, perhaps direct from farmers or through a local outlet.

Although the health impacts of junk food are being widely discussed, the impacts on the land, of this way of feeding ourselves, is not. Millions of acres worldwide are needed to produce the raw materials for junk food production, many of which also have a high water demand. Agri-chemical inputs, processing and international distribution produce very significant levels of GHG emissions, as well as, sometimes, other negative environmental impacts, not reflected in the statistics. A little of these products occasionally may do us no harm, and some foods have to be processed to be edible, for example oils. There are some processed foods that are carefully produced to high environmental, ethical and nutritional standards, however it is widely recognised that many are high in sugar, salt and fat and low in micro-nutrients and also contain many ingredients that we would not include in home cooking, including a dizzying range of non-food additives.

It is not known whether a healthy, nutritionally balanced diet for all would take more or less land and be responsible for more or less GHG emissions than present food production. It is clear though that a vast acreage of land could be put to better use in terms of the type of foodstuff which is being produced in nutritional terms, and of whether the produce is destined to be made into a healthy end-product.

15) The Global Health Crisis and Land Use

"*The junk food toll: global health crisis warning as child obesity heads for 91 million by 2025*", with subtitles "'Adult' illnesses rise due to bad diet and couch culture" and "Poor countries will suffer the worst, study finds": - this is an article by Sarah Boseley, Health Editor of *The Guardian* published on 8 October 2016. It is based on data from the World Obesity Federation and says that "Junk food and sugary drinks are taking an enormous toll on children across the globe, with soaring numbers who are obese and millions are now developing diseases such as type 2 diabetes and high blood pressure previously seen only in adults.

Children are facing crippling illnesses and shortened lives thanks to the spread of the heavily marketed fast-food culture, while health services across the world will struggle to cope, experts warn….More than 3.5 million children worldwide, now have type 2 diabetes, which was once unknown in this age group and can lead to horrible complications in later life, such as amputations and blindness….Some 13.5 children now have impaired glucose tolerance, which is a precursor of diabetes. Some 24 million have high blood pressure and more than 33 million have fatty liver disease as a result of obesity, which is more often associated with alcoholism and can lead to cirrhosis and liver cancer. If anything, the experts say, the figures are an underestimate because they are based on the number of obese children and some classified as overweight will also have these diseases." The article highlights the fact that low and middle income countries are now the worst affected by the numbers of children with excess bodyweight and it is associated with high levels of stunted growth in underdeveloped regions. It quotes Lobstein, one of the authors of the report, published in the journal *Pediatric Obesity*, "…it is obvious that something is severely wrong in the way that our food supplies are developing. You cannot replace contaminated water with Coca-Cola or Nesquick, or lack of good meals with a pack of fortified noodles, and still expect children to grow healthily….Healthy food supplies are also a basic human right for this and the next generation." The article refers to the fact that consumption of sugary drinks has increased by a third in the last 10 years and the power of fast food advertising to influence choices. The problems of inadequate levels of physical activity are also emphasized. (*The Guardian*, 2016, ref 292).

Academics from Oxford are currently teaming with Sainsbury's to reinforce the reduce meat/eat vegetarian message to consumers, on health and environmental grounds, based on an American study. (*The Guardian*, ref 383). The encouragement to eat plenty of fruit and vegetables message is to be welcomed. However, the reinforcement of the "vegetarian=good / meat-eating=bad" message which has become so widely touted, is not a message that is borne out by this literature search. Is this the right message to achieve best health and environmental outcomes? The issues concerning the environment and meat and dairy products have been explored and discussed extensively through this document. According to many experts animal products have health benefits and in recent years have been demonised, without the evidence for adverse health effects being robust. Dr Zoe Harcombe indicated at the Bristol Conference, *'Debating the Role of Livestock'* in November 2016 (Sustainable Food Trust, ref 341) that many people in this country now have a range of nutrient deficiencies that could be corrected by eating meat (ref 341). Feeding grain to animals does use land that could grow food directly for people, grazing uses much land that is either unsuitable for arable production, or as part of an arable rotation which improves the fertility of that land. The conclusion from this literature search is that there are likely to be health and environmental benefits to promoting the message to eat British pasture-fed meat and dairy products. This would hopefully have the effect of bringing animals back on to the land where they should be, rather than in intensive housed systems, where they do not have access to grazing. (ref 412). A rising price might lead to an automatic reduction of consumption but would help to ensure that our grassland farmers could achieve a viable income. As emphasised throughout this document, it is a responsibility of governments to ensure that citizens have economic sufficiency to be able to afford a good diet: it should not be farmers who have to bear the economic brunt. At the present time in the UK, our grasslands are being underused and intensification of livestock production is increasing; the future availability of this vital resource of our grasslands for high quality nutrient production is threatened by competing land use demands.

The data from the US study on which the initiative between Oxford University and Sainsbury's is based, do not tally with the figures found in this literature search for GHG emissions from meat production in the UK. The US figure given in the article that eating less meat could cut GHG by 30-70% is surely misleading? This does not bear any relationship to the fact that the majority of livestock emissions in the UK are attributed to methane and the total methane emissions from agriculture in the UK in 2014 work out as 5.3% of total UK GHG emissions in carbon dioxide equivalence (DECC, 2014 statistics ref 229, pp.97-99) (see also section 20 below). As mentioned earlier in this document, production methods for foods vary throughout the world and are very different between the US and the UK, so the same message is not appropriate everywhere. It is ironic that in a store packed with processed foods (many of which will be high in fat, sugar or salt and low in micro-nutrients) and junk foods of all descriptions (as all our supermarkets are), that the health message that Oxford University academics are choosing to work with Sainsbury's to promote is to cut

back on meat which is a key source of first class proteins and other important nutrients. And surprise, surprise, the store is taking this initiative as an opportunity to promote "novel products". How is it that Oxford academics are not working with Sainsbury's and other supermarkets to promote the UN's recommendation that to eat a healthy diet whilst reducing GHGs: "we should be eating a very limited intake of processed foods that are high in fat, sugar or salt and low in micronutrients"? (FAO and FCRN, 2016, ref 237, p.86; also see the UN dietary recommendations in section 34 of this document). This message would also be consistent with the concerns expressed in the paragraph at the beginning of this section and by obesity experts across the world. And it may be worth considering in this context, that a considerable amount of the high levels of saturated fats in processed foods is not of animal origin.

Anyone wondering why the UN's Food and Agriculture Organisation recommends that a healthy diet should involve a very limited intake of processed foods (that are high in fat, sugar or salt and low in micronutrients) is well advised to read Joanna's Blythman's behind-the-scenes investigation of our processed food industry in *Swallow This* (ref 71), where the sagacity of this advice becomes abundantly clear.

There are indications that our bodies are aware of the nutrients we need - sometimes we clearly know whether we need to eat something which is savoury or sweet, for example, and in pregnancy or if we are unwell we may also have a strong preference for certain foods. Many foods may now be low in natural nutrients due to both primary and secondary production methods. Nutrients are often added to processed foods although not always in the foods in which they would have been naturally present. So, could it be that we sometimes crave the foods in which certain nutrients have been artificially added, but perhaps consume more calories than we would have when eating a food that was a natural source? For example: eating breakfast cereals fortified with vitamin D will involve consumption of more calories than absorbing vitamin D from sunshine, and a different range of nutrients compared to foods in which vitamin D occurs naturally.

16) Some of the World’s Largest Crops

Some of these crops are also the world's 'thirstiest crops':

Agriculture in England and Wales accounts for less than 1% of water abstractions by volume (ref 143), however, what about our imports? Although we don't have figures relating to the UK's share of the water footprint of the food and drink that we import, the World Wildlife Fund says that agriculture is the largest industry in the world and is also the biggest threat to the environment. Agriculture wastes 60% or 1,500 trillion litres of the 2,500 trillion litres of water that it uses each year - this is 70% of the world's accessible water. Cotton, rice, sugar and wheat are the world's 'thirstiest crops' in 9 large river basins rich in biodiversity. Together these 4 crops account for 58% of the world's irrigated farmland.

Many big countries like US, China, India, Pakistan, Australia and Spain have reached, or are close to, their renewable water resource limits.

The lack of sustainable agriculture harms the environment by sucking rivers, lakes and underground water sources dry, increasing soil salinity and thereby destroying its quality, and by washing pollutants and pesticides into rivers that in turn destroy downstream ecosystems such as corals and breeding grounds for fish in coastal areas.

The main causes are:

- leaky irrigation systems
- wasteful field application systems
- pollution by agrichemicals
- cultivation of thirsty crops not suited to the environment

The waste and pollution of water is made worse by misdirected subsidies, low public and political awareness of the crisis, and weak environmental legislation. (All of this information comes directly from the

WWF website (ref 145).

Sugar:

Sugar cane was the largest global crop in 2013 with 1,877,110 thousand tonnes produced (2015, FAO, ref 74, p.28).

Through the millennia people have always enjoyed sweet foods and a certain amount in our diets may be quite acceptable. However, now, high levels of sugar or alternative forms of sweetening have been introduced into a wide range of foods where one would not expect to find them. Much of our processed food and drink contains high levels of sugar (or alternative sweeteners), fat and salt and this is partly to restore flavour to food that has been denatured of some of its natural nutrients through the production process. Not only this, but fruit and veg are being bred to be sweeter to pamper our changed tastes.

The consumption per capita worldwide of sugar has increased twenty-one and a half times since the beginning of the 20th century, even though the world population has only(!) increased by four and a half times. The increased production has been achieved partly through significant gains in productivity and partly through expansion of land use. Highest consumption rates are in America and the EU. Approximately 80% of sugar comes from cane, largely grown in tropical countries; the other 20% is produced from sugar beet grown mostly in the temperate zones of the northern hemisphere. Although the market for white sugar is considered to be more or less at saturation point in developed countries, there is thought to be a considerable prospect of increasing markets in developing countries, in Asia particularly, and in the Middle East and Africa (ref 170, 171).

Research reported in *The Lancet* in 2015 showed that the 4 regions with the highest consumption of sugar sweetened beverages to be North America, Latin America, Australasia and western Europe. By country: Chile, then Mexico, have risen to the position of highest sugary drink consumption per capita, displacing the US from the top spot to third position in the ranking. (ref 174).

Globally, at the beginning of the 21st century, 20.42 million hectares of land was used for sugar cane cultivation (FAO 2003). The World Wildlife Fund says that sugar cane is one of the world's thirstiest crops and has arguably had as great an impact on the environment as any other agricultural commodity (the rest of this section on sugar is all from the WWF):

Sugar production today - whether from cane or beet - has a wide range of negative impacts on soil, water and air, including in parts of the world that conservation organisations, such as WWF, have identified as globally important. The Great Barrier Reef off Australia's coast, which suffers from effluents and sediment from sugar farms, is one such case.

Sugarcane plantations in many tropical and sub-tropical countries have led to perhaps the largest losses of biodiversity caused by any single agricultural product.

The EU Common Agriculture Policy (CAP) and measures of the US Farm Bill encourage over-production of sugar in rich countries and dumping of subsidised sugar on the world market. By lowering the world price and allowing unfair competition, these schemes undermine livelihoods and environmental standards in poor countries.

The EU's Sugar Regime needs radical overhaul. WWF is calling for changes that will mean:

- European production being cut by about 8 million tonnes;
- Preferential access being granted to environmentally sustainable sugar from developing countries;
- CAP money being used to finance development aid packages linked to mitigating impacts and raising environmental and labour standards in developing countries' sugar industries.

A World Trade Organisation (WTO) panel recently ruled that the EU is illegally dumping millions of tonnes of subsidised sugar on world markets, increasing the pressure for change in Europe. (ref 145).

Sugar cane, as so many crops worldwide, is also grown on a massive scale for the global biofuel industry. Other products include bioplastics, and biohydrocarbons for transport fuel are being developed (ref 171).

53,000 tonnes of sugar beet were used for biofuel production in the EU in 2014 (FAOSTAT 2016).

Corn (maize):

After sugar, corn is the largest global crop with 1,016,740 thousand tonnes being produced in 2013 (ref 74). The US is by far the largest producer, followed by China, Brazil, the EU (only about a seventh of US production), The Argentine, Ukraine, India, Canada and others.

90 million acres of maize is planted in the US (USDA 2017, ref 329). GM seed is widely used across the world and 93% of the US corn growing acreage was planted with biotech hybrids in 2016, of which some were insect resistant or herbicide resistant, however 76% had "stacked traits" (ref 331). See also section 23.

"*It's time to rethink America's corn system*" by Jonathan Foley describes the American corn belt as dominating the country for 1,500 miles from Pennsylvania to western Nebraska. In 2013, 40% of the corn crop went for biofuels, 36% for animal feed, some was exported and some was used in the food chain, much as high fructose corn syrup. Animal feed is partly a co-product of ethanol production. Corn is also used in bio-based plastics. Corn production in the US is estimated to use 5.6 cu miles/year in irrigation water withdrawn from America's rivers and aquifers. Massive fertiliser use and manure application for nitrogen are polluting lakes, rivers and the ocean (for example the Gulf of Mexico) and causing widespread ecosystems damage. The subsidy system encourages the production of corn and between 2006 and 2011 the increasing demand, especially for ethanol, led to an increase of 13 million acres of corn, and a resulting decrease in wheat, oats, sorghum, barley, alfalfa and other crops. A further 1.3 million acres of grassland and prairie were converted to corn and other uses. Foley makes the case that there should be a shift away from biofuels and corn-fed livestock and the resulting monocropping. He advocates more diversification of the corn belt with grass-fed livestock and crops in mixed farming systems. He argues that this would provide more food, and a more diverse and nutritious diet for people, as well as being a more resilient system of food production. (*Scientific American*, 5 March 2015, ref 328)

Maize has overtaken the production of traditional cereals in Africa, such as sorghum, pearl millet, teff and African rice. Wheat is widely cultivated in North Africa.

Rice:

Paddy rice was the world's third largest crop in 2013, with 745,710 thousand tonnes produced (FAO 2015, ref 74, p.22).

Rice is one of the largest human-induced sources of methane and according to some sources produces more than livestock globally; according to other sources it is less (ref 255, 256). As with livestock and all products the functional unit used to measure the emissions can give different results (refs 167, 163) (also see section 22). Ways of mitigating the methane emissions from rice production have been developed successfully in some countries, although they are not necessarily replicable everywhere. It is predicted that global warming will have a serious impact in increasing the emissions very markedly. (refs 254, 255, 256, 258).

Rice is reported as consuming 40% of all irrigation water (World Resources Institute, 2014, ref 163). "Traditional farming needs 3,000-5,000 litres to produce just 1Kg of rice! By a system of rice intensification (SRI) more rice can be grown per litre. Results from the SRI projects in India, supported by the WWF, have shown substantial increases in crop yields - and farmers' incomes - while using about 30% less water" (ref

145). A range of ways of reducing the water consumption as well as methane emissions are being extensively researched.

Looking at the FAO data, in 2012, thirteen of the top 20 rice exporting countries (all in Asia) are also in the list of 17 Asian countries with the highest levels of under-nourishment. (ref 74, pp.22 and 28). This is a recurring scenario, where land is not being used to adequately nourish a country's population and the foreign currency earned from exporting foods does not reach those in food poverty either. The same is indeed true in the UK as the current Conservative government gears up to "turbo charge" food exports.

Wheat:

Wheat is one of the world's most important food crops. In 2015 it was the world's 4th largest crop yielding 713,183 thousand tonnes (FAO, ref 74) and providing around a fifth of human calories. However, in spite of all the scientific modifications to wheat there has been a decline in the rate of increase in wheat yields. Rothamsted Research and Oxford University are reported in the *Farmers Weekly* to be developing a '*New synthetic chemical that can increase wheat yields by 20%*" which "modifies the way wheat plants use naturally occurring sugars to build up starch content and the size of the grain" (2016, ref 421). Both the necessity and the sagacity of the global push to develop ever greater yields from crops and livestock is surely open to question and more sustainable approaches should be to the forefront.

Wheat is used directly for food for people and for animal and poultry feed, biofuels and industrial purposes.

In the UK 1,935,737 hectares of winter wheat were planted in 2015 (DECC ref 13).

Potatoes:

In 2015, potatoes were the world's 5th largest crop yielding 368,096,000 tonnes (FAO, ref 74). In the UK in 2015, 129 thousand hectares of main crop potatoes were planted (ref 85). Since 1974 there has been a 67% drop in fresh potato consumption in the UK as reported in the *Daily Telegraph* article '*Whatever we do shops tell us to get cheaper: the growing crisis on British farms*' (10 April, 2017).

Palm Oil and Soy:

Soya is used extensively as animal feed in the UK, especially for pigs and chickens. Jim Paice, then Minister of State for Agriculture and Food, stated in November 2010 that we import about 3 million tonnes of soya into the UK annually, and that 'about two-thirds of all our manufactured food contain derivatives of, or ingredients made from soya'; also that 'soya is a major ingredient of vegetarian food.' *The Guardian,* 10 May 2011, reported that palm oil is in about a third of supermarket products, from biscuits and margarine to shampoo and confectionery. Palm kernel meal (10% of world production is fed to UK animals) is used in feed for cattle, pigs, cats, dogs and goldfish. The report, *Mapping and Understanding UK Palm Oil Use* (ref 272), said none of the palm kernel meal Britain imports is sustainably grown. Unsustainably grown soya and palm oil are both implicated in environmental damage and rain forest destruction and this is ongoing.

The goal of the UK government was to source 100% credibly certified palm oil by the end of 2015. The CPET 4th and final review for Defra on the 'UK Consumption of Sustainable Palm Oil' (Feb 2017, ref 273) says that the volume of UK palm oil purchases supported by **RSPO (Round Table for Responsible Palm Oil)** certification almost trebled between 2009 and 2015 to 87% or as much as 108%. The latter figure demonstrated the problems encountered with data accuracy and completeness. (Their Stakeholder Survey was sent to 51 stakeholders from 40 organisations. Only 6 responded and many respondents skipped several questions.) The review says that also there is “no single, straightforward, universally-applied definition of sustainable palm oil.” (ref 273). Now that the final review of CPET is completed, it would be interesting to know what ongoing scrutiny will exist to ensure more secure reassurance is established going forward that the palm oil, and derivatives, so widely used in the UK in food industry, animal feedstuffs and biofuels, are

sustainably produced.

Both soy and palm oil are imported into, and used, in the UK under a wide range of different names depending partly on their stage of processing and the nature of the final product. Tracking of these products through the stages of production to final product is, it seems, very difficult.

The use of palm oil in our bakery goods and processed foods has increased over recent years and CFB members have complained about how difficult it is find products that do not contain palm oil. This is substantially due to the fact that they have replaced the partially hydrogenated fats that have now been found to be injurious to health (ref 123, 124). The traditional fats that were used in British home baking - butter and lard - have been considered unhealthy, although, as highlighted in the section on 'oils and fats', many experts now think that they have been demonised and the evidence against these fats may not stand up to scrutiny. Vegetable oils are usually blended and may contain combinations of some of, for example, palm, soya, rapeseed (canola), sunflower, peanut, cottonseed, palm kernel, coconut and olive oils. Some of these are produced through highly industrialised chemical processing. Extra virgin and cold pressed refer to extraction of oil through mechanical pressure rather than chemical means.

Proforest **"**is a unique, non-profit group that supports companies, governments and other organisations to implement their commitments to the responsible production and sourcing of agricultural commodities and forest products." and "...provides advice on sustainability initiatives, such as RSPO and FSC (Forestry Stewardship Council), or technical aspects of the HCV (Higher Conservation Value) approach." (ref 295). The sustainability accreditation for soy is **RTRS** {**Round Table for Responsible Soy** (ref 296)}; there is a **Brazilian Round Table for Sustainable Beef** (and **Bonsucro** for sugar). Ask the manufacturers of your favourite foods whether they are using ingredients that are sustainably sourced. Packaged foods have the manufacturer's contact details on them and they will respond. You are 'a valued customer'.

Clearing of rainforests for such products as soy, palm oil, sugarcane, cocoa, livestock rearing, rubber tree plantations (originally from South America, the amount of rubber produced in South East Asia tripled between 1983 and 2013; it has many uses including significantly for car tyres and natural latex) and timber has very significant environmental and social impacts. At the same time it can lead to large employment and economic benefits for the countries involved. In some countries some of these products are substantially produced by small and medium sized producers, sometimes giving employment and income to the rural poor, in other cases large scale production is the case. Proforest is increasingly developing expertise working in different product areas and tends to work with small and medium scale producers.

Greenpeace highlighted (Nov 2016) that the Congo basin rainforest is now threatened with logging and industrial palm oil production (ref 297). *Proforest* estimates "that up to 22 million hectares of land are under consideration for oil palm plantations over the next five years in West and Central Africa. This represents about 2 per cent of the total land area of West and Central Africa, but is likely to affect the 328 million hectares of forest in the region disproportionately. This could have significant positive impacts through its contribution to the national economy and improved rural livelihoods. It will also be a major contributor to deforestation. Good planning is needed to balance development with conservation."

There is a serious economic and environmental dichotomy with regard to countries developing land for trading and wealth creation (through exports), which results in damage to or destruction of forests and other habitats, thereby contributing to climate change (this is by no means restricted to rainforest). Land use change can lead to major loss of wildlife habitats in the world's most biodiverse regions and loss of homelands for indigenous peoples. Once land use change has occurred (anywhere in the world), livelihoods quickly become dependent on it, increasing the difficulty of returning the land to natural habitat regeneration. And, if demand for one product declines, production of another is likely to take its place. The development of industrialised agriculture and manufacturing in many countries may increase wealth for some, whilst at the same time damaging the environment and not necessarily realising benefits for local people.

Members of CFB who have visited Borneo have witnessed how the wildlife have been confined

effectively to the edges of what was their natural habitat - in narrow ribbons of natural forest along river edges, for example, whilst, behind, there are just vast monocrop plantations of oil palms.

Greenpeace (March 2016) has published "*Cutting Deforestation out of the Palm Oil Supply Chain Company Scorecard*" assessing (in November 2015) "14 global consumer goods manufacturers with 'no deforestation' policies in place, including snack food, confectionery and personal care companies". None of the companies could be sure that there was no deforestation as a result of their sourcing of palm oil. Only Ferrero could trace nearly 100% of its palm oil back to the plantation that it was grown on. With some companies there is a lack of transparency. This report is worth looking at. The Rainforest Foundation UK have also produced a very useful guide of which of our manufacturers are sourcing palm oil responsibly - "*How Your Daily Routine Can Help the Rainforest - Palm Oil Guide*". Both documents can be found on line.

17) Africa

It seems that Africa has many areas which are affluent, but also areas of great poverty, and sub-Saharan Africa has the world's highest numbers of hungry and malnourished people. Although the percentage is decreasing as overall population increases, the actual numbers of hungry people are increasing.

John Seymour (1914-2004), mentioned earlier in this document, lived in southern Africa during the 1930s. He described the people of Kenya as being healthy and happy and the country as being extensively forested. When he returned years later, the effect of the opening up of the "lush interior" of the country during the 1930s, and later decades, by the extension of the railroads started around the turn of the century, (there were no roads), had incrementally resulted in the forest being felled and land cleared for estates for agriculture, ranching and tea and coffee plantations. (The first experiments in Kenya with coffee growing took place in 1905, and the first tea plantation was founded in 1923.) People had been displaced to more marginal land, where the women were struggling to work poor land and look after their children, whilst many of the men had gone to work in office jobs in the towns. The women were having to walk further and further for fuel and the removal of trees for firewood was further impoverishing the land and causing erosion. Seymour was appalled by the changes he saw - the damage done to the land and to the people. The best, most fertile land was being used to provide cash crops for export, whilst the local population was being marginalised. This feels like a continuing scenario. (ref 297).

Murithi Mutiga's article in *The Guardian 'As drought sweeps Kenya, herders invade farms and old wounds are reopened' (GNM,*19 March 2017, ref 405) is very interesting relating to this historical context and to the present day situation, which is also illustrated by the following account from a CFB member:

"The first I heard about the drought in north-east Africa was in 2006 from Maasai people I met in the tourist resorts north of Mombasa. I feel this gave me a very small personal insight into the effect the drought was having even then, because they had been forced to leave their traditional herding way of life in the north to make a living doing tribal dances and selling crafts. My friends in Nairobi have seen areas such as Lake Turkana change from grazing land to uninhabitable desert within the last ten years.

On later trips I met other Maasai in Nairobi and around the Maasai Mara National Park, where they have some herding rights within the National Park and many traditional villages in the area. I also learned the Maasai have long been in conflict with other tribes. Villagers today in the Tata Hills above Mombasa perform ancient dances designed to repel Maasai marauders from invading their farmlands.

Now the drought has grown to massive proportions, climate change being exacerbated by the war in South Sudan, chaos in Somalia, and general poverty in the region. Kenya is the richest and most successful East African country and has absorbed many Somalian refugees into communities. However, in the north-east it has Dadaab, the world's largest refugee camp, home to half a million people mostly from Somalia, which it plans to close.

Now the Kenyan Maasai and others like them from other countries, whose life was always tough and on the margins, are faced with a massive disaster that their deeply unchanging life has not equipped them for, and it is driving them all to press into the agricultural areas where they have always been strangers and traditional enemies. Truly an example of the people who have done least to cause the climate to change bearing the brunt of it." (See Ref 406 for more related information.)

Contributed by Vivienne Kynaston

Large parts of Africa have been in the grip of severe drought again over this last year (2016-17) and there is a renewed, widespread crisis of hunger and malnutrition. The latest appeal from the Red Cross cites famine and drought particularly now in Kenya, South Sudan, Ethiopia and Somalia, although the drought has reached down as far as South Africa also. Nevertheless, we continue to receive our imported food and drink from these countries: it comes to us whilst leaving the indigenous people without, although at the same time the trade gives many people a livelihood. What a dilemma.

There is still now an extensive and increasing impetus for the exploitation of land and resources in Africa, as well as other "developing" regions in the world, by foreign companies from many countries including the UK. As mentioned in section 13 on Land Grabs, this is particularly problematic in countries where land governance with regard to land rights is poor.

'*Biofuels and African transformation'* (NCBI 2015, ref 333) illustrates how massive "development" of African land resources for biofuels is being presented as a positive benefit: but is it? *"Biofuels boom in Africa as British firms lead rush on land for plantations"* (*The Guardian*, 2011, ref 334) described plans for projects to amass millions of hectares of land and lists UK and other companies involved. It raises the issue that these controversial fuel crops are linked to rising food prices and hunger as well as rising GHG emissions. Some experts make the point that major causes of global food price volatility are not necessarily linked to biofuel land use and that energy prices and speculation on food on the financial markets, amongst other factors, were likely to be responsible, for example, for the 2007-8 world food price spike.

A doctoral thesis by Jennifer E. Hodbod submitted to the School of Environmental Sciences at the University of East Anglia studied *The Impacts of Biofuel Expansion on the Resilience of Social-Ecological Systems in Ethiopia* (ref 428). In the Conclusions (sections 8.2.1. and 8.2.2.) she identifies *Implications for Biofuel Policies in Ethiopia* and *Implications for Biofuel Policies on a Global Scale.* Hodbod's final sentence of the thesis is that "...whilst biofuels have not had detrimental impacts on the majority of sub-systems influenced by their introduction, there are significant negative impacts on the most vulnerable groups of the population, and as such, biofuels are a part of the problem, not part of the solution to both economic development and decarbonisation." The displacement or relocation of nomadic and smallholder pastoral households with weak property tenure rights, frequently associated with biofuel feedstock plantations leads to the loss of traditional livelihoods and food systems and a loss of cultural diversity. She describes how land grabs may vary in the agents involved in shaping the land acquisition process in different countries which may be led by foreign investors, the state (as is the case in her study in Ethiopia), or other key actors within a state, or in some countries para-military groups, narcotics traffickers, cattle ranchers or plantation managers (p.303).

The rush to capitalise on the continent's oil and mineral potential is described in the *"New 'scramble for Africa' led by UK companies"* by Milmo in the *i* newspaper on 12 July 2016. At the same time acquisition of millions of acres of land in Africa and elsewhere, by foreign investors, is taking place for food production for export, including by countries such as China, India and Middle Eastern countries. (refs 104, 105, 106, 107.)

"*Agriculture at a Crossroads*" highlights the extent and objectives of these large-scale land acquisitions and how readily accessible fertile land, in densely populated areas cultivated by small-scale farmers, is often targeted (ref 351, p.18), although some biofuel production plans also target millions of hectares of marginal land (ref 339).

There are wide-reaching initiatives that are focused on developing agricultural productivity to help to

alleviate the hunger and malnourishment, which is still such a concern in some African countries. However, '*Agriculture at a Crossroads*' (ref 351) highlights that some of these are based on unsustainable industrial food systems of high productivity based on high inputs, which has had so many negative environmental impacts globally. It emphasises that countries need to develop their own capacity to produce food and protect their farmers. An interesting 20-page scientific report on Kenyan agriculture "*Building resilience in East African agriculture in response to climate change*" (*Greenpeace*, ref 70), looks at positive developments in how small-scale, low cost, sustainable food production can increase food production and food security. (Also see ref 351, p.21).

(A number of further documents in the bibliography give interesting insights into the issues with regard to land use, biofuels and environmental impacts - refs 191,192, 293, 297, 327, 335, 336, 337, 338, 347, 353.)

18) Behind the Brands

Land is one of the criteria in *Oxfam's* Campaign *'Behind the Brands*'. Much interest has been shown in this campaign particularly as the products investigated by the campaign are produced by well known companies such as Nestles, Unilever, Coca Cola, Associated British Foods (ABF), Mars and Kelloggs.

These companies produce a whole host of our well-known food and drink products, for example: Unilever produce Ben&Jerrys, Colman's mustard, Flora, Knorr, Hellmann's, PG Tipps Tea, Elmlea, Lipton, Bovril and others. ABF produce Kingsmill, Ryvita, Jordans, Allinson, Sunblest, Ovaltine and others.

Companies are rated by the following criteria: Land, Women, Farmers, Workers, Transparency, Water and Climate. Unfortunately the *'Behind the Brands*' campaign is not current in the UK but companies are still rated in April each year and more can be found out by going to Behind the Brands Oxfam International where you can read the latest score chart.

There has been some progress made between 2013 and 2016 when all the criteria are added up. Most surprising is Unilever whose joint score was 49% in 2013 and 74% in 2016. Coca Cola made reasonable progress: 41% in 2013 and 57% in 2016. Associated British Foods (ABF) have risen from 19% in 2013 to 36% in 2016. (ref 395). ABF produce Primark, probably not that surprising that they don't score well as a company producing cheap clothing, but they also make Dorset Cereals, a product which has a good image.

It does seem that the campaigning around *'Behind the Brands*' has achieved some improvement in standards. Even ABF have a Corporate Responsibility website and another section on their website called 'Doing good every day'. They also say they have set up Farmers' Schools in Malawi.

So it seems *'Behind the Brands'* has been a good influence on Multinational companies but there is a long way to go! By looking at the charts you can see that many companies have improved their scores. Multinationals do worry about their image and want to be seen as socially responsible**.**

(This section has been contributed by Hazel Jones, CFB SFADG member and Coordinator of the Bradford on Avon Oxfam Group.)

19) The UN Food and Agriculture:

"**Economic and political stability**: Over the last ten years, food and agricultural markets have entered an unexpectedly turbulent phase, characterised by large supply shortfalls and price swings. Political and economic uncertainties, coupled with extreme weather conditions, can have direct and adverse effects on food security. The poorer the household, the stronger the impact of external shocks, as poor households spend a proportionally higher share of their incomes on food" (p.20).

"**Crop Production**: The majority of people in developing countries live in rural areas, and most of them depend on agriculture for their livelihoods" (p.26).
"**Crops**: Cereals, which include wheat, rice, barley, maize, rye, oats and millet, make up the majority of the production of the crop sector. They continue to be the most important food source for human consumption. Yet external factors, such as rising incomes and urbanisation, are causing diets to shift towards diets that are higher in protein, fats and sugar. In addition, livestock and biofuel production have and will most likely grow at a faster rate than crop production. This is causing a shift away from crops, like wheat and rice, towards coarse grains and oilseeds to meet demand for food, feed and biofuel." (p. 28).
"**Water**: Agriculture accounts for approximately 70% of total freshwater withdrawal in the world, mostly through irrigation. This has been crucial for gains in food production since irrigation reduces drought risk and encourages crop diversification, thus also enhancing rural incomes. While irrigated agriculture represents about 20% of the cultivated land, it contributes to 40% of global food production." (p.38). [However, there is worldwide concern about increasing scarcity of fresh water availability and over-extraction affecting water tables. (*IAASTD*, ref 351, p.30 and WWF, ref 145). See also section 16.]
"**Forestry**: Forests make vital contributions to biodiversity. They also sustain a range of economic activities and act as a source of food, medicine and fuel for more than a billion people. The latest estimate of the world's total forest area is more than 4 billion hectares, corresponding to about 30% of total land area. But today's forests face unprecedented pressures. Changes in land cover have caused the most pressing environmental issue in recent decades. The impact of deforestation and land use intensification, especially on soil degradation, have been significant." [In the list of top forest product importing countries in the world, UK is the country ranked 5$^{th.}$ (p.42).
According to the FAO (2016) "Putting a halt to deforestation and forest degradation arguably has the largest potential for emission reduction in the agriculture sectors. This should be top priority" (ref 237). The 5th Carbon Budget (ref 283) states the recommendations for afforestation of the UK by 15,000 ha/year and increasing agro-forestry from 1% to 1.6% of agricultural land.]
"**Climate Change**: The severity and speed of climate change is presenting an unprecedented challenge. Current global surface temperatures are now 0.6 degrees Celsius higher than the average for the last century. This increase is consistent with model predictions of the effects of rising atmospheric concentrations of carbon dioxide and other GHGs, which are a result of human activity. The poorest and most food-insecure regions around the globe are the most vulnerable. Already scarce land and water resources will be likely to become even more scarce, and insufficient technical and financial means will make adaptation to changing climate very difficult." (p.44).

(Extracts from FAO, 2015, ref 74)

20) More on Greenhouse Gas Emissions

GHG gas emissions from dynamic biological systems, like food production, are difficult to measure and there are many different assessment tools, some of which may give contradictory results. There is much ongoing research and many gaps still in the evidence base. Methane and nitrous oxide are much more potent as GHGs than carbon dioxide, although carbon dioxide persists in the atmosphere for much longer, and accumulates. Figures from different documentary sources vary for the persistence in the atmosphere of all these gases. The DECC statistics below are adjusted for potency and persistence - CO2 equivalence (CO2e).

Department of Energy and Climate Change (DECC, 2014 statistics, ref 229, pp. 97-99):
UK greenhouse gas emissions - in megatonnes carbon dioxide equivalent (MtCO2e) - consist of:

- 82% carbon dioxide
- 10% methane
- 4.3% nitrous oxide

Total emissions from different sectors in 2014 were as follows:

- energy 83% of total emissions (428 MtCO2e)
- industrial processes and other product use 6.8% (35 MtCO2e)
- agriculture 8.7% (45 MtCO2e)

- LULUCF -1.7% (minus 9.0 MtCO2e)
- waste 3.7% (19 MtCO2e)

The 8.7% of total UK GHG emissions attributable to agriculture is comprised of 61% methane, 35% nitrous oxide, 3% carbon dioxide. [So, **this means that agricultural methane is 5.3%, nitrous oxide is 3% and carbon dioxide is 0.26% of total UK GHGs.**] Total agricultural GHG emissions decreased by 16% between 1990 and 2014 mainly due to decrease in cattle numbers and a decrease in synthetic fertiliser application, particularly to grasslands.

In the UK in 2014:
Carbon dioxide emissions (29% less than 1990) were dominated by the energy sector.
Methane emissions (61% less than 1990 due to methane recovery systems at landfill sites and reductions in number of livestock) are produced mainly by agriculture, waste disposal, leakage from gas distribution system and coalmining.
Nitrous oxide emissions - agriculture is the main source contributing 72% of total N2O emissions (down 15% since 1990). Fuel combustion is also a significant source of N2O (16% of total), especially from road transportation, industrial combustion and power generation.
Sulphur dioxide emissions - 93% associated with the energy sector.

LULUCF (Land Use, Land Use Change and Forestry) - in this respect the UK has been a net sink for GHG emissions for all years since 1991. The greatest effects are forest which is a net sink and cropland which is a net source. Emissions from croplands have decreased by 23% since 1990. Emissions resulting from deforestation have increased since 1990 due to harvesting of mature trees and creation of open spaces within woodlands.

(All of above information in this section is sourced from DECC 2014).

According to the 5th Carbon Budget (ref 283) there has been an 18% reduction in agricultural GHG emissions in the UK since 1990 and in 2016 agriculture accounts for 9.5% of UK emissions.

Although agriculture has the potential to very substantially reduce its GHG emissions, as well as other environmental indicators, it seems to be recognised that this sector will not in the future be able to become completely carbon neutral; and that other sectors will ultimately have more potential to achieve carbon neutrality as the technology develops. Agriculture will then represent a higher percentage of emissions, even if it has significantly lowered emissions from the sector. If the remaining emissions from the sector are well balanced out by the overall LULUCF GHG sink this could be an acceptable situation, as long as industry, business and other sectors are not also offsetting their emissions against that same natural carbon sink. The carbon sink can be made much more of a potent means of mitigating climate change by conservation of forests globally, more tree and woodland planting, increasing grasslands, increasing organic matter in depleted soils and various measures such as protecting cultivated soils from exposure by cover crops. The biological life in soils is vital for carbon and methane sequestration.

A Defra supported, nationwide survey carried out by researchers from the Universities of Manchester, Lancaster, Reading and Newcastle and Rothamsted Research in 2016 found that the highest levels (60%) of the UK's total soil carbon stored in grasslands is between 30cm and 1 metre deep. The team estimated that this level of Great Britain's grasslands stores 2097 teragrams of carbon. "The greatest soil carbon stocks, were at intermediate levels of management, where carbon stocks were 10% higher than in intensively managed grasslands…. Though the effects of high intensity agriculture is strongest in surface soils, the team discovered impacts at considerable depths, where carbon was previously unmeasured." (2016, Rothamsted Research, ref 284)."

Other new research in 2016, involving a team led by Prof Pete Smith, Professor of the Institute of Biological and Environmental Sciences at the University of Aberdeen, and Professor Dave Reay, of the University of Edinburgh's School of Geosciences, indicates that "natural surfaces could store an extra 8

billion tonnes GHGs, helping to limit the effects of climate change…..Growing crops with deeper root systems, using charcoal-based composts, applying sustainable agriculture practices and restoring drained peatlands could help soils retain an amount of carbon, equivalent to a significant proportion of annual emissions released by the burning of fossil fuels. The role that soils could play in efforts to combat climate change has until now been largely overlooked…." (Reported by Sheddon in the *Scotsman* 2016, ref 224).

More on Carbon Dioxide (CO2):

This is by far the most significant GHG. Globally the burning of fossil fuels is the major cause of atmospheric sources of carbon dioxide: coal, natural gas, oils (for energy and transport systems), deforestation and degradation of soils are the other major contributors. Although methane and nitrous oxide are more potent GHGs, carbon dioxide persists much longer in the atmosphere and is particularly significant in emissions in the food system post-farm-gate. (See section 28.)

More on Methane (CH4):

Globally the main sources of methane include agricultural activities, waste management, energy use and biomass burning. Although significant rises in atmospheric methane continue to be reported, the cause appears not to have been not fully established. Press reports have emphasised increases in livestock (ruminant) numbers globally as the cause, however US shale oil and gas, including from fracking extraction were assessed as being a major cause in research by Harvard University (*The Guardian*, 2016, ref 152).

It came as a surprise to find that, as well as livestock, rice paddy cultivation is a very significant producer of global methane emissions and is also responsible for a substantial amount of the water used for irrigation globally (see section 16). The FAO 2016 states that mitigation is possible in rice and livestock systems and that farming system diversification and crop-livestock-tree integration could increase farm scale efficiency, decrease emission intensity and increase productivity. Developments on reducing the water footprint of rice are referred to in section 16. General adoption of sustainable practices could cut livestock emissions by up to 41% while also increasing productivity through better animal feeding, animal health and herd structure management (ref 236). Crucially, the health implications of some approaches to reducing methane from enteric fermentation need to be very carefully assessed.

DECC 2015 (ref 13) says "quantification of CH4 emissions from agriculture are more uncertain than from waste "because they are dependent on a range of variables such as temperature, age and breed of animals, feed types and manure management practices." Some research funded by Defra has demonstrated that methane emissions from sheep are less when grazed on mixed species, permanent pasture than rye grass; and this made more difference than the sheep breed. (Fraser, 2015, ref 414).

Ruminants have always been around - for a very long time anyway: well, at least, dinosaurs were ruminants! They include, cattle, sheep, water buffalo, llamas, vicunas and so on. So, it seems logical that there is something in the natural world that makes use of that methane. It took a long search online to find that there are methane-eating bacteria methane in all soils - methanotrophs.

Methanotrophs use methane as a carbon or energy source and are present in all soils and various other environments, including freshwater and marine environments. The numbers of methanotrophs increase in the presence of higher levels of methane and "different types of methanotrophic communities respond to different concentrations of methane" (Gregg), and to whether the methane is produced for example in boggy ground, or in the atmosphere. Soils, and other environments, for example peatlands, may be a methane source or a methane sink depending on the balance between methane production by methanogenic bacteria and the oxidation process by methanotrophs. A great many variables, for example atmospheric temperature and whether soils are compacted, dry or water-logged, will influence the ability of natural systems to act as a sink for GHGs. Although it is known that there is a significant variation in methane oxidisation rates in different land use/land management situations, much research is still needed to more fully understand this complicated area, especially in natural environments. Highest uptake of methane occurs in the aerated soils

of forests. The potential for soil to act as a methane sink can be interfered with by soil disturbance, fertiliser, pesticide and fungicide applications. Increased nitrogen concentration levels in soil, for example, are known to impair the action of methanotrophs. It is likely that species-rich grassland, managed without chemical applications, will absorb more atmospheric methane than arable land or grassland managed with chemical applications.

“Dung itself represents a significant return of organic matter to the soil and the carbon it contains provides energy for the whole system. Modern farming often doesn’t utilise manures as effectively as possible, relying on fertilisers and not always returning plant matter/animal wastes to the soils appropriately. It is the storage of dung or the application to wet fields where the significant methane emissions occurs due to the anaerobic, wet environment” (Thanks to Dr Ruth Gregg, Senior Environmental Specialist in Soils and Climate Change Mitigation at *Natural England*, who has generously answered questions, providing more insight into the methane sink, which has partly been drawn on for this section, including the last quote.) (The website GHGonline has also been a useful resource.)

Some livestock deworming preparations interfere with the absorption of animal dung into the soil, as they are harmful to the dung beetles and other mini-beasts affecting complex processes within soils which should aid decomposition. The *Wildlife Trusts* say that dung creates a whole ecosystem by itself! With low intensity conservation grazing there is little need to use chemical animal treatments for internal parasites and as a result a whole range of wildlife moves into a cowpat and sets up home - more than 250 species of insects are in or on cattle dung in the UK and these in turn provide food for birds, animals and bats (ref 210). 'The Dung Beetle UK Mapping Project' (Dump!) has found that they (dung beetles) are both good for animal health and they and their grubs provide food for birds and mammals. Dung beetles have a wide range of benefits including aerating the soil and allowing nutrients and water into the ground and eating animal droppings with parasites harmful to livestock. (ref 382). The aeration of the soil helps the drainage and faster drying of the dung pats, helping to reduce the methane emissions that can increase in wet anaerobic conditions. In a study in Finland, Slade (ref 381) found that dung beetles also play a significant role in the sequestration of GHGs, especially methane and nitrous oxide into the soil, in grazed pasture in extensive livestock management systems. This benefit was not replicated by the manure management practices of intensively reared livestock. Also, the mitigation effect is interfered with by the extensive loss of dung beetle populations.

The numbers of dung beetles have declined to a worrying extent across temperate and tropical eco-systems, and some species are thought to have become extinct "due to changes in agricultural practices, including intensification and reduced pasture grazing, habitat loss and overuse of anthelmintics (dewormers), such as ivermectins.....Longer grazing seasons may benefit dung beetle populations, increasing the abundance and diversity of dung beetles in the pasture, and hence increasing the dung removal over the long term " (Slade E.M. et al, 2016, ref 381). Some local farmers who are using mixed species herbal leys have told us that certain grassland plant species, chicory and others, have natural deworming properties, reducing the need to use synthetic worming preparations. Field mushrooms, which were once commonly found, particularly in the lush grass growth around cow pats, in the autumn on grazed pasture, have greatly reduced due to modern farming practices and are rare in some parts of the country now.

The UK GHG Inventory (updated April 2016) says that methane is produced from the decomposition of manures under anaerobic conditions. When stored or treated as a liquid in a lagoon, pond or tank it produces a significant amount of methane. However, when manure is handled as a solid, or when it is deposited on pastures, it tends to decompose aerobically and little or no methane is produced (ref 266, page 331-2). This is of particular interest as some sources in the past have indicated that the use of animal manures increases the emissions from organic production systems.

In 2016, 67% of holdings with livestock in the UK had storage facilities for solid manure in temporary heaps in the fields, about 25% store their slurry in a tank and 14% store slurry in lagoons. (DECC, ref 248).

Burping as a result of enteric fermentation is responsible for most of the methane produced by ruminants. A UK dairy cow produces about twice as much methane as a non-dairy cow, both through burping and

through manures (the latter being a much lower figure). The ratio for emissions of nitrous oxide for a dairy cow is also about twice that of a non-dairy cow (measured in kilograms per head per year - 2013 statistics, UK GHG Inventory, ref 266, methane - p. 330, nitrous oxide - p.337).

Innovative Farmers is a part of the Duchy Future Farming Programme. 750 farmers have been involved over the last 3 years, in networking groups and farm-based studies with research backing. In Wiltshire, three farmers have been doing a study using the French Obsalim diagnostic tool for dairy herd health and management. The feed has been split between morning and afternoon and the cows allowed to eat together, lie down together and 'chew the cud' (ruminate) undisturbed, to improve rumen function and enable more efficient feed conversion. The calves are integrated into this cycle from the beginning. Straw and hay are added to the diet to increase structural fibre and help with rumen stability. It was possible to decrease both silage and concentrate feed without milk production dropping and in one case there was a 6,000 litre increase in milk production during the period of the trial over what was expected. Two of the farms particularly found an improvement in the overall condition of their herd and none needed drying off early. It would be interesting to know whether this improvement in rumen function and feed conversion reduces methane production, as some more technologically interventionist measures (some of which could have adverse animal health implications) aiming to achieve these aims are being actively researched. (ref 318).

Decreasing atmospheric nitrogen pollution, and more specific and restrained use of nitrogen fertilizers, are both important in maximising the soil's ability to absorb methane (Reay, ref 223).

Although decreasing livestock numbers leads to a quick gain in decreasing GHG emissions (through reducing methane emissions), and this is helpful to the Government's needs to achieve GHG reduction targets, a decrease in warming from methane emission reduction may result in an increase in nitrous oxide release into the atmosphere; the potency of nitrous oxide as a GHG is much greater than that of methane. If the cuts in livestock are primarily to those raised under grass-fed systems there may also be a cost in terms of decreased soil fertility and increased requirements for artificial fertilisers if the land is converted to arable production. Replacing the protein and other nutrients with alternatives may lead to increased imports.

More on Nitrous Oxide (N2O):

Nitrogen makes up 78% of the atmosphere and, along with phosphorus and other nutrients, is essential for the growth and production of vegetation (crops and grass). The various organic sources of these nutrients include dung deposited by grazing animals and livestock manures and slurries applied to the land; treated sewage sludge is another source. Mineral fertilisers are also a major means of providing these nutrients to the soil. A short explanation of the Nitrogen Cycle can be found on the Rothamstead Research website (ref 285). Excess of nitrate application may lead to more rapid vegetation growth however this fast, soft growth may also make plants more vulnerable to pests and disease. Not only do high nitrogen concentrations in the soil interfere with the soil sink for GHGs, it also increases the release of nitrous oxide into the atmosphere contributing to climate change. Rapid plant growth of some species reduces biodiversity by allowing certain plant species to out-compete other wild flowers that are important for varied insect life. This has a knock-on effect on reptiles and birds. Nitrogen (and phosphate) can accumulate in the soil and both can cause major problems if they contaminate water courses. Leaching of excess nitrates into ground water is a serious problem and can impair the blood's oxygen-carrying capacity (if consumed) in small infants and can be toxic for ruminants such as cattle and sheep. High nitrogen levels on land can result from agri-chemical application and high levels of nitrogen dioxide in the air due to traffic and power stations (*The Independent*, 2014, ref 282). On recent testing of the River Avon, Climate Friendly Bradford on Avon Biodiversity Group, found nitrate levels to be a cause for concern.

Farmland nitrogen application in this country has declined somewhat over recent years. Applications of nitrogen, through mineral sources and manures and slurries from livestock, have always been lower for grasslands than croplands (Defra, 2016, ref 84). Animals are implicated in nitrous oxide through emissions related to production of their feed (nitrogen application to grassland and crops for feed) and through emissions from their waste. The animals do not necessarily produce nitrous oxide themselves.

Interestingly, nitrous oxide emissions from sewage sludge (ours!) is substantial. (UK GHG Inventory Report, 1990-2012)

Nitrogen pollution and the effect of nitrous oxide as a significant GHG remain a serious problem. A benefit of robotics is to help with better targeting, and dosage calibration, of agricultural fertiliser applications.

'Herbivores influence nutrient cycling and plant nutrient uptake: Insights from tundra ecosystems' is an interesting doctoral thesis by Helene Barthelemy. Findings included that reindeer dung and urine in the tundra in Finland increased plant productivity, that the nutrients from urine were rapidly incorporated into plant tissues and that the grazing-induced regrowth had higher nutrient contents, which "could drive the high N cycling in arctic secondary grasslands by providing litter of a better quality to the below ground system and thus increase organic matter decomposition and enhance soil nutrient availability." (Umea University, 2016, ref 287).

Globally, the use of fertiliser (combined total for nitrogen, phosphate and potash) is far higher in Asia than anywhere else in the world, followed by the Americas, then, some way behind, Europe, Oceania and very low levels of use comparatively in Africa. (2012 stats) (FAO, 2014, ref 74).

21) How GHG Emissions are measured - productivity, efficiency, intensification. Does this necessarily indicate the best way forward?

A question which arises from this literature search is: does the way the GHG emissions from food production are measured, drive advocacy for food and farming policy making in the direction of increased intensification?

Although some commentators in the media on food and the environment indicate that it is possible now to measure very accurately the **carbon footprint** of different foods, that is not really the picture that has emerged from this literature search. It has become apparent that understanding the emissions associated with food, (which partly involves the wide natural eco-system, and partly, an often very extensive, man-made intervention) is extremely complex, with many variables and often results are difficult to compare from one study to another. The point is made that this is a relatively new area of research, there are many evidence gaps and natural systems in particular remain under-researched.

GHG emissions and sinks in the complex biological systems involved in food and drink production are clearly very challenging to measure and will often vary, for example: during the day; with the weather and the seasons; with soil type; and soil carbon may vary across a single field. With regard to livestock, when animals have eaten, what they have eaten and the size of the animal are just a few of the variables which will influence the results. Research may be based on real or modelled scenarios. There are many different tools for measuring emissions and they may well give different, even contradictory results.

It has been difficult to gain an understanding about how emissions are measured; however, the *Food Climate Research Network (FCRN)* has been the most helpful source of information. The measurement of different foods may be based on GHG emission efficiency for a product per area of land use, for example, or by the weight, volume, protein, fat or calorie content and so on. This is referred to as the functional unit and the resulting calculation is a measure of product output efficiency in relationship to GHG emissions. Researchers choose the functional unit according to what they are trying to find out. For the same food the resulting GHG emissions may be different depending on what is being assessed: for example, the GHGs per kilogram of protein (GHG/kg protein) or calories (GHG/kg calories). Because ruminants (eg cattle and sheep) emit a lot of methane, no matter which functional unit is looked at in these studies they rank at the top, or near the top, for GHG emissions. Where nutrient production (for example protein or carbohydrate) is

measured in relation to land use, the less land that has been used to produce the food, the better it will be rated.

Life Cycle Analysis methodology (**LCA**) is defined as 'cradle to grave' although in many studies it is only 'cradle to farm gate' that is studied and looks at the various impacts of production (ref 309); it was originally applied to analyse industrial process chains but has been adapted to assess the environmental impacts of agriculture (ref 37). Another approach to assessment is to look at whole diets, assessing per gram the carbon footprint of the foods consumed. These studies may look at real diets or "idealised" diets which reflect recommended nutritional standards (Many thanks for this enlightenment and useful links to Sam Lee-Gammage, Research and Communications Officer, *FCRN*).

There may be up to 50% difference in GHG emissions from different diets. It is worth noting that both healthy diets and unhealthy diets may be associated with either high or low GHG emissions. Assessment of GHG and carbon footprint are often taken as indicating environmental impact as a whole; however this is not the case and often other impacts, such as depletion of resources, water use in areas of water stress, animal welfare and so on, are not included. Most research into the carbon footprint of foods does not take into account the potential that grazing may increase carbon sequestration (ref 311), or that the cultivation of land for crops may release stored GHGs back into the atmosphere.

Intensively reared dairy and beef animals take up much less space and the land area needed to grow grain to feed them is less (grains are more nutrient-rich than grass) than the area needed if they are grazed, leaving more land over for other food, or feedstuffs or biofuels, for example. Intensively reared pork and chickens are also more land efficient. Pigs and chicken are considered to be more GHG efficient than cattle and sheep, even though in the UK they (pigs and chickens) are the livestock sector that consume much more grain that could be consumed directly by humans. Pigs and chicken do not emit methane and convert feedstuffs more quickly into edible protein suitable for humans. Intensively produced food is consistently found to be more GHG efficient than extensively reared food - broiler chickens as opposed to free range chickens, intensively reared beef cattle, kept in housed systems, compared with free range, grass-fed beef cattle etc. This is partly because feed is more efficiently converted into meat if the animals are very restricted in the extent to which they can move around, as they are not then 'burning-off' the energy they have consumed (ref 309). It feels as if there is something a little wrong here, and a few more things need to be taken into account.

The FAO report *'Tackling Climate Change through Livestock - a Global Assessment of Emissions and Mitigation Opportunities'* reports on a 20 year research trial done between 1987 and 2006 using the Century and Daycent dedicated grassland ecosystem model to assess the carbon sequestration potential of different management strategies in the world's grasslands (rangelands and pastures). "Of the three mitigation scenarios, only improved grazing and legume sowing were estimated to have net positive mitigation potentials at the global level. For the fertilization scenario, the additional nitrous oxide emissions from nitrogen fertilizer were estimated to offset all related increases in soil carbon stocks." (Rome 2013, ref 236, 2.3, pp.11-12).

Increasing research is emerging demonstrating that well managed grasslands store vast amounts of carbon dioxide and there is potential for a very significant extra uptake of GHGs into many depleted soils. According to *Foodsource* (*FCRN*, ref 311, 8.3) - "If sequestration is assumed, the carbon footprint of beef (*from grass-fed systems*) can shift from very high to very low" and "It is claimed that this sequestration can partly or entirely outweigh the methane and nitrous oxide the animals emit; potentially, grazing livestock systems can even be 'emission negative'". <u>However</u>, at the present time, it seems that this is still <u>not</u> generally factored into the assessment of the carbon footprint of different food and drink products (nor is the potential for grazing to increase fertility and perform a range of other "eco-system services"). The release of GHGs from disturbed (cultivated) soils is not generally taken into account when calculating the carbon footprint associated with annual crops either, it seems. *Foodsource* highlights some of the reasons why this is the case, including: that this is still an under-researched area. The lack of certainty regarding the carbon sink includes a lack of knowledge as to whether the carbon sink on permanent pasture can reach a saturation point after which it will not absorb more GHG emissions, and how the effect of temporary grass as part of an

arable rotation plays out with regard to storage and then release of GHGs. “What is clear is that grasslands are major carbon stores - so it is important not to plough them up" (ref 311). In a mixed farming system where a proportion of the arable cropping area is always under temporary grass, one might expect that the total emissions in the atmosphere at any one time will be reduced.

Does the focus on low GHG emissions/unit of food production equate to improved sustainability, or achieve the desired long term result?

So…..intensive food production systems may be flagged up as having greater production efficiency per unit of GHG emissions. However, sustainability in food surely goes far beyond this. Although in this document there has been a significant focus on livestock, the issues apply to other foodstuffs as well. A wide range of ecosystem, ethical, nutritional quality, human social factors, resource sufficiency and many other factors should surely be considered in the round. The fact that the soil’s ability to act as a carbon sink or emitter is not included at present, because of the complexities of assessing the way that ecosystems work, could completely falsify the results of the GHG assessment tools and drive food production policy in entirely the wrong direction, if best environmental, climate, nutritional and social outcomes are the goal.

The overriding need to keep soils (eg through incorporation of organic matter and appropriate rotations), water systems and air quality healthy, is not part of the way that GHG are measured yet is critical to sustainability. Depleted and eroded soils will not sustain us or the natural world in the future. Nor will polluted soils and marine and freshwater systems. Air quality is a major health concern here and even more so in some parts of the world now responsible for producing a high percentage of goods for our consumption. Other forms of environmental and landscape damage and habitat/biodiversity loss are not accounted for in the LCAs, such as loss of mangrove swamps and their eco-systems and resulting coastal erosion, associated with intensive shrimp and prawn farming for example, or the biodiversity loss in rainforests and other habitats globally associated with food and biofuel and other land uses. Also, intensively produced foods, including fruit and vegetables, often have a very high water footprint (maybe in localities/regions of water stress). There are serious ethical issues around animal welfare associated with intensive livestock production (**Confined Animal Feeding Operations - CAFOs**). Animal welfare (including farmed fish) and soil health may in fact be jeopardised by the paradigm of maximising production efficiency/ unit of GHG emissions.

In *Intensive versus extensive livestock systems and greenhouse gas emissions* (*FCRN* briefing paper 2010) Dr Tara Garnett concludes that **CAFOs** “although highly efficient when defined in their own terms (ie emissions per kg of output), have nothing to offer in terms of soil efficiency, carbon sequestration, or biodiversity benefits and indeed cause multiple problems as regards unsustainable water use, and air and water pollution.” She describes an alternative possible ‘livestock for resource efficiency’ scenario, where grazing animals are confined to grazing grass, supplemented with byproducts (excluding soy). “Livestock may also have a role to play in some mixed farming systems because of the fertility and draught power benefits that they bring.” This scenario “could yield multiple benefits in terms of ecosystem management, biodiversity preservation and GHG reductions, but the amount of meat and dairy products that would be produced and available per capita would be much lower than the level that current forecasts suggest will be demanded by 2050.” (ref 250).

More on how carbon footprint is measured, for example, why has dairy produce got a lower carbon footprint than beef?

Beef and dairy cattle eat much the same things, although dairy cattle consume more concentrates per head. Both emit methane and nitrous oxide - a dairy cow emits more per head than a beef cow. According to 2014 figures a dairy cow emits 130.9 Kg CH4/head/year and a beef cow 96.1. The nitrogen excretion factor was 128 for dairy cattle and 79 for beef. These figures do not identify if the differences are associated with different feeding and management practices. Dairy cattle are also more likely these days to be in intensive housed systems without access to grazing (52%), than the beef cattle in the UK. (refs 13, 678) However the **Life Cycle Analysis** looks at the goods and services produced and makes allocations. For example, livestock produce a range of by-products and the dairy industry produces both milk and meat - about half the beef in

Europe comes from culled dairy cows (2012, ref 309), so the meat produced from the dairy herd may result in an **allocation of emissions** with emissions deducted from the milk production, because of the beef it produces.

The calves not needed for replacements in the milking herd are generally fattened up as beef cattle, however all of their emissions will be allocated to the beef industry. **Allocations** are frequently made on the basis of relative economic values of byproducts (eg meat/leather), however it might be reasonable to question whether this can be regarded as having any validity in terms of GHG emissions. (FAO, ref 236, p.25). The emissions from manure produced by livestock are normally allocated to the livestock; however, arguably, they could be allocated to a following crop where a reduction in artificial fertiliser application has been made possible; instead the crop carbon footprint is reduced due to less artificial fertilisers being needed. **The trouble with numbers** can be understood clearly also in a study by Casey and Holden (2006) which showed that 60% of the carbon footprint of Irish beef was due to enteric fermentation (methane), 18% due to fertiliser production, about 8% to concentrate production, and 4% to the use of diesel and electricity. Organic beef has a somewhat higher percentage of enteric fermentation emissions because the share of fertiliser production is zero, and that of concentrate production is much lower than for other beef (Nijdam et al, 2012, ref 309, p.766).

Grazed livestock in sub-Saharan Africa are regarded as having a much higher footprint than intensively reared livestock in many other countries because of the low level of productivity on much of the land. This is partly because of low quality forage with reduced digestibility leading to increased methane emissions (FAO, ref 236, p.26). However, if area of land use is the chosen measure, it is difficult to see that if a cow has sole grazing over two acres of land, for example, that it is more GHG intensive than if it is grazing one acre. The main output will be methane, which will be likely to be relatively unchanged. Yes, the productivity per acre of land is less, but surely the GHG emissions are not more? Increasing productivity may lead to degradation of the land, or require extra inputs, such as fertiliser, which may allow a greater yield. This may increase productivity per acre, however there will surely be more emissions, both from the fertiliser manufacture, transport and application and more animals per acre will emit more methane. Additionally, the use of agrochemicals may incur unmanageable costs to people in poverty.

The same is true of crop production: crop yields per acre are low in much of sub-Saharan Africa and are therefore considered to have a high GHG emission intensity compared with intensive crop production. However much of it is cultivated by hand without fossil fuel inputs (fertilisers, machinery, transport for export). Higher yielding crop varieties may need more fertilisers, irrigation or other inputs (with more associated emissions); this may be justified if rural communities are taken out of hunger and poverty, however if this increased intensification and use of fossil fuels does not achieve this and mainly produces goods for export to wealthier populations where extra calories are not needed and much food is currently being wasted, then the emissions associated with this type of land use change are difficult to justify - even though on the current model of GHG emission intensity it appears as a more "efficient" use of land. The FAO's '**17 Sustainable Development Goals**' say that "Hunger is no longer an issue of insufficient global supplies, but mainly of lack of access to the means to produce or purchase food" (FAO, ref 345). There are a wide range of issues to be taken into account and it is not straightforward.

Much of the discourse relating to decreasing GHG emissions from food production appears to promote ever greater exploitation of animals and soils to try to produce more and more food from less animals or less land area through technologically intensive systems.

22) Sustainable Intensification (SI)

First mentioned in the Foresight report, '*The Future of Food*' (Oxford Martin Programme) says "The goal of sustainable intensification is to increase production from existing farmland, while minimising pressure on the environment. It is a response to the challenges of increasing food demand for food from a growing global population, in a world where land, water, energy and other inputs are in short supply, over-exploited and

used unsustainably. Any efforts to ‘intensify’ food production must be matched by efforts to make it ‘sustainable’. Failing to do so will undermine our capacity to continue producing food in the future.”

The Nuffield Scholarship report '*Understanding and Implementing Sustainability*' (2012) by farmer Tim May (first mentioned in section 4: Eating the Food that Grows Well Around Us: Arable Crop Production) raises a very good point: **“The problem with this ‘sustainability’ word is that it has become a bureaucrat's utopia**. It is so easy for any person, or group, to bring ‘sustainable’ into a sentence and then attain absolute attention because sustainability is viewed as some kind of holy grail for us all to aspire to. But not many people really seem to understand what it means and, of the few that do, the implementation of the supposed ‘sustainable practice’ often seems to miss the point that it was originally supposed to address.”

The truth of this becomes clear when one considers different examples of how sustainable intensification is being interpreted.

Perhaps the following example of Canadian beef production highlights that reduction in GHG gases in food production may come at the cost of ethical and health concerns which would not be acceptable to all; and that it is not enough to look at the raw GHG emissions data alone: the Global Research Alliance on Agricultural Greenhouse Gases document on *‘Reducing the emissions intensity of livestock production: case study Canada’* (ref 294) describes how compared with 1981, Canada produced 32% more beef in 2011 with significantly lower GHG emissions and less land used. This has been achieved through a range of measures including breeding larger animals, with higher carcass weights, through “improved genetics and growth promoting technologies, such as hormonal implants.” Vaccines and antibiotics are found to reduce digestive and respiratory disorders and lead to better conception and survival rates, increased feed intake and body weight. Canadian cattle consume 80% forage and 20% grain, however increasingly they are being finished on high-grain diets to enable them to be marketed earlier (this reduces the GHG intensity). By 2011 more calves were being sent to the feedlots immediately after weaning. (Routine use of growth hormones and antibiotics in livestock is currently banned in the UK. The Rt Hon Michelle Donelan, Cons MP for Chippenham, reassures us that Brexit will not lead to Britain’s food standards being compromised in trading agreements. It is rather difficult to see how this will work.)

There are many questions and many views as to what are the most sustainable approaches to food (and drink) production. *'Food security and sustainable intensification'* by Charles H et al (2014, ref 265) lays out many of the issues and options being discussed in the debate around sustainable intensification. In human terms, the media dialogue (particularly since the vote for Brexit and the need to form our own food and farming policy) around farming has included some talk that farmers should be forced to modernise, become more efficient and produce more (the rising world population and climate change being the pretext), or get out. It was disappointing to hear Jay Rayner using this line of rhetoric on *Farming Today* on Radio 4. **This talk surely has no place in a better world?** This is the talk of an aggressive business model of production.

Focussing mainly on what is measurable whilst not sufficiently respecting the more complex dimensions which are not easily measured, leads to the demoralisation of people working in a sector, as it has indeed in our health and education services. It may be straightforward in a factory to assess output efficiency in relationship to GHG emissions. The measure of efficiency of output/GHG emissions, which does not acknowledge the very complex wider issues in farming and environmental ecosystems, should not drive this dialogue. Already farmers have high rates of suicide, (both here and elsewhere in the world), and many are highly indebted. The world has no need to produce more food at the present time; we are already wasting a third of what is produced.

The UK does however need to be contributing to world food production and our own self-sufficiency rather than relying so heavily, and putting pressure, on the land of others. Encouragement and, vitally, adequate financial return for producing food to high environmental and ethical standards can potentially help keep people (and knowledge and skills) in the sector, encourage a younger generation, and be good for the health of food and the nation, the land, the water systems, biodiversity and climate change, and best enable adaptation as that becomes necessary. Some high-tech innovation also has a very useful part to play.

Research and development into how natural, safe and low-cost systems, which respect our biological heritage, can best contribute to this, needs much more support from government.

There is much potential in agroecological approaches for increasing food production, whilst safeguarding animal welfare and the environment. Some have been mentioned in other parts of this document, as well as the call for more investment into research in this area. Tim May gives various examples in his report of "**enterprise stacking**" to increase productivity that he saw being practised by Joel Salatin at Polyface Farm in the US, (ref 298, pp.26-7), where a regenerative approach to agriculture is being practised, as well as other examples from different parts of the world. There seems to be considerable gains to be made for food production, the environment, pest and disease control in agriculture, and decreased land use, by integrating production of various foodstuffs. Joel and Tim are following on different sorts of livestock or poultry production on the same grassland, with mutually beneficial effects and productivity gains.

In Herefordshire (and elsewhere), some commercial orchards are now grazing Shropshire sheep under the trees - they are the one breed that does not damage the bark of the trees and they are also being used in some vineyards. At Broome Farm, they find that - the sheep improve the soil, reduce mowing costs, attract pollinators and keep pests under control for a better crop. At the same time as reducing costs, two products from the same land mean extra income and heavy machinery is not needed. Leaf litter is removed whilst the sheep are in the orchard, perhaps due to the higher numbers of earthworms processing the leaf litter down into the soil and subsequently alleviating the risk of scab infections. The sheep also nibble down the suckers. This sounds like a win-win situation. Bees kept to fertilise the fruit trees produce a third product, chickens could make a fourth. Bird boxes in the orchards are providing a natural form of pest control. Of course, the orchards with the taller standard trees in the past enabled pigs also to eat the windfalls, and the more substantial trees allowed woodpeckers and owls to nest in holes in the trunks of older trees, as well as providing nesting for a host of other birds.

Agroforestry has potential for pigs, nuts and for production of many other foods: the *Eden Project* runs courses in this. In the Fairtrade section above, the producer from Nicaragua was producing from a small amount of land cocoa, coffee, with intercropping of other vegetables and livestock and poultry as well. **Small scale integrated production** can do a great deal to boost overall food supplies and enhance the environment and bring vitality to communities. **Home growing** also was an important part of the nation's food supply during the war.

So, we can see around us these environmentally friendly methods of increasing yields working across the spectrum, from large scale enterprises like Tim May's 2,500 acre estate, producing grain and livestock, to smallholdings and kitchen gardens, with our farmers, growers and gardeners leading the way. These developments are life enhancing: they bring vitality to the countryside through increased human engagement and community interaction, improved soil fertility and increases in biodiversity, and tastier, more nutritious food. Climate change may bring some opportunities for increased numbers of crop sowings during a year in some cases. Adaptation will be important and the extraordinary diversity of genetic stock of crops and other foodstuffs across the world that are well adapted to such a wide range of different conditions will be an important resource for the future: so it is vital that we protect biodiversity at all levels.

For interest: CFB's Sustainable Food and Drink Group adopted a **definition of sustainability** based on the Brundtland Report of 1987 *'To be able to meet the needs of the present without compromising the ability of future generations to meet their own needs.'*

23) Genetically Modified Organisms (GMOs)

GM crops have been grown commercially since 1996. Drawing on ISAAA (Brief No 52-2016) figures *Global Agriculture* says that by 2016, 185.1 million hectares of GM crops were grown. The largest areas of GM cultivation are in US, Brazil, Argentina, Canada and India. Other significant producers are Paraguay, Pakistan, China, South Africa, Uruguay and Bolivia. Globally the most widely grown GM crops in 2016 are

soybeans, maize, cotton and rapeseed (canola). 91.4 million hectares of GM soy were grown. Total GM cropland area in 2016 was 13.8% of global arable land. (ref 404).

"Modern biotechnology generally means modification of living organisms (plants, animals and fish) through manipulation of the genes", according to the FAO. This can be done in two main ways - 1) using marker-assisted selection to help speed up conventional breeding programmes without modifying the genetic stock of the organism 2) by modifying the genetic stock of the organism (GM) "by introducing a gene or genes, or by deleting a gene or genes. 'Imported' genes can come from different organisms or species." (FAO, ref 356).

This is clearly an exciting and absolutely fascinating field for scientists who now see the potential to modify our food in countless different ways and see it as the only way forward in providing for our future food needs. The most common modifications to date have been to make a crop resistant to the application of herbicides, or insect resistant. However, many other traits have been developed or are being researched. These include greater productivity, disease resistance, better storage capabilities and extending shelf life, reduced bruising, drought tolerance, improved photosynthesis, introducing nutrients into foods, introducing micro-organisms to enhance soil fertility. Single traits or stacking of several different traits (even 7, 8 or 10 traits are being considered) (of alteration(s) of the genetic stock) may be involved and almost any characteristic of a food or other organism can be altered (although subject to strict controls). Weeds, diseases and pests resistant to the modifications are developing and further genetic modification is likely to become necessary. So over the course of years and centuries, the artificially modified DNA in our foods could become increasingly changed and remote from the present day, in a way which could not have happened through natural evolutionary processes or conventional breeding techniques. It is likely to be accompanied by newly evolving pests and diseases. And what are the human health and environmental impacts of a "cocktail" of GM foods?

"Proteins are the bedrock of living systems, intimately involved in every physiological process from triggering an immune response to thinking. Good health requires a fine balance of proteins……After a half century we can identify 100,000 protein shapes. But we have a database of 100 million proteins. That is why we have few molecular keys capable of picking the lock to understanding disease-causing proteins…..We have no idea how altering the gene sequences changes proteins' forms and functions." (ref 368). This extract is from a leader article in *The Guardian* (20 April 2017). It is not about GM food, but about musings on artificial intelligence by Eliezer Yudkowsky: it does perhaps highlight, though, the extreme complexity of the human organism and how little is still known. Most common medical conditions remain poorly understood and subject to controversy amongst experts. The same seriously incomplete level of knowledge is true of the cellular functioning and ecosystems interaction of the biological world more generally, including crops, animals, soil organisms and so on, and new and surprising discoveries are being made on a frequent basis. So, in altering the genetic sequencing of our food, even with the rigorous safety procedures, there are many unknowns and unforeseeable risks. We know that with medicines, agro-chemicals and many other products very serious adverse effects may be identified sometimes decades after introduction.

IAASTD - the International Assessment of Agricultural Knowledge, Science and Technology for Development, was an investigation by more than 400 scientists over 4 years, on behalf of the UN and the World Bank, into the state of global agriculture, its history and its future (ref 352). On setting up the *IAASTD* process in 2003, it seems that one priority for the World Bank was to gain a broad scientific consensus over the use of genetically modified organisms (GMOs). However, in 2008, *Croplife*, the association of biotechnology companies, withdrew from the *IAASTD* process as agreement could not be achieved on the benefits and risks of this form of technology. (ref 351, pp.46-47). The *IAASTD* emphasises instead the importance of genetic diversity of food crops and animal stock and an agroecological approach to feeding the world and combating climate change (See also section 26)

The FAO lists arguments for and against GMOs (2003, refs 367, 355). Under 'Food Safety and Quality' (FAO, ref 363) it says that "The application of modern biotechnology to food and food production (GM

food) presents new opportunities and potential benefits, as well as challenges in ensuring consumer protection. Recent developments have posed concerns, both real and perceived, about the safety of these technologies." The UK Food and Safety information about GM food and other novel food technologies, such as nanotechnology and GM animal feedstuffs, can be seen on their website (FSA, ref 264).

Proponents promote GM as essential for feeding the increasing world population and tackling climate change. However, it is widely reported that there is more than sufficient food produced globally to feed the projected world population in 2050 and about a third is currently wasted (FAO, ref 354). The *IAASTD* report recommends that agroecological approaches are the way forward for the mitigation of climate change and feeding the world. There is concern that too much of the world's research and development funding is being devoted to GMO research and insufficient to other potentially helpful technological and natural means of safe and sustainable food production: i.e. with a focus also on what is both locally adapted, maintains genetic diversity of crops and livestock and is affordable by farmers and producers across the world.

Agriculture at a Crossroads - IAASTD findings and recommendations for future farming, 2016, raises the issue that there have not been any verifiable yield increases from use of GM crops; it has not been effective in relieving world hunger; that weeds and pests become resistant; there has been a quadrupling of glyphosphate use on GM soy in Argentina; that there are problems relating to the "privatisation and patenting of knowledge and seeds, including patents on individual naturally occurring DNA sequences that are treated like inventions." The document also talks about "the imponderable risks at the expense of society and future generations." (ref 351, p.46-48).

Agrobiodiversity has diminished markedly with the concentration and control of the majority of the world's seed markets in the hands of a small number of very powerful multi-national companies (ref 351, p.45). ("75% of the world's food is now generated from only 12 plant species and five animal species. Just five cereal crops (rice, wheat, maize, millet and sorghum) provide 60 percent of the energy intake of the world population.")

National, international and global corporations now have immense power throughout the world in all aspects of the food chain.

'*A Damning Legal Opinion on Monsanto'* was the outcome of a tribunal of the GM corporation in April 2017 (ref 360). The International Monsanto Tribunal took place in The Hague in October 2016. On 18 April 2017 the judges publicly presented the outcome. The judges concluded that companies and international trade agreements take little account of human rights. Their legal opinion included that Monsanto has: had a negative effect on the environment and the rights of indigenous peoples; by reducing biodiversity, Monsanto has undermined the right to food; Monsanto has manipulated scientific research on the effects of its products; Monsanto has consistently exerted pressure on scientists in order to prevent publication of negative research on its products and that this abuse deprives society of the possibility to protect itself against fundamental risks to health and the environment; the judges' opinion was that several of Monsanto's activities may be classed as ecocide.

Although Monsanto called this a "mock trial" and refused to attend, the trial was supported by dozens of groups and organisations across the world (ref 384). Looking at the website of just one - the **Asian Peasants Organisation** - brought up a report entitled '*Asian farmers decry revival of* ***Golden rice*** *field* trials'. Amidst their Earth Day celebrations in Quezon City in the Philippines, "farmers and civil societies coming from Vietnam, Thailand, Indonesia and the Philippines, as well as regional organisations, such as Pesticide Action Network Asia Pacific, Asian Peasants Coalition and GRAIN, called for the utmost protection and preservation of the environment by rejecting corporate dominated technologies such as golden rice and GM crops that are currently threatening the lives and livelihoods of Asian farmers.....as well as their countries' food security and environmental health." (ref 385). This is interesting as **Golden rice**, which inserts vitamin A into rice through GMO technology, is promoted as a way to resolve the widespread blindness caused by vitamin A deficiency in many Asian communities; and it is widely cited by people here as a reason why we need to accept GM as it could particularly help developing countries. However other research has indicated

that vitamin A deficiency can be solved by higher fat consumption (2002, ref 102). Fortification seems to be high on the GM research agenda. Can this really replace the complexity of a balanced nutritional intake and how different foods can work together to promote absorption of nutrients?

Although GM crops have been banned in the EU because of concerns over safety, in 2015, the EU voted to allow member states to make their own decisions about whether they grow GM crops which have been through the appropriate scrutiny, with Britain keen to have this option. Over half of the 28 states will maintain the ban on GM crops including Germany, France, Scotland and Northern Ireland. *The Independent* (26 October 2017, ref 372) published *Brexit: Government to review GM crop regulations in preparation for leaving EU.* (See p.84, under ref 352, for quote of the IAASTD's concerns about GM safety).

Some of the Key Terms commonly heard are defined by the FAO in 'Biotechnology and food security' (ref 356): **DNA**: the chemical molecule at the heart of life itself, made of four chemical elements called bases. These form a double helix, or spiral, in which two strands twist around each other. Thousands, or millions, of these bases form a: **Gene**: the smallest complete unit of coded information in an organism. This constitutes the "source code" of the organism, just as sequences of 1 and 0 define a computer file or program. Large numbers of these form a: **Genome**: the collection of genes, contained in a cell and organised in a particular pattern, that defines the organism. These patterns can be defined by the use of: **Molecular markers**: DNA sequences that can be associated with a trait, such as cold tolerance or the ability to produce a certain toxin. Molecular markers can help researchers characterise genetic diversity more quickly and speed up breeding programmes without modifying the genetic stock of the organism. Another useful biotechnology involves reproducing a cell by placing it in an artificial environment that provides nutritional elements; this is known as: **Tissue culture**: a technique used for micropropagation and breeding purposes. **Genetically modified organism**: an organism whose genetic stock has been modified by introducing a gene or genes, or by deleting a gene or genes. "Imported" genes can come from different organisms or species.

Most imported animal feedstuffs are now GM; nevertheless, many UK farmers raise their livestock on pasture, or on home grown feedstuffs.

Organic standard requirements do not permit the use of GM. GMOs can cross-pollinate crops in the area, thereby altering their genetic stock. An Australian organic farmer lost his organic registration on most of his land as a result of wind-blown GM pollen contamination from a neighbour's land in 2010. In the ensuing court case, it was ruled that the neighbour could not be held responsible for growing the GM crop in the conventional way and the organic farmer was ordered to pay thousands of pounds of legal costs (ref 376). The issue of cross-contamination is an issue for all organic farmers and for Scotland, for example, where there is a wish to stay GM-free. It is also an issue for consumers who feel strongly that they do not want to be consuming GM food.

Mary Mead from Yeo Valley Organics in an article in *Somerset Live 'Pushing GM farming in the UK defies US evidence'* highlighted concerns identified by the United States Department of Agriculture Data (USDA) on GM. The evidence raised by the American Academy of Environmental Medicine into health risks, including "infertility, immune problems, accelerated ageing, insulin regulation and changes to major organs and the gastrointestinal system", is also highlighted. (19 Jan 2015, ref 373).

GM crops also affect the soil. The *Ecological impacts of GM cotton on soil biodiversity* was a study for the Australian Government Department of Environment and Energy in 2004 (CSIRO, Gupta V and Watson S, ref 375). This showed that the Bt toxin (GM pest resistance) enters the soil through the roots throughout the growing season. "If more Bt toxin enters the soil environment than is degraded by microbes, eaten by insect larvae or inactivated by sunlight there is potential for the toxin to accumulate if it is bound and protected by soil particles (clays, minerals and humic acids)." The authors posed the question "Could accumulation of active Bt toxin constitute a hazard to non-target organisms and impact the biodiversity and functionality of the organisms inhabiting the soil?" The authors also noted that "the microflora (eg bacteria, fungi, actinomycites etc) associated with the Bt cotton stubble were significantly different to those observed on non-GM cotton." and that GM stubble had a slower decomposition rate.

In some instances Bt toxins for insect resistance have led to significant decreases in pesticide applications, however the long term effects on human health and health of the soil are not known.

Researchers at Rothamsted have found that *'Wheat choice has a lasting effect on soil health and yield'* . To their surprise they found that the variety of wheat grown one year sets the scene in the soil, and what is going on in the soil, long after harvesting the initial wheat crop, has a major influence in determining the subsequent year's root health and yield (ref 29). This interesting discovery is being taken as an opportunity for GM wheat research trials. The UK now has GMO research into a range of crops and a variety of proposed modifications.

There are a range of views on genetic modification within CFB. However, despite having had a talk from a member who is directly involved in a GM crop research project and sees GM as essential, the prevailing view of members of the Sustainable Food and Drink Group is that GM technology is not essential and carries unwarranted risks. The preponderance of opinion in the group is that **the agroecological approach to agriculture advocated by the IAASTD is the preferential way forward.**

It would be good to know what the Government's view is on the position of organic farmers and growers who are concerned about contamination from GM crops. The British Government has been a strong proponent in the recent relaxation of EU regulations which banned GM crops. After Brexit there will be increasing trade with countries where GM is widely used: how will farmers and growers be protected from pressure by GM seed corporations? And, how will the right to choice be protected for the many consumers who do not wish to eat or drink genetically modified products?

24) International Trade

Following this extensive literature search, it remains as clear as mud where the emissions associated with our imported food and drink (almost a half of what we buy) are identified! Of the 30% of UK GHG emissions associated with the food chain: just over a third comes mainly in the bracket of energy, including fuel (however the DECC figures (ref 229) appear to just be covering UK produced food here, not imports and not necessarily food and drink going for export either); just under a third is from agriculture (however these seem to be figures from emissions within the UK and may not even include emissions related to exports); the other third is the UK's proportional allocation of global land use change emissions (e.g. CO2 from destruction of rainforests). There seem to be some suggestions that the third allocated to land use change includes other things as well, but does it? So, in the statistics, where are the emissions produced by the production of our food and drink abroad, along with the journey it frequently takes between numerous countries and stages in its processing? (See McSweeney, 2014, ref 16). We need the CFB Energy and Transport Action Groups to dig into this for us, please. (See also section 28).

"**Agricultural Trade** (FAO, 2015, ref 74, p.34): Most of the food consumed worldwide is grown locally. Where there is not enough local production to meet demand, trade has been instrumental in filling the gap. The scale of food and agricultural trade today is unprecedented. In real terms, the value of international trade flows has increased around fivefold over the past 50 years, reflecting global trends in overall volume of trade. However this expansion has been unevenly distributed across regions. High-income countries have generally outpaced developing regions, although several of the latter have comparative advantages in food and agricultural production." Exports and imports of food in million US$ - (2012) -

	Export value	Import value
Europe	403	418
Asia	160	264
Americas	266	159
Africa	29	64
Oceania	45	14

The UK is ranked 5th in the world in the list of top importing countries, although does not appear in the top 20 exporting countries and in fact has a large trade deficit in the food, feed and drink sector.

In this FAO document, the data shows that four of the world's top 20 exporting countries in terms of value in million US$ are also in the list of countries with the highest levels of under nourishment, all in Asia. Thirteen of the top 20 rice producing nations per capita (all in Asia) are also in the list of 17 Asian countries with the highest levels of under nourishment. And in 2013, eight of the countries worldwide with the highest value of fish capture production, and seven of those with the highest value of aquaculture production, were all in Asia, and nevertheless in the list of Asian countries with the highest levels of under nourishment (ref 74, p.22).

The IAASTD (key findings - at a glance) conclude:
Point 17: "**Negative Impact of International Trade**: Opening national agriculture markets to international competition can lead to long term negative effects on poverty alleviation, food security and the environment.
Point 18: **Export Agriculture Unsustainable**: Intensive export agriculture has adverse consequences such as exportation of soil nutrients and water, unsustainable soil or water management, or exploitative labour, in some cases."

"*Agriculture at the Crossroads: IAASTD findings and recommendations for future farming*" (ref 351, p.12) says that "Within all upstream and downstream industries to agriculture, an increasing global and national concentration is taking place in the hands of just a few companies that dominate the market. This is exacerbated by a growing vertical integration along the value chains - chemical companies are controlling the global seed market; raw material traders are controlling transport routes, mills and refineries; supermarket chains are dominating wholesale trade and processors their contract farmers. This process is reinforcing the economic marginalisation of small-scale and subsistence farmers who are of no interest to the global industry, neither as customers or suppliers."

An issue which is also raised in the literature is the problems in the developing world (and elsewhere) when there is "dumping" on the world trading market of high volumes of produce, which deflate prices and jeopardise livelihoods. An unfortunate side effect of food aid in areas of crisis it seems is the under-cutting of the value of local/regional produce, which can compound problems of poverty in an area.

The (former) Environment Secretary, Andrea Leadsom, addressed the Oxford Farming Conference on 4 January 2017, and emphasised the government's plans to substantially increase exports of British food, particularly citing distant markets such as China, US, Australia, India and UAE. (Defra, ref 238). At the same time an increasing percentage of our food is being imported (almost half). Does this make sense in terms of GHG emissions or in terms of ensuring that people are fed good food? Should we be increasing exports or decreasing imports, and doing more to feed ourselves with our home-produced food, which she flagged up as having some of the highest standards in the world?

Ms Leadsom laid out an economic vision centred on increased exports; she also said that the government wanted to leave the environment in a better state than it found it; good to hear this latter point. But where is the vision around, or mention of, food for the health of the nation, ensuring that all British citizens have access to good quality food so that we do not have foodbanks and children and adults are not suffering from nutrient deficiency related disorders? The Pacific islanders mentioned earlier in this document, who plan to protect the health of their people by banning imports to ensure that their people have the local and traditionally produced organic food, have an understanding and a vision for the wellbeing of their people. Bhutan aims to return its country to 100% organic production whilst sharing ideas on how that production can be optimised. In 2015 the Danish Government launched a plan for a more organic Denmark. Ms Leadsom on the other hand is instead extolling the corporative fast food manufacturers in her speech. What a stark contrast of priorities.

(Update 30 July 2017) - Michael Gove, in his first speech as the new Secretary of State for the

Department of the Environment, Food and Rural Affairs, on 21 July 2017, expressed a strong commitment to maintaining and improving the environmental standards of food and farming in the UK (refs 435, 431). This has been widely welcomed (refs 432, 433, 434). Nevertheless, the commitment to a focus on significantly increasing exports remains. Helen Browning OBE, CEO of the Soil Association in her written response entitled "New Hope for the Future of Farming" says "The speech committed Britain to leading the way on environmental standards, from pesticide regulation to animal welfare and soil protection.....These goals resonate strongly with us.....We would welcome further thought to how this will interact with public health objectives, ensuring that good food is accessible to all. It is not just about delivering the highest standards in animal welfare and environmental protection, but about ensuring those benefits are translated into availability of high quality food where it is needed most. There remains a danger as Britain leaves the EU that substandard imports will undercut UK farmers and dilute what could be a strong food culture based on ethical, sustainable and healthy British produce for all. Better procurement policy can play a surprisingly big role here and is one cross-departmental issue that we hope the Secretary of State will champion - for the benefit of farmers, animal welfare, public health, and the environment alike." (ref 434).

25) La Via Campesina - International Peasant Movement

'*Social Movements and Civil Society Make the Difference! We are the Difference! Now is the time for food sovereignty!*' Platform for Collective Action ***Forum Terra Preta*** Rome 1-4 June, 2008.

The *Forum Terra Preta* comprising 100 organisations from the 5 continents meet in parallel with UN FAO Summits where they do not feel represented. In the above document they say that "food crises have been exploited by agribusiness companies, local and global elites to concentrate control over farming, fisheries, land and territory, water, forests, seeds, breeds, transportation, distribution and energy sources. The rapidly emerging and cumulative climate crisis is being exploited by the same elites through market transactions such as carbon trading and emission offsets, and profitable techno-fixes such as agro-fuels and patented technologies, including synthetic biology. Some multilateral agencies are creating policy conditions to enable corporate conglomerations across energy, agribusiness, bio-technology and automative industries." They criticise the UN, the World Bank and International Monetary Fund and say that the wisdom of sustainable small-scale food provision and the recommendations of IAASTD that call for a move towards a more agroecological, non-proprietary practices "are being deliberately ignored." (ref 357).

The ongoing nature of all these problems in 2017 is clear, including displacement from land and many instances of violence and death (ref 358). In April 2017 Global Justice is asking for signatories to call on the British Government to support a UN declaration for rights of small-scale food producers:

Global Justice Now - "Time to fight for small farmers' rights"

"Small farmers feed the majority of the world's population, yet they are experiencing escalating levels of violence and oppression. Their way of life stands in the way of global agribusiness expansion and they are losing their land and their livelihoods.

"They are often pushed into buying dangerous chemicals, fossil fuel-based fertilisers and privatised seeds, creating debt and dependency on global agribusiness companies. And they are being murdered as state security services, paramilitaries and hired thugs are persecuting and killing activist leaders, often with impunity. Over the last 15 years at least 1,024 activists have been murdered protecting their communities across the world. Only ten of these killings have led to convictions.

"Negotiations are taking place at the UN on a declaration of rights for small-scale food producers. This would be an important step to protect small farmers across the world from violence and persecution.". (April 2017, ref 343)

26) The Heart of the Matter: IAASTD and Recommendations for Agroecology
(The International Assessment of Agricultural Knowledge, Science and Technology)

The *IAASTD* report (ref 365, 351) was commissioned by UNDP, FAO, UNEP, UNESCO, the World Bank, WHO and Global Environment Facilities. The 400 scientists from different disciplines (natural and social scientists, biologists and economists, biotechnologists and anthropologists) from all regions of the world, reported in 2008, after four years of research, that **"business as usual is not an option."** "It is only in the past 100 years that the development and use of fossil energy sources allowed one part of the world's population to replace existing practices, which involved careful interaction with nature, with the use of machinery and modern chemicals. Over the last 60 years, this has led to an unprecedented global transformation and exploitation of natural habitats, along with regional agricultural and food systems. Today the consequences of this transformation have become a central problem for humanity……The *IAASTD* attributes a crucial role to **agroecology** in shaping the future of sustainable agriculture, demonstrating that it is now at the heart of scientific and political debates." It defines **Agroecology** as *"The adaptation of agriculture to natural conditions and cycles, as well as to local needs."* It also emphasises the crucial importance of the small farmer or producer globally in feeding the world (ref 352).

Globally, researchers have found that an estimated 51-77% of major food groups, including cereals, livestock, fruit, pulses, roots and tubers and vegetables come from farms of less than 50 hectares (with many much smaller than this). Lead author, Mario Herrero, of the Commonwealth Scientific and Industrial Research Organisation, Australia, says that "The historical intensification of agriculture has yielded more but less diverse food and a reduction in the sources of key essential nutrients." (*Global Agriculture*, April 2017, ref 371).

Land grabbing is now recognised as a problem in Europe as well as in the developing world, with land tending to concentrate in fewer and fewer hands, not only in the former communist countries, but all over Europe. Large-scale purchasing of land by corporations for financial investment and industrial agricultural production, often through legal loopholes, has led to a call by the EU parliament for better access to land for small and medium farmers. (*Global Agriculture*, April 2017, ref 370).

The way that farming has changed over the last century is the result of many drivers including the fossil fuel energy sources and agrichemicals, government policies and subsidies, the development of supermarkets, a vast increase in globalised trade and corporative control of food systems, and our food and shopping choices. There is every reason to think that small farmers and producers in the UK, as well as elsewhere, have a pivotal role to play in feeding the population. Large scale farming can, of course, produce good food in an environmentally-friendly way too. We need our large, medium and small producers to be encouraged in this direction.

The FAO's '*17 Sustainable Development Goals*' (2015, ref 354), say that a third of farmland globally is degraded, up to 75% of crop genetic diversity has been lost and 22% of animal breeds are a risk. In an interview in 2015, **Professor Hans Rudolf Herren**, who was the **co-chair of the *IAASTD***, says that "…present agriculture and food systems are not in line with the need for a sustainable world. Agriculture must transform from being a contributor to a solver of problems such as climate change, public health, environmental degradation, loss of farmers and rural to urban migration. The need for a radical reset towards sustainability in all three dimensions, environmental, social and economic…are now slowly moving towards the mainstream, despite a very strong pushback by vested interest, agro-industry and large foundations."… "the basic premise is to work together with nature, not against it, using natural processes to regenerate soils and seeds and work in highly diversified systems, with diverse crops and animal breeds of very distinct genetic makeup." Herren emphasises the need for the developed world to move away from the paradigm of "feeding the world" with basically unsustainable industrialised agriculture and food systems to sustainable, agroecology, ensuring that smallholder farmers have land rights, information and market access. He criticises the "productivist models" being "promoted by the World Bank and the Bill and Melinda Gates Foundation etc". Herren says that governments need to refocus research funding on agroecology, organic and

regenerative agriculture. He is reassured that the debate and action around agroecology as the way ahead to deal with the challenges of sustainable and equitable development has picked up momentum and is now increasingly reflected in the recommendations of the FAO, the Rio+20 declaration, the Sustainable Development Goals and into the COP21 Climate Conference in Paris in 2015. (2015, ref 351, pp.48-52).

CFB member, Rachel Berger, worked for the NGO, ***Practical Action***, as the Coordinator of the Food and Agriculture Programme and, when asked if she knew Hans Herren and whether she knew whether *La Via Campesina* had a wide base of support, said "I didn't know Hans Herren, but my colleague Patrick Mulvany knew him well. *Practical Action* strongly promoted the findings of the *IAASTD*. And worked with *La Via Campesina*. The latter was strong in Latin America and francophone Africa, but not in eastern and southern Africa, where we had three country offices. I was involved with several events at conferences where *Practical Action* hosted a speaker from *La Via Campesina*."

The original *IAASTD* report can be sourced through the website 'global agriculture' which also lists very interesting current relevant news and research. '*UN experts call on states to phase out pesticides and promote agroecology'* says that UN experts have debunked the myth promoted by the agrochemical industry that pesticides are necessary to feed a growing world population. They say that many pesticides persist in the environment for decades and are harmful to the environment, and to people, and call for a new global treaty to phase out dangerous pesticides in farming and move towards sustainable agricultural practices. "The recommendations are for a move away from harmful industrial agriculture to agroecological practices to enhance biodiversity and naturally suppress pests, and to adopt measures such as crop rotation, soil fertility management and crop selection appropriate for local conditions. Incentives should be provided for organically produced food through subsidies and financial and technological assistance, as well as by using public procurement." These "approaches are capable of delivering sufficient yields to feed and nourish the entire world population, without undermining the rights of future generations to adequate food and health." (9 March 2017, ref 346).

Human beings are part of the natural world, although in modern, urbanised societies there is now a substantial sense of disconnection: an issue about which Sir David Attenborough has expressed concern. Mankind has always been in competition for food with the rest of the natural world, much of which shares our tastes in what to eat! Throughout the majority of the food chain predators will fend off the competition to capture and eat their prey. Although they fight off their competitors, they very rarely kill them. In this way human beings are different: not only trying to defend their food from competition but exterminating the competition on a grand scale. However, it is the immense variety of biodiversity and the extraordinary interconnectedness (surely beyond our understanding), which has endowed the earth with its health, vitality and beauty, which sustains us, both nutritionally, and, for many, psychologically and spiritually.

The earth is not our inheritance alone, it is the inheritance of the rest of the natural world too. Conservation areas are crucial in giving a measure of protection to some of the world's biodiversity. Some advocate conserving areas for wildlife and intensively cultivating our food on other areas: a silo approach. However even with intensive methods, our food production requires rather a large area. Actually, the figure for total global land use to produce food, according to the FAO in 2014, was 18,963,881 sq miles, and total land area under arable cultivation was 5,391,431 sq miles. By our increasingly effective means of destroying our competitors and the natural world as never before, from large mammals to soil micro-organisms, from whales to corals, we are destroying biological soil systems and damaging freshwater and marine ecosystems too. And yet: this is jeopardising the long-term ability of our soils and fresh and marine waters to produce food for us, our children and grandchildren and future generations. It is the sharing of a living earth that brings fertility to our soils through cycles which bring structure and nutrients to the soil mediated through plants and creatures, which are crucial also for mitigating climate change. We need all of our soils and water to be actively involved in these fundamental biological processes. We need to see the emergence of a renewed abundance in the natural world to keep our world healthy. We are lucky to have many local farmers and growers who are producing wonderful food for us, whilst seeing increases in biodiversity on their farms when they have returned to managing their farms in keeping with biological and ecological principles.

27) Economic Sustainability

Tim May's Nuffield Scholarship Report (ref 298) focuses attention on the fact that unless a business is sustainable financially it is very difficult to have the time, money or energy to focus on the environmental and ethical aspects of that business. For farming to be able to pay due regard to these aspects financial viability is needed.

Contracts which treat farmers and producers fairly can give vital financial security and therefore increase our food security.

Family spending on food in the UK stayed fairly flat between 2011 and 2015, having fallen from the level of expenditure in 2005 recorded in the survey by the Office for National Statistics. The fall coincided with the increase of discount supermarket chains, increasing consumer choice and competition in the market. Average family spending on food each week is recorded to be less than on either recreation or on transport. (ref 419). The average percentage of income spent on food is less than half what it was in the 1950s.

Professor Hans Herren (Co-chair of the *IAASTD*) highlights that "the present pricing system for food is actually at the root of most problems on farms and in rural areas" with prices not reflecting the costs of production. Instead of pricing food to accommodate the poor, the need is to eliminate poverty and deal with the increasing inequality. (ref 351, p.49).

The "treadmill" of industrial agriculture is described in *'Agriculture at the Crossroads IAASTD findings and recommendations for future farming':* the constant drive for technological advances to produce more (ref 351, p.23). This incurs large capital costs to the farmer; however large outputs (often associated with specialization, mono-cropping and intensive livestock production) which drive down costs to the consumer, mainly through corporative outlets, leave less intensive or "cutting edge" systems of production unable to compete. The latest technological or scientific "innovation" will always be round the corner and it becomes necessary to stay one step ahead to stay in business. In spite of the rhetoric from scientists, the multi-billion pound corporations, and politicians, who can not turn their back on the revenues from this system, this scenario is a treadmill, and is not necessarily in the interests of soil fertility, animal welfare, the environment, the spectrum of farmers and producers - large, medium and small - across the world, or ultimately the consumer. It also decreases the flexibility within farming. The same may also be true in the fishing industry.

Despite the dominance of the global food systems by corporative vested interests, there is an encouraging movement back towards a more sustainable approach to food and drink production. *The Real Farming Conference* in Oxford this year attracted 800 researchers, farmers and other experts on both days. Consumer interest in sustainably sourced food is increasing and needs the support of government.

28) Not All of the Answer Lies in the Soil

In fact, the **highest levels of emissions in the food chain (about 60%) are the combined emissions from energy, transport and waste**.

1) More on Waste

About **one third of all food produced in the world is lost or wasted post-harvest.** 40% of losses in low income countries occur at storage, transport and processing levels. 40% of losses in high income countries occur at retail and consumer levels (CCGIAR CCFAS, ref 4). Decreasing waste would increase efficiency of the food system: decreasing both pressure on land and other natural resources, and emission of GHGs. (FAO, ref 237, p.86). The GHG impact of waste will be due to associated wasted inputs (fertilisers, cultivation, transport, processing, storage etc) and associated emissions right up to point of waste, plus extra emissions associated with disposal. There may also be a large water footprint associated with the wasted

produce and other environmental and land use change impacts.

UK households have decreased their overall avoidable food waste by 17% between 2007 and 2015. Nevertheless 2016 statistics show that the UK food and drink chain produces 10 million tonnes of waste post farm-gate, 60% of which is avoidable. It is associated with 20 million tonnes of greenhouse gas emissions. 71% of this waste takes place in the home. This costs the average household £470 a year or £700 for a family with children (equivalent to £60 a month) (WRAP, Jan 2017, ref 241).

A Parliamentary Select Committee interview with WRAP on efforts to help us change our behaviour and decrease food waste is interesting and can be heard online. The earlier successes from the 'Love Food Hate Waste' campaign in encouraging UK households to decrease waste have reached a plateau (EFRA, 28 Feb 2017, ref 411).

Every day in the UK we throw away the equivalent of approximately: 5.8 million potatoes, 24 million slices of bread, 1.4 million bananas, 1.5 million sausages, 1.9 million slices of ham, 1.1 million eggs. An area almost the size of Wales would be needed to produce all the food and drink currently wasted (WRAP 2017).

A survey into '*Understanding Out of Home Consumer Food Waste'* (WRAP, 2013, ref 80) found that 41% of people eating out in pubs and restaurants left food because the portion size was too big, particularly younger women and people over 55. The most commonly left foods were chips (32%) and vegetables (18%), meat/meat products (11%), salads/coleslaw (11%) and potatoes (11%).

Waste associated with wonky veg has been highlighted by Hugh Fearnley-Whittingstall, in his War on Waste campaign, and showed very high tonnages of good vegetables being rejected by supermarkets, when they do not conform to “cosmetic” standards that consumers seem to expect. If 20% of a crop is rejected for this reason, this represents the produce of one acre in every five acres being ploughed, sown with the crop, fertilisers and pesticides probably applied, harvested (all with associated GHG emissions) and then promptly wasted. Additionally there is a very serious impact on farmers through loss of income.

Excessive food packaging is associated with unnecessary GHG emissions (and resource use, including fossil fuels to produce the frequently plastic packaging) and disposal problems, which include pressure on landfill sites, contamination of soils, watercourses and seas/oceans and litter. Plastic pollution is now a very serious problem indeed in our oceans and the ingestion of high levels of plastic detritus by sea birds, fish and other marine life is a threat to the food chain. Urgent global, local and individual action is needed to address this. (See also Refill project in section 5).

"Alternatives to Plastic when Refrigerating and Freezing, or: Frugal Use of Resources!" has been researched and compiled by CFB SFADG member Eunice Parker, and can be seen in the appendix.

2) Transport Emissions: Now You see Them; Now You Don’t

The UK is increasingly exporting its carbon footprint with only about half of our food being produced within the UK in 2016 (ref 75) compared with 75% in the 1990s, even though population increase over the same period was only just over 11%. Shockingly, the transport emissions of food and drink that is imported into the UK, as well as that produced in UK which is exported, have in the past been excluded from the transport emissions statistics. If they are included now, it has not been possible during this literature search to date, to track them down, or indeed any very recent and clear figures. The 2009 food transport figures which showed that a quarter of the heavy goods vehicle (HGV) and half the HGV tonnage were due to food transport, only took into account the food both produced and consumed within the UK (Defra 2012, ref 245). Globally, most food is consumed locally (FAO 2015) (although this is not the case in the UK). Nevertheless, the scale of movement of food and drink across the globe, with its associated fuel emissions, is truly immense. It also involves a huge level of infrastructure (holding and distribution depots, roads etc) and manufacture of transport vessels (HGVs, ships, planes + containers), probably none of which is accounted for when identifying the emissions linked to the food chain.

If the emissions from imported products (all products, not just food and drink) are not accounted for, this seriously distorts our responsibility for global emissions (for example, how many emissions in China result from producing a wide variety of manufactured goods for UK consumers?). Most food in the UK is purchased from supermarkets. Many of the products, or ingredients they contain, will have made an extraordinary journey passing through multiple countries during various stages of production, processing and packaging. Even food which is produced locally, may have travelled a long way, sometimes even to other countries and back, to processing, packaging and distribution centres before appearing on a supermarket shelf. It is difficult to find where there is data that indicates our liability for that movement of our food and drink in and out of multiple countries; and where are the data on emissions for the food and drink we export? There is now an evident disconnection between us and where our food comes from, however much we might enjoy the local food ambiance of many foreign holiday destinations! Importing ever larger quantities of our food (even if it has a lower footprint) is not the answer. New Zealand lamb is often quoted as having low emissions because it is grass fed - however it is not mentioned that much of UK lamb (especially from late spring) will also be grass fed only. There is in any case no decrease in GHG emissions being achieved by eating imported lamb, whilst 38-40% of our own is being exported (mainly to the EU). Imported meat finds a market over here as it is often cheaper and is widely used in the service industry.

We need to find ways of minimising the emissions from home produced food and our very fertile country needs to be fully contributing to UK self-sufficiency and total world food production, with products that grow well here.

The majority of the world's goods are transported by ship and large ships have the lowest GHG emissions per tonne-kilometre. Trucks have a variable, but very much higher emission rate than shipping. Air freight emissions are several times that of trucks, so goods that are air-freighted should be avoided whenever possible. However suggestions that trans-oceanic shipping of food and drink is associated with a lower carbon footprint than transport by road from the EU does not appear to take into account that the goods may have been transported long distances by road to ports prior to shipping and will also be transported by road after import to the UK. Although the issues around the carbon footprinting of transport, as with all else, are complex, increasing trade with more distant countries in the world post-Brexit may well lead to a significant increase in transport emissions.

It is understandable in terms of transport that long haul journeys have efficiencies of scale with larger ships and lorries, for example, potentially causing less emissions than many small vehicles. Depending on whether all the "hidden emission costs" are fully accounted for, it could be the case that the GHGs emissions of an imported foodstuff is less than that of the same food which has been produced locally in an emissions-intensive way. However, this measure only takes into account GHG emissions and not other impacts, such as whether water use during production was high in a water-stressed region. Although there are efficiencies of scale during the long haul stage of transport, at either end of the journey the situation is less clear cut: using large vehicles to move produce from small producers, or those without trunk road access, or delivering to small and less accessible outlets is not necessarily the best option. So it is easy to see why the corporative food system has marginalised small producers and outlets.

When the above is considered, the efficiency of local food provision, which cuts out the long hauls and the multiple stages of the processing journey (and all the infra-structure), becomes more compelling.

Generally it is considered that choosing fresh, seasonal, local foods is a good choice. The trend towards eating fruit and vegetables, as well as other foods, out of season, will commonly increase the GHG emissions. This has become such common practice in the UK that many people now have little idea of the natural seasons for fruit and veg, or indeed other foods.

It should be borne in mind however that not all producers live near a conurbation or adequate population outlet for their produce and they will need, in any case, to find markets further afield.

Car journeys made by consumers for food and drink shopping make up a significant part of the transport emissions in the food system. Walking (muscle power is surely now one of the most underused sources of energy!) where possible is a great saver of GHGs, and here the trend for shopping trolleys makes very good sense. A little forward thinking and combining journeys, may also help save on time as well as fuel emissions.

3) Energy, including Biofuels

Energy is used throughout the food chain for agricultural production; post farm gate transport by road, sea and air; processing; retailing; refrigeration; freezing; cooking; and waste management.

The majority of UK GHGs emissions **in the food system**, about 60%, are not directly agricultural-based emissions but related mainly to energy, transport and waste management.

Foodsource gives the following breakdown (of the 19% of UK GHG emissions attributed to the food system) - 5% fertiliser manufacture, 40% agriculture, 12% food manufacture, 7% packaging, 12% transport, 10% home food related, 7% retail, 6% catering, 1% waste management (3.1.4, ref 311). (These figures do not include the approximately 10% of emissions allocated to the UK for global land use change.) Although waste appears here as being responsible for 1% of food system emissions (relating to waste management), since one third of all food is wasted, mainly at the consumer end, it could be said to be responsible for a very much higher level of total emissions. Wasted food and drink will account for more and more wasted emissions the further along the trajectory it is between primary production and readiness for consumption.

On energy in the agricultural sector, the UN says that “Energy: is an important input for the agri-food chain and is used to power agricultural machinery, heat greenhouses, power irrigation systems, but also to manufacture equipment, fertilizers, pesticides and other agro-chemicals. The amount of energy consumed by agriculture is increasing worldwide as mechanization, especially in developing countries, increases."

Agricultural land sourced bioenergy production:

This has been rapidly expanding over recent years to meet the new demand for liquid biofuels for transport (e.g. ethanol and biodiesel) and solid biomass for power such as pellets or wood chips. (FAO 2015, ref 74, p. 40). See Biofuels below.

In terms of competition for land in the UK, 122,000 hectares of agricultural land was used for bioenergy in UK in 2014 (2% of total arable land) (remember though that our self-sufficiency in food is declining and we are now importing almost 50% of our food). This was double the 2013 area. Crops for bioenergy included oilseed rape, sugar beet, wheat, barley, maize, miscanthus, short rotation coppice and straw crops. About 68% (83,000 hectares) of this was used for biofuel (biodiesel and bioethanol) and this constituted 33% of biofuels used in the UK for road transport; the other 67% was imported from many different countries. Some UK bioenergy crops may also have been grown for export that are not included in these figures. Crop feedstocks that were imported include palm, corn, sugarcane, oilseed rape, barley, sugar beet and wheat. Imports came from many European countries, Indonesia, Malaysia, the Russian Federation, India, South America and Central America. (Defra 2015, ref 207). Many other crops are also used globally for bioenergy.

A very substantial percentage of some of the world's largest crops are now grown for bioenergy. Some of the imported fuels come in at different stages of refinement and under different names and it seems that they are difficult to track through their journey and be sure that they are sustainably sourced.

As highlighted in the sections on Africa (18) and the World's Largest Crops (16), bioenergy crops now have a gigantic and growing global land footprint and are contributing to land use change, habitat destruction and degradation, and displacement of peoples with poor land rights. Section 18 raises a range of deep concerns over this land use. More information can be found in the bibliography about the plans of companies from UK and other countries across the world over recent years to expand land use in developing countries

for biofuel crops by millions of hectares. Some documents highlight that bioenergy may be cheaper, but it is not necessarily greener in terms of emissions and it may also come with other serious environmental impacts. (refs 104, 105, 106, 107, 191, 192, 293, 297, 333, 335, 336, 337, 338, 339, 347 and ref 351, p.18).

Biofuels:

Current global land use statistics for biofuel crops have not been found. According to the International Energy Agency in 2006 an estimated 14 million hectares was used for production of biofuels and biofuel products, with a projected growth by 2030 to 35-45 million hectares (FAO, ref 337). 'Biofuel crops: food security must come first' (29 Aug 2013, *The Guardian)* highlights that "UK biofuel use in the first year of monitoring [in 2009] *required around 1.4 million hectares [ref 424]* of farmland, most of it overseas. That's the size of Northern Ireland, just to provide 3% of our transport fuel."

It is worth looking at the Solar Feeds website which gives a clear explanation of biofuels and their pros and cons: Biofuels are liquid fuels made from biomass. The most common are ethanol made from starches and sugars, and biodiesel made by mixing alcohol, which is usually methanol, with vegetable oils, animal fat or recycled cooking oil. Solid biofuels include wood, sawdust, grass trimmings, domestic refuse, charcoal, agricultural waste, non-food energy crops and dried manure (often a by-product or residue of other processes, such as farming, animal husbandry and forestry. Second generation biofuels utilise a variety of "sustainable" feedstocks. The pros of biofuels that are listed include that they are produced from plants and other organic matter: they can be replenished, unlike fossil fuels which are becoming depleted, and they are cheap. However, fossil fuels are often used in their production: agrichemicals and fuel, and the burning of materials to produce biofuels emits enough nitrous oxide to "create the GHG effect". So they are not necessarily as clean as they might at first appear. There are also the issues of food vs biofuels and loss of habitat. (ref 336).

Globally, as well as in the UK, demand for biofuels increases pressure on land use (see sections 18, 13, 16) with the EU Renewable Energy Directive and other national mandates and targets for greener fuel driving the process. The US is the world's largest producer of ethanol by far, followed by Brazil, then the EU. In the EU about 30% of production goes for industrial use. The EU sources ethanol from croplands within the EU and also sources from many other countries, including: Brazil, Guatemala, Peru, Pakistan, Russia, Bolivia (ref 170).

Biofuel production is rising rapidly and is competing for farmland and continues to expand across the world. There are increasing amounts of biofuels crops and crop residues being used in the UK for electricity and gas production, and for transport (including to replace diesel in agricultural production).

According to *'Bioenergy and Biofuels: Opportunities and Constraints'* "removal of crop residues, such as leaves and stalks, can negatively affect soil structure, promote erosion and reduce eco-system sustainability; heavy extraction of water for irrigation of feedstock crops could affect water availability, particularly in water-stressed regions; in South-East Asia oil palm plantations for biodiesel production have caused deforestation and biodiversity loss." (ref 260).

Ecotricity is developing its first green gas mill to produce clean gas for household use from grasslands. It aspires to be able to expand this model to provide 97% of UK household gas demand. It is being reported that grasslands are also being seen as a potential energy source for aeroplane fuel. Clearly, demand for grass for biofuels could increase exponentially. At the same time livestock are increasingly being kept under cover without access to grazing and animal fodder is becoming more difficult to source. Using some crop residues and unavoidable food waste for energy production may be positive, however, crops, grass and crop residues which would normally have been used for food for people, animal feed or returned to the land as organic matter, are now being used as biofuels.

Tying more farmland in to energy production could be very problematic for global food sufficiency in the future, especially if climate change impacts increasingly on food production, as warned by the FAO. The UN

International Year of Soils (2015) also raised grave concern about increasing demands for farmland, from all directions, compromising land available for food production in the future.

Renewable, carbon-neutral energy sources for electric, gas and fuel that are not farmland-sourced are urgently needed. Much more focus on reducing energy usage (and importantly, transport requirements, since there is at present no really feasible alternative to fossil fuels, which is not land sourced) throughout the food chain should surely be a priority.

An article worth looking at is *'The Struggle for Sustainable Food Transportation'* (Matthews, 2015, ref 275).

(See also sections 17, 18 and 16.)

29) The literature search

Carrying out this literature search has been both absolutely fascinating and a complete nightmare! Comparing the statistics on GHGs emitted by different parts of the food chain is difficult, as different research bodies rarely use the same parameters, so the figures are not comparable, and it is not easy to achieve clarity on what they are including or excluding from each of their categories. Data from authoritative sources have been used. It has often been difficult to find statistics for the most recent years. Many documents emphasise that there are considerable uncertainties and inconsistencies in the data and that data from some aspects of such complex systems are difficult to capture. Soft evidence and analysis has been useful in raising questions about the interpretation of data, as well as the evidence of our own eyes and people telling us what is happening locally.

Many of the documents in the bibliography/reference list are extraordinarily interesting and enlightening and make recommended reading!

30) Conclusions of the literature search

Overview:

The world population is predicted (by the UN in 2015) to reach 9.7 billion by 2050. However, the rate of increase is diminishing and it is not known whether it will remain under that level or exceed it. In some countries birth rate is now declining below replacement level. Emergent nations are becoming wealthier and in many cases their populations are consuming more food and increasingly adopting a Western-style diet (not necessarily leading to good health outcomes). Hunger and under-nutrition remain a huge problem, particularly in sub-Saharan Africa and in South Asia. This is not because there is insufficient food currently produced in the world. Indeed, there is **already sufficient calories produced in the world to feed 9 billion (some sources say 12 billion) people**. (See also sections 8-18, 26)

With the world population currently at 7+ billion this means that, there is **no need to urgently produce more food now and increase intensification of food production, as we are being frequently lead to believe; there may instead be a real opportunity to produce less, but better** food - healthier food produced to higher environmental and ethical standards. At the same time ongoing research is needed into how to produce more food, if needed in the future; and finding ways to enable everyone to eat a nutritionally-balanced diet, whilst reducing climate and environmental impacts over the next 30 + years and on into the future. (See also sections 8, 26-27)

Competition for land globally is a serious concern with impacts for sensitive habitats and land rights of people in countries with weak governance. Land suitable for food production is increasingly in competition with other land use demands, including development, natural resource extraction and energy production from land. (See also sections 6, 12-18, 23-26, 28)

The UN International Year of Soils 2015 highlighted the threat to future food security through loss of farmland and of degradation of soils globally. It has warned that the **damage to the structure of soils globally, associated with modern agricultural practices and reductions of organic matter in soils** is leading to loss of topsoil and erosion, reduced fertility, reduced ability of soils to withstand drought and flooding and reductions in biodiversity. Scientists from the University of Sheffield have warned that there may only be 100 harvests left in our soils if we continue in the way that we are (*Farmers Weekly*, 2014). (See also sections 1, 3-5, 20, 26, 31)

The ability of the soils to store vast amounts of carbon, acting as a natural carbon sink, has been greatly diminished by forest clearance and modern agricultural practices globally. Forest stores the greatest amount of Greenhouse Gases (GHGs); followed by grassland. The disturbance to soil caused by cultivation for annual arable crops is particularly prone to cause the release of GHGs back into the environment from the soil. All soils can act as sinks or emitters of GHGs depending on the conditions. Wetland areas are also important in this respect. There is great variability and much still to be researched and some of the issues have been highlighted through this document. (See also sections 3-5, 20-22)

The Committee on Climate Change's document '***Meeting Carbon Budgets - Impacts of Brexit for UK Climate Policy***' *(*Oct 2016, ref 401) states that: "The cost-effective path for agriculture involves a reduction in emissions of 15% (8 MtCO2e) below 2014 levels by 2030. The cost-effective path for land use and forestry involves an increase in afforestation to 15,000 hectares per year." (See also sections 19-20). (It is not clear where it is planned to create extra forestry. Perhaps the Biodiversity Group know what is being proposed?)

The document goes on to say: "There could also be opportunities for the UK to develop approaches which are currently prohibited within the EU but legal in other markets such as the United States. These include use of ionophores in cattle (which inhibit the production of methane and could save over 2 MtCO2e in 2030) and use of genetically modified crops and livestock. However, these would have to be considered alongside other concerns such as animal welfare and wider ecosystem impacts." **This course of action would be entirely counter to the recommendations of this CFB document,** based on our literature search, which has concluded that such approaches are unnecessary and incur significant risks, some of which cannot be predicted. [Ionophores are antimicrobials that are used as growth promoters. They have been linked to human antibiotic resistance (EU, ref 402). Of course the disputes rage. It is worth noting that the US is concerned about the very high levels of antibiotic resistance there. The UN's FAO factsheet "*Antimicrobial resistance in food and agriculture*" says that minimising the use of antimicrobials is critical and the use of antimicrobials in animal feed as growth promoters is discouraged. Antimicrobials such as antibiotics and fungicides are also applied to agricultural crops and are used in the agro-industries, for instance for the production of biofuels by-products (April 2017, ref 403)]. (See also sections 22-27). (Hopefully we can take some reassurance from the first speech of the new Sec. of State for Defra - ref 431.)

The **Agroecological approach** to sustainable food production recommended by the **International Assessment of Agricultural Knowledge, Science and Technology (IAASTD)** is considered by CFB Sustainable Food and Drink Group **to be the preferential way forward** to achieve a sustainable food system for now and the future for the wide range of reasons stated throughout this document. **Agroecology** is defined as "***The adaptation of agriculture to natural conditions and cycles, as well as to local needs***." The **IAASTD** and the **FAO** say that this approach **can feed the projected 2050 world population.** Research investment into this approach to providing safe and sustainable food into the future is regarded as a priority to optimise benefits. (See also section 26)

The data about the **carbon footprint** of different foods is important information, although this data perhaps cannot necessarily be extrapolated to create a cohesive approach to producing food in a way that protects the environment and ensures sustainability. It **is particularly likely to misguide policies and choices as long as it is unable to reflect** other environmental impacts, such as water use, land and fresh and marine water system degradation, and, very importantly, the ability of the food production system to retain

fertile soils with good structure, which both enhance the ability of soils to sequester and store GHGs and support wider natural ecosystems. The sociological effects of how our food is produced are also of great importance, particularly with regard to land rights and human rights of the world's most vulnerable populations. (See also sections 20-22)

A varied and nutritionally balanced diet with a good variety of fresh, seasonal foods is recommended. The findings of this literature search do not endorse the need for a restricted diet in terms of food type, except that processed foods, high in fat, sugar and salt and low in micronutrients, should be kept to a minimum. A different public dialogue which does not demonise meat and other animal products, and ruminants (cattle and sheep) in particular, is needed. Although methane is a very powerful GHG, it persists in the atmosphere for a much shorter period of time than carbon dioxide or nitrous oxide. Methane is the main GHG contributor from beef and dairy cattle and sheep in the UK; based on the Department of Energy and Climate Change (DECC) statistics the total methane emissions from the UK agricultural sector was 5.3% of total UK GHG carbon dioxide equivalent emissions in 2014. The media commonly give a misleading impression of the level of emissions attributable to the UK livestock sector and the red meat topic is probably distracting public attention from other very important contributors to climate change. There are many environmental benefits to producing food from grassland and traditional mixed farming systems. It is very important to ask for dairy and meat products from pasture-fed animals. Chickens and pigs in the UK consume more grain than UK ruminants (cattle and sheep). Vegetarian and vegan diets can also be associated with high GHG emissions and other environmental impacts (such as high water usage in areas of water stress). What we eat depends on many factors including availability, affordability, access, beliefs, health issues, preferences, facilities, knowledge and skills. It is more important how our food is produced, than what we eat, from the environmental point of view. Gradually finding out more about our food and choosing food and drink produced to high environmental standards can make a big impact on the wider environment. The power of advertising, promotional offers and other business strategies is unduly influential and often not associated with positive health or environmental outcomes. (See also sections 4-6, 14-16, 18, 33-34)

Governments have responsibility for **ensuring that everyone can afford good food and that farmers receive a fair return for their produce.** This is required for environmentally sustainable and ethical food systems. (See also sections 4, 8-11, 13, 15, 24, 26-27)

The establishment of **renewable energy sources for all purposes**, and importantly also transport and agricultural fuels, **which do not depend on fossil fuels or agricultural land use, is a very high priority** (except for lowest grade waste, which has no uses further up the waste hierarchy, and does not reduce organic matter returns to the soil; and traditional low scale sourcing eg for firewood). Increased sourcing of the exponential energy requirements of a modern society from biomass or other land-based production systems is not sustainable and increases global land use pressure, with multiple adverse effects as discussed. Every effort should be made to **promote energy and fuel efficiency and reduce use** significantly, until viable alternative technologies have been realised. (See also sections 12-13, 16-17, 19, 28)

Major issues for a sustainable food system include:

- GHG emissions from primary production, agri-chemicals (production and application), processing and from transport, energy and waste through all stages of the food chain
- degradation of soils, marine and freshwater systems, and air quality
- land use change with loss of forests and other important eco-systems
- that much land and resources is used to produce food and drink which does not end up as part of a healthy nutritional intake
- depletion of natural resources
- competition for land use
- land grabs and human rights abuses
- hunger and malnutrition
- increasing obesity and nutritional deficits
- ongoing losses of biodiversity

- animal welfare
- ensuring that nutritious food is available to the global population, now and in the future
- that the way that GHG emissions are measured is a contributory factor in driving increased intensification of food production, without consideration of the wider issues being sufficiently taken into account

Achieving a sustainable food system:

1. **Reducing emissions related to energy, transport and waste management** could together give the largest reductions in GHG emissions attributable to the food system. This could be achieved through promotion of much greater reductions of demand for energy and fuel, and implementation and technological advances in supply of renewable energy, as above, with reduced reliance on biofuels.
2. **Reduction in the third of all food which is wasted** would bring reductions in GHG emissions much higher than the 1% emissions associated with waste management alone: it would alleviate need for production and associated emissions throughout the food chain commensurately according to stage of wastage, both here and abroad.
3. **Afforestation** is likely to be associated with multiple ecological and climate mitigation benefits in addition to GHG sequestration, and, according to the Climate Change Committee would achieve the officially required UK GHG reduction for the forestry and agriculture sector by 2030, as stated higher up in this section.
4. **The health of the soil** - very significant reductions in GHGs - mitigation of climate change - multiple improvements in ecosystems - food which is produced on more fertile and nutrient-rich soils, with less dependence on agrichemicals - can all be achieved through a widespread transition to an agroecological approach to food production. This would ensure that organic matter is restored to soils and that the biological life within the soils can enable significant levels of carbon sequestration. It would also ensure that soils are fit to keep producing food into the future. Government funded research and sharing of good practice, as well as positive encouragement and incentives for large through to small farmers to adopt this approach would help to achieve these goals.
5. **British farming** There is a need to address the issue of British farming being able to provide more of our core nutrients. To achieve this, Government needs to prioritise British food for British people and ensure that farmers and growers are not undermined by cheaper imports and have fair financial returns for their produce. It is vital to retain skills and ensure food security. For farmers and producers to have to sell their goods at a price equivalent to the lowest cost global competitors, drives intensification of food production; diversification into non-food farmland use; products for the top end of the market or farmers out of business: this is not the way to achieve best environmental gains or food security. Our large, medium and small farmers are all needed to contribute to sustainable food production.
6. **Small farmers and producers** should be a very important component of the total food production capacity in the UK. Much more fruit and veg can be produced in this country, with small scale growers and home growing able to make a significant contribution.
7. The **corporative control and lobbying power of all aspects of the global food system** has many very serious downsides and should not be allowed to dominate policies and decision making.
8. **How our imports are produced**, as well as the activity of UK food and drink companies globally, is responsible for many negative environmental, ethical and sociological impacts in other parts of the world, and particularly in developing nations, including land grabs. It is something that we should not turn a blind eye to and actions are needed, such as: government support for the UN declaration of rights for small-scale food producers; addressing international corporate tax evasion; ensuring fair trading here and abroad. We all need to think more about how our food is produced.
9. **Our outsourced carbon footprint** for food produced abroad (almost half of our consumption) has a role in driving climate change, as well as using water resources in areas of water scarcity and other forms of environmental degradation, including land use change. Much of our food and drink passes through multiple countries during processing and packaging.
10. **Local food** has many benefits for farmers and growers and consumers, however, at the present these benefits are only realised by the few. Enabling all sections of society to afford and have ready access to good quality local food should be possible. This cannot be achieved by forcing down the producers'

prices as has happened through the supermarket sector, to the detriment of our farming. Redistribution of wealth to ensure that all can afford good food and also that people are not reliant on food banks, is a prerequisite of a civilised nation.

11. **Restoring employment and vitality to rural areas, and attracting young people into the sector,** is enhanced by local and regional food systems and can work for urban areas also. This sector is helping to re-energise and bring vibrancy to the food and drink sector. It promotes more understanding of seasonality and helps connect people with where and how food is produced. It is good for tourism too.
12. **Education which enhances connectivity with food production and a good understanding of a nutritionally balanced dietary intake** is vital. Climate Friendly Bradford on Avon supports the wide-ranging benefits of the whole school approach, and sustainable sourcing of food for school catering, of the **Soil Association's *Food for Life* Awards framework**. One school has withdrawn from the scheme locally due to financial cut-backs. This is a serious matter, as good school dinners and nutritional and environmental knowledge and skills, have the potential to impact positively on children's health and wellbeing on into adulthood, as well as teaching a broader sense of environmental awareness, connection and responsibility. Central funding for schools to implement, with support, this excellent scheme, is recommended. Learning about growing food, cooking and understanding where our food comes from can be integrated with literacy, numeracy, science, geography and other subjects.
13. **International Trade** has an important role to play in feeding the nation and food security. However, the UK now has a very low level of self-sufficiency in many key nutrients. International trade can have positive or negative outcomes for the environment and people. Increased trading to distant countries post-Brexit is likely to increase GHG emissions. The *IAASTD* says that “Opening national agriculture markets to international trade can lead to long term negative effects on poverty alleviation, food security and the environment.” (see section 23). Respect for land rights and human rights should be at the forefront of our trading practices. Our government should be active in supporting international measures to protect these and the safeguarding of the environment and biodiversity across the world.
14. The combination of the **UN FAO Recommended Dietary Guidelines and the Government Buying Standards** lay out some good guidelines which should be widely advocated. Additionally, examples of positive progress in achieving improved environmental sustainability in the food and drink system in the Bradford on Avon area are cited, along with recommendations and discussion points for working towards Climate Friendly Bradford on Avon's goal of Carbon Neutral 2050 (see section 34).

The food chain is immensely complex and there is a substantial measure of inconsistency in the statistics in different documents. The statistics, however, cannot be viewed in isolation and bringing down GHG emissions needs to be done in parallel with, among other things, ensuring that soils are healthy and fit to feed people across the world with a nutritious diet now and in the future, safeguarding the integrity of fresh and marine water systems, clean air and stewardship of the world’s biodiversity and natural environment. Protecting forests and creating restored and new areas of forest and woodland, including in the UK, is highly desirable and some food production may be able to coexist with that: agro-forestry.

There are benefits for soil fertility and many eco-systems in integrated food production which includes crops and livestock. Grasslands which are unsuitable for crop production (65% of UK farmland) can be converted to high quality nutrients, suitable for human consumption, by grazing livestock. This literature search does not indicate that a restrictive diet in terms of food type should be advocated on environmental grounds. It is likely that most food types can be produced in a way that is environmentally friendly. However, throughout the food chain from 'farm to fork' there are major environmental and ethical issues that need to be addressed. Our outsourced footprint, associated with food, animal feedstuffs and biofuels is a particular concern in a variety of respects discussed in this document.

The UK is pushing ahead rapidly on a highly technological, intensive, industrialised and corporative trajectory with regard to the future of our food and drink system. The findings of this literature search questions the wisdom of that paradigm. The prevailing discourse on a number of issues is questioned in this document. The recommendations of the *IAASTD* that "business as usual is not an option" and that the world needs to move rapidly towards an agroecological approach is strongly supported as the way forward. Research and development monies need to be focussed in this direction. This transition is likely to be a low

cost, achievable option, able to achieve the best outcomes for the health and wellbeing of ordinary people across the world, biodiversity, and able to create the conditions necessary to reduce GHG gas emissions and mitigate climate change.

The means are available for radical improvements in the environmental impact of the food and drink chain. However, it needs the will and focus of international bodies and governments, producers and businesses, large and small, and consumers. There are a wide range of very powerful vested interests throughout the food industry: national and multi-national corporations now have massive power worldwide over all stages of the food chain. Their main concern is not likely to rest primarily with the health of the world population or the environment; profitability and financial returns for investors are key drivers. Nevertheless, even though these massive businesses are so powerful, individuals are even more powerful and the power of the purse and our day to day choices, of what we choose to buy to eat and drink, can change all.

What **we choose to buy** for drinks, snacks, breakfast, lunch, tea and dinner **shapes the world** that we live in.

31) Earth, water, air and climate change

Clean and healthy air and water, healthy soils capable of providing food rich in nutrients, landscapes, rivers, seas and oceans which have not been despoiled, healthy eco-systems with abundant biodiversity – together these provide a vision of a legacy for future generations. Action to safeguard these basic necessities and mitigation, and adaptation to the effects, of climate change on food production and food security, now and in the future, is the responsibility of all of us.

32) "Decisive Action Needed Now"

UN Food and Agriculture Organisation Climate Change, Agriculture and Food Security document 2016 states that it "cannot rule out the possibility that climate change at some more, or less, distant point in the future may make it impossible to feed humanity… Societies at large need to take decisive action, today, to mitigate climate change in order to avoid the risk of serious food insecurity…..Changes will be needed on the consumption side - decreased demand for emission and resource-intensive food products will help to accelerate the transition towards sustainable agriculture, as well as promoting climate change mitigation" (ref 237, p.10).

Key messages from the FAO (2016):

1. Until about 2030 global warming is expected to lead to both gains and losses in the productivity of crops, livestock, fisheries and forestry, depending on places and conditions.
2. Beyond 2030, the negative impacts of climate change on agricultural yields will become increasingly severe in all regions.
3. In tropical developing regions, adverse impacts are already affecting livelihoods and food security of vulnerable households and communities.
4. Because agriculture, land-use and forestry make a considerable contribution to GHG emissions, they have a significant mitigation potential.

33) Can we achieve the Bradford on Avon goal to be Carbon Neutral by 2050?

Environmental Stewardship agreements for Wiltshire and Swindon cover 52% of the total area and 66% of the farmed area. This includes a significant area of organic and Higher Level Stewardship agreements. Only 1% of the land in Wiltshire is used for vegetable production. (Wiltshire Intelligence Network Land Use and Development, ref 242).

The National Farmers Union (NFU) says that total GHGs from agriculture have now fallen 19% since

1990 and ammonia emissions fell 28% between 1990 and 2013. Under agri-environment schemes in England over 30,000km of hedgerows have been planted and restored, providing habitat and shelter for a wide range of wildlife. There has been an increase in biodiversity on farmland, an increased number of ponds, bats and birds and otters have returned to rivers in all English counties from near extinction in the 1970s. There has been a significant increase in plant species richness in arable and horticultural land since the 1990s. Sowing temporary grassland with a clover mix can be cost-effective and beneficial to environmental protection. In 2014 78% of livestock holdings had sown some or all of their temporary grassland with a clover mix. Farmers have created 37,000km of grass margins which help reduce pollution of water and protect hedgerows from agricultural activities. Agriculture accounted for just 0.7% of water abstraction in England and Wales in 2012. Surveys from 2013 and 2014 suggested that more than one-third of all farmers have diversified into renewable energy with solar PV, biomass heating and wind power remaining the most popular technologies. (NFU, '*Farming and the environment*', 11 April 2017, ref 330). Other data are less encouraging: for example, regarding farmland bird numbers: "The long-term decline of farmland birds in the UK has been mainly driven by the decline of the 12 species known as the 'specialists' that are restricted to, or highly dependent on, farmland habitats....Between 1970 and 2014, populations of farmland specialists declined by about 70% whereas farmland generalists have declined by about 10%. In 2014 the farmland bird index is less than half (46%) of its 1970 level" (UK 2015 National Statistics, ref 85).

An increasing number of farmers and producers in the Bradford on Avon area over recent years have moved to an agroecological approach, where they are putting fertility of the soil, and care for the environment at the heart of their business. Some have organic or biodynamic registration, others are producing food using organic principles, or using minimal chemical inputs. Supplying to local outlets with a short supply chain, or direct to the public, gives the producer a higher percentage return for their products and makes their business more viable, whilst increasing employment for local people and bringing back the heart to the countryside and our locality. Alternatives to corporative distribution and retail systems have been gradually developing and strengthening over recent decades. Shorter supply chain routes between producer and consumer include farm shops, markets, independent shops selling some local produce, box schemes, Bradford on Avon Community Agriculture scheme and, most recently, a local Food Assembly where a wide range of local and seasonal products from producers in the area, can be ordered and paid for online and then collected once a week from the assembly point. Some pubs, restaurants, hotels and cafes source local food and some partly grow their own. Some indicate the producer where the food has been sourced - a practice that it would be good to see more widely adopted. Many of our local producers have won awards for the quality and flavour of their food and drink. Bradford on Avon is a Fairtrade town and Christine's Sustainable Supermarket has won the silver award for the best Fairtrade Retailer of Multiple Products in the South West in 2017, and an award in the Best Fairtrade Advocate section.

Waste, energy and transport comprise a larger component of the GHG emissions in the food chain than the emissions from agriculture and need to be addressed. Many businesses in the food system and consumers in the Bradford on Avon area are focussing on generating renewable energy, or using a 100% renewable energy supplier. Transport emissions will hopefully be decreased by a strengthening of local food supply chains. Gradually more people are turning to electric vehicles. Many producers are doing really well with minimising waste and 'closing the loop' by using residues and waste appropriately to feed livestock, return as organic matter to the land, or sending, otherwise unusable, waste for bioenergy production. Although there is still much to be done, it is very encouraging to see how active some businesses, organisations and individuals have been in developing good environmental practices.

As emphasised throughout this document, buying well-produced food and drink, is more difficult when finances are very constrained. Government has a central role to play in ensuring that everyone can afford good food and that farmers and producers can make a living out of producing food in an environmentally-friendly way that also ensures high nutritive value.

The Soil Association's ***Food for Life*** (FfL) Award framework for schools has been considered by CFB to have great benefits and we have been delighted that some of the schools in the area and other public sector catering services are enrolled. For schools, it includes education for pupils in growing, cooking and healthy

eating and also includes standards in school catering with a structure and guidance to promote environmentally-friendly sourcing of school food. Wingfield School along with The Mead Primary School, has achieved the FfL Silver Award, as has Bath Spa University, one of our nearest Universities. This is a wonderful achievement. It is very disappointing that one school in our community area has withdrawn from this excellent framework because of budgetary constraints. Many other schools in the area have also been doing very good work with high quality school dinners and education around growing and cooking. We would welcome central funding to bring all schools nationally into the **Food for Life** framework.

There is much happening locally that is very positive, which enthuses people and fosters a sense of connection with the local community, with the land that our food comes from and the wider environment. Valuing well-produced food and the protecting of the natural environment need to go hand in hand. Looking after the environment and reducing greenhouse gas emissions is a step by step process that we can contribute to in our everyday lives through small as well as large choices, decisions and actions. It can enhance our lives.

34) Dietary Recommendations for low environmental impact

Dietary Recommendations from the UN Food and Agriculture Organisation 2016
"There is increasing evidence that dietary patterns with low environmental impacts are also healthier. Common features of such diets are:

- the diversity of foods eaten
- a balance between energy intake and energy expenditure
- the inclusion of minimally processed tubers and whole grains along with legumes, fruit and vegetables
- meat, if eaten, in moderate quantities
- healthy diets also feature dairy products in moderation, unsalted seeds and nuts, small quantities of fish and aquatic products, and very limited intake of processed foods that are high in fat, sugar or salt and low in micronutrients"
  (FAO and FCRN, 2016) (ref 237, p.86)

The British Government Buying Standards add further positive recommendations about priorities for sourcing more sustainable food -

- Seasonal produce
- Seafood from sustainable sources
- Fairly traded produce
- Food produced to high environmental standards, such as organic or integrated production (eg LEAF - Linked Environment and Farming)
- High animal welfare
- UK or equivalent production standards

Glaring opportunities (!) to decrease emissions and achieve a more sustainable food and drink system:

Decrease waste food.
Decrease waste of energy.
Switch to a 100% renewable energy supplier. Install own renewable energy generation.
Urgent need for non-farmland sourced "green" alternatives to gas, electricity, diesel and petrol.
Decrease transport emissions.
Avoid: air-freighted foods; "thirsty" products from areas of water stress.
Decrease excess packaging.
Replace some drinks during the day with tap water. Use a refillable water bottle when out, rather than buying bottled drinks.
Improve ability of soils to act as a sink for GHGs - choose food, if possible, that has been produced

without, or with minimal, chemicals and where organic matter levels in soil are at good levels.
Buy from producers or outlets that you trust.
Reduce pressure on land use, including (urgently) drivers for land use change such as loss of land rights for small farmers and destruction of rainforest and other sensitive habitats, by reducing over-consumption and waste, and, for example, checking for responsible sourcing, such as palm (RSPO) and soy products (RTSS).
Base core diet on well-produced British, preferably local, food.
Eat a varied nutritious diet, which is as inclusive a possible.
Ask for British (local if possible) pasture-fed dairy produce and meat, preferably from animals grazed on species rich grassland.
Choose fish rated 1-3 by the Marine Conservation Society (with 1 being the highest environmental rating).
Choose Fairtrade products (with high ethical and environmental standards).
Eat rice only occasionally (high methane emissions and water use).
Choose vegetables and fruit produced with minimal chemicals.
Make well-produced food a high priority in personal/family finances.
Make a high priority of the UN advice to have only a very limited intake of processed foods that are high in fat, sugar or salt and low in micronutrients.
Cook from scratch as often as possible. Batch cooking and freezing some portions and sharing meals can help reduce energy consumption and time. (Can be cheaper and no more time-consuming than processed food.)
Education - nutrition, growing, cooking. Children usually enjoy growing food and cooking with parents and grandparents.
Eat round a table whenever possible - said to have multiple benefits.
Value and enjoy well-produced food. Take an interest in how it is produced. Ask questions.
It should be easy to make a difference, if we all give a little extra thought to what we eat and drink.

35) One size does not fit all

Many documents from the international organisations give generalised data based on global statistics. However in seeking to reduce greenhouse gas emissions, it is likely that one size does not fit all. As well as some global and national measures, local and individual solutions need to be found.

36) After Word

This is clearly an immense subject. An attempt has been made to take a wide view, which has led to a number of questions regarding some of the prevailing discourse. This document is offered as a basis for discussion.

The overarching objective of the Climate Friendly Bradford on Avon (CF) Sustainable Food and Drink Group (SFADG) is to establish a sustainable food and drink culture in the Bradford on Avon Area, so that we can all have confidence that what we eat and drink is of sound environmental and ethical provenance.

It is clear that positive change can happen quickly if the will is there: it does not need to take decades. Ultimately sustainably sourced food and drink is in everyone's interest.

African proverb quoted by the IAASTD:

"If many little people, in many little places, do many little things,
they will change the face of the world"

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Ros Edwards
On behalf of CFB Sustainable Food and Drink Group

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• Lingering doubts about the adequacy of efficacy and safety testing, or regulatory frameworks for testing GMOs [e.g., CWANA Chapter 5; ESAP Chapter 5; Global Chapter 3, 6; SSA 3];
• Suitability of GMOs for addressing the needs of most farmers while not harming others, at least within some existing IPR and liability frameworks [e.g., Global Chapter 3, 6];
• Ability of modern biotechnology to make significant contributions to the resilience of small and subsistence agricultural systems [e.g., Global Chapter 2, 6]."
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Appendix

Alternatives to Plastic when Refrigerating and Freezing

Or: Frugal Use of Resources!

To start with: **there is no perfect answer**! Just living creates carbon. So when talking about alternatives to using plastic in the fridge or freezer to store food, it is impossible to use anything that doesn't add to our carbon footprint. So this article provides ideas for you to choose the best alternatives for you and for the environment.

First there is REUSING: (the appendix contains links to many of these ideas, both suppliers and articles on their use)

- ✓ Reuse plastic containers that come with food you buy such as spreads, soup and yogurt pots. Those pots that come with lids are especially good and can be used to store your own soups, meals, stewed fruit etc.

- ✓ Reuse plastic food bags. Don't reuse ones that have contained raw meat or fish as you don't want to encourage contamination, but many people have carefully washed bags that have held bread, fruit and the like to no ill effect and plastic bags can have long lives.

- ✓ How about trying to reuse wax cartons? Carefully washed to remove any food, these could prove to have another use in them – see the 'rodalesorganiclife' article below.

- ✓ Create small portions of food by using muffin tins or ice cube trays, then once frozen transfer to a larger container/bag and these will then take up less 'plastic' space.

- ✓ Use your pottery or china bowls in the refrigerator and cover the food with a plate or a reusable cover such as cotton bowl covers or stretch food covers, rather than one use cling film – see Lakeland, eBay, etc.

- ✓ Reuse aluminium trays and dishes, e.g. from take-away meals, and wash sheet foil for reuse.

- ✓ Reuse all the plastic containers you already have!

Then there are ALTERNATIVES to plastic:

- ✓ Instead of buying new plastic containers when yours have finished their useful life, try using glass.

Some containers come with glass lids, others with silicone ones. Most jars are suitable in the refrigerator, such as reusing jam/pickle jars. However jars for freezing need to be strong, like Kilner or Mason jars, to withstand the low temperatures. It is important to only fill them to 70% capacity as food expands when frozen and glass will crack if put under pressure from expansion. Care needs to be taken with any glass of-course to avoid breakages.

- ✓ Or try stainless steel containers – very expensive though.
- ✓ A new product is Buzzcloth – made from organic cotton, beeswax and jojoba oil. It is reusable, washable and crushable so that you can seal it around food for keeping sandwiches fresh and for use in the refrigerator.
- ✓ Recycled aluminium foil is available – some feel that aluminium should not be used in food storage for health reasons – see the links below.

If you have anything to add to this please let us know and we can include it in this article for future use.

Appendix of articles and suppliers:

- If You Care recycled aluminium foil:

http://www.hawthornhealth.com/general-health-c7/all-products-c2319/discontinued-if-you-care-recycled-aluminium-foil-10mx29-p69903

Plus other products like paper sandwich bags, parchments and baking sheets

- Stainless steel containers

https://www.notonthehighstreet.com/greentulip/product/u-konserve-stainless-steel-nesting-trio

- Glass containers

http://weangreen.eu/

http://glasslockusa.com/

http://www.costco.co.uk/view/p/glasslock-premium-food-storage-boxes-18-piece-set-403780

http://www.smartkart.co.uk/glasslock-premium-food-storage-boxes-18-piece-set/?gclid=CIvdg7m7z9MCFYYp0wodlt0Jzg

https://www.wayfair.co.uk/Food-Storage-Containers-l1289-c1860291-O10368~Glasslock.html

http://www.pyrexuk.com/

- **Silicone, silicon, plastic lids?**

http://plasticisrubbish.com/2012/05/17/what-is-silicone/

- **Foodwrap**

http://www.buzzcloth.com/

https://www.amazon.co.uk/s/?ie=UTF8&keywords=bees+wrap+sandwich&tag=googhydr-21&index=aps&hvadid=165016328876&hvpos=1t1&hvnetw=g&hvrand=4569248657811876144&hvpone=&hvptwo=&hvqmt=b&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9045611&hvtargid=kwd-270320428295&ref=pd_sl_67m1vgjw4m_b

http://www.uncommongoods.com/product/beeswax-food-saving-wrap?aw_cid=280606497&aw_aid=44143285409&aw_dev=c&aw_loc=9045611&aw_key=%2Bbees%20%2Bwrap&aw_mtype=b&aw_net=s&aw_ad=190065378611&aw_pos=1s4&aw_shopid=&aw_prod_partid=&gclid=CNHForK_z9MCFY0V0wodr2EKkw

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http://www.smarticular.net/en/how-to-freeze-food-in-glass-jars-and-without-plastic/

http://www.attainable-sustainable.net/plastic-free-freezer-storage/

http://luvoinc.com/blog/how-to-freeze-food-without-plastic/#yjh5X1uPyBhZLmXo.97

http://www.huffingtonpost.com/the-conversation-africa/why-you-shouldnt-wrap-you_b_9622502.html (possible effects of wrapping food in aluminium foil)

https://wellnessmama.com/91772/aluminum-safe/