Sustainability and Food Consumption: The role of protein and diet diversity across Europe

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Food sustainability and food security. For the continued viability of present-day society sustainability is a clear prerequisite.

Definitions of sustainability are manifold, generally founded on its three familiar pillars: ecology, economy and society. These may - or they may not - include issues such as human health, equity, and animal welfare. As a human activity, food production is one of the main drivers responsible for environmental degradation and resource depletion, if only due to its sheer bulk, appropriating major shares of all ice-free land (35%), freshwater (70%) and energy production (20%). Since global production and consumption continue to increase, the associated environmental impacts tend to increase in tandem. Consequently, what was sustainable yesterday is not necessarily sustainable today, let alone tomorrow. Sustainability depends on the ambient circumstances. Therefore, it is evidently a moving target, and the rate of change is mind boggling.

Due to continued growth of both world population (Fig. 1) and per capita income, a major proportion of global environmental pressure is generated by food-related activities. The environmental impacts of food production include pollution and resource depletion on all scale levels from local to global. Prominent examples include impacts on biodiversity (Nierenberg, 2006), climate change, and human health (McMichael et al., 2007). This clearly illustrates the importance of anthropogenic impacts on the environment by food production.

From the perspective of food security the take-home message has been aptly summarised thus: "Continuing population and consumption growth will mean that the global demand for food will increase for at least another 40 years. Growing competition for land, water, and energy, in addition to the overexploitation of fisheries, will affect our ability to produce food, as will the urgent requirement to reduce the impact of the food system on the environment. The effects of climate change are a further threat. But the world can produce more food and can ensure that it is used more efficiently and equitably. A multifaceted and linked global strategy is needed to ensure sustainable and equitable food security ..." (Godfray et al., 2010).

In the next four decades we will face an unprecedented dual challenge of global food security and global food sustainability. By 2050, a world with 2.3 billion more people will need 70% more food (Bruinsma, 2009). Simultaneously, the environmental impacts of food production must be reduced. Taken together, this outlines the daunting task of quartering the impacts per tonne of food within the next 40 years.

Prioritizing environmental impacts

In order to get to grips with sustainability, the groundbreaking paper by Rockström et al. (2009) summarizes and ranks the most important anthropogenic environmental issues (Table 1). Further analysis indicates a) that food production is an important driver underlying all of these impacts, b) that the top three environmental impacts, i.e. biodiversity loss, nitrogen cycle disruption and climate change, are strongly interlinked - rather than independent of one another, and c) that protein is the linking pin - rather than carbohydrates and calories (Aiking, 2011). Below, the underlying causes will be revisited in detail. In addition, animal protein production appropriates a disproportionate share of natural resources, making it ideally suitable as a goal for significant reduction. Reducing animal protein consumption will therefore benefit both food security and food sustainability (de Boer and Aiking, 2011).

TABLE 1. RANKING ENVIRONMENTAL IMPACTS (BOUNDARY VALUE FOR SUSTAINABILITY = 1).

RANK	ENVIRONMENTAL IMPACT	CURRENT STATUS
1	Rate of biodiversity loss	→10
2	Nitrogen cycle disruption	3,45
3	Climate change (carbon cycle disruption)	1,1-1,5
4	Phosphate cycle disruption	0,77-0,86
5	Ocean acidification	0,81
6	Land-use change	0,78
7	Freshwater use	0,65
8	Stratospheric ozone depletion	0,50

Source: Rockström et al. (2009).

So far, food production has been able to keep up with population growth mainly by increasing the yield per hectare (primarily by increasing irrigation and fertiliser application), and protein production by intensifying animal production. The latter resulted in problems with human and animal health, as well as a decrease in animal welfare, as is evident from a string of food scares (including BSE, foot-and-mouth disease, swine fever, avian influenza, Q fever, EHEC) and an obesity epidemic. Resistant bacteria (e.g. MRSA, ESBL) result from antibiotics used in intensive livestock production (Johnson et al., 2009; Price et al., 2012). Since prophylactic addition to feed was forbidden in the EU in 2006, however, therapeutic use for livestock increased. At any rate, the latter amount is considerably (ca. fivefold) higher than is used in human health care. Research by the European Medicines Agency shows that in the EU antibiotics resistance kills about 25,000 people and costs about 1.5 billion Euros per annum (EMEA, 2009). Consequently, protein production is also strongly implied in impacts on human and animal health.

Why protein and nitrogen are pivotal

Producing enough food for 10 billion people seems technologically feasible (Evans, 1998), but doing so without compromising sustainability - both by pollution and by resource depletion - is a formidable challenge (Tilman et al., 2002). Dietary protein is nutritionally crucial (Smil, 2002), since nitrogen is an indispensable constituent of DNA, RNA and protein. Smil (2001) calculated that before large-scale application of fertilisers, world population was capped at ca. 3 billion people by nitrogen limitation, less than half the current number. The tremendous energy input in nitrogen fertiliser alone is responsible for 37% of all energy expenditure in US agriculture (Lang et al., 2009: p. 193) and causes significant climate change (Smil, 2001; Erisman et al., 2008), thus linking the disruption of the nitrogen cycle to the disruption of the carbon cycle, i.e. climate change.

Invariably, a large proportion of fertiliser nitrogen is lost to the environment. In 2005, just 17% was consumed by humans in crop, dairy and meat products, and the global nitrogen use efficiency of crops is decreasing consistently. In parallel, ammonia emissions from manure are rising. Much of this "reactive nitrogen" is transported by air to be deposited in nitrogen-limited ecosystems. There it leads to unintentional fertilisation of ecosystems (such as several types of forest) unable to cope with this nutrient inflow, which is one of the leading causes of terrestrial biodiversity loss (Townsend and Howarth, 2010). Pollution from livestock enterprises impacts both terrestrial and aquatic ecosystems (Raney et al., 2009: p. 59). In addition, fertiliser run-off in coastal ecosystems may lead to algal blooms and dead zones, with inevitable repercussions on aquatic biodiversity (Erisman et al., 2008). Thus, the nitrogen cycle is strongly linked to biodiversity loss everywhere.

In short, nitrogen is crucial to terrestrial and aquatic biodiversity loss, climate change, human health and many other issues (McMichael et al., 2007; Erisman et al., 2008; Townsend et al., 2010). Anthropogenic contributions to the natural carbon cycle are 1-2% (by mineral fuel combustion), but to the natural nitrogen cycle 100-200% (by production of artificial fertiliser). Consequently, Rockström et al. (2009) rank the impacts of this nitrogen cycle disruption in between those of biodiversity loss and carbon cycle disruption, because the current status of biodiversity loss exceeds their proposed sustainability boundary by a factor of more than 10, that of nitrogen cycle disruption by a factor of 3.45, and that of carbon cycle disruption (climate change) by a factor of 1.1-1.5 (Table 1). Since nitrogen cycle disruption has strong impacts on both biodiversity and the carbon cycle, protein production is the pivotal link between the three top environmental issues in the Rockström ranking (Aiking, 2011).

Disproportionate environmental impacts of animal products

Within the realm of food, meat takes a unique place for its conventionally high social status (Beardsworth and Keil, 1997). While the world population doubled during the second half of the 20th century, its appetite for meat increased fivefold, resulting in 40% of the world grain harvest to be fed to livestock (Evans, 1998). Table 2 illustrates this effect of increasing average income. While another 50% will be added to the world population during the period 2000-2050, it is estimated that another 100% will be added to meat production. This projected doubling holds for animal food products in general, since dairy production is projected to increase from 580 to 1043 million tonnes (Steinfeld et al., 2006: p. 275). Important increases in meat consumption are projected in China, for example, and in dairy consumption in India.

Conversion of plant protein into animal protein is a metabolic process optimised for animal survival. Turning protein from feed crops into animal protein for human consumption is inherently inefficient, however. This makes intensive animal protein production responsible for a disproportionate share of environmental pressure (Gilland, 2002; Steinfeld et al., 2006). Thus, 6 kg of plant protein is required to yield 1 kg of

TABLE 2. WORLD POPULATION AND MEAT PRODUCTION 1950-2050.

YEAR	WORLD POPULATION (BILLION)	MEAT PRODUCTION (BILLION KG)
1950	2,7	45
2000	6,0	229
2050	9,1	465

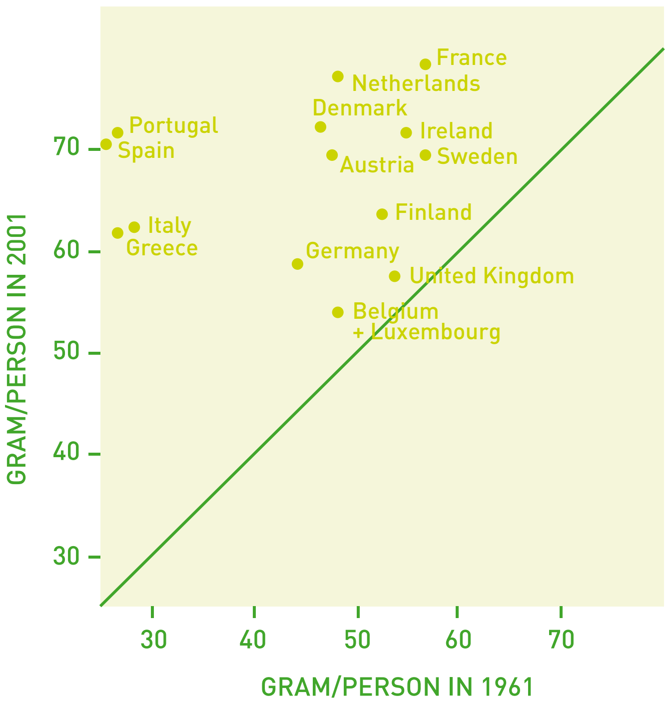
Source: Steinfeld et al. (2006).

meat protein, on average (Smil, 2000; Pimentel and Pimentel, 2003). Consequently, a mere 15% of protein and energy in these crops will ever reach a human mouth (indirectly), and 85% are wasted. In 2000, for example, 942 and 617 million tonnes of grains were required for food and feed, respectively (Msangi and Rosegrant, 2009: p. 27). Of the latter, therefore, over 500 million tonnes are essentially wasted for human consumption and, moreover, turned into emissions (such as from manure) polluting the terrestrial and aquatic environment, resulting in biodiversity loss. In addition to 40% of the grain harvest, some 75% of soy is fed to livestock, with similar resource losses of some 85%. Evidently, the actual protein conversion efficiency depends on the type of animal under consideration. Poultry and pigs are more efficient protein converters than beef cattle, but when grass-fed, the latter do not appropriate feed crops. In a watershed report on the environmental impacts of livestock production, the FAO are explicitly addressing both resource depletion and pollution (Steinfeld et al., 2006). At any rate, animal protein production without exception is playing a crucial role in all three of the "planetary boundaries" that have already been overstepped by humanity, i.e. biodiversity loss, nitrogen cycle disruption and carbon cycle disruption (Rockström et al., 2009).

Protein diversity in European diets

As indicated above, dietary protein is indispensable. The proportion of animal protein in the diet is primarily income dependent (Keyzer et al., 2005), but the actual protein source also depends on cultural aspects (Beardsworth and Keil, 1997). GDP turned out to be a relatively insignificant driver in EU-15 and, in spite of diet globalization, in Europe the differences between nations are much larger than anticipated (Table 3). The high plant protein consumption observed in Greece, Italy and Spain is not surprising, considering that both Greek and Roman cultures were built on agriculture. In fact, the East Mediterranean diet of the early 1960s, characterized by high consumption of plant protein and low consumption of animal protein (Grigg, 1999), may not only be relevant for a healthy population but also for a sustainable system of food production and consumption. However, according to our analysis (de Boer et al., 2006), plant protein supply in EU-15 remained virtually unchanged during 1961-2001 but, in contrast, animal protein supply increased everywhere, and by far the most in Mediterranean countries (Fig. 2).

FIGURE 2. ANIMAL PROTEIN IN 1961 AND 2001



Source: de Boer et al., 2006

Please note that the FAOSTAT-derived data sets used in Table 3 and Figure 2 illustrate national supply (= production + imports exports), which tends to be 20-30% above actual consumption (Smil, 2000). Total protein supply was relatively constant across EU-15 (Table 3), ranging between 95.8-118.9 g/day. Compared to current guidelines, however, this is approximately 160% or more of RDI values, which are 50-60 g/day (Health Council of the Netherlands, 2001). Consequently, there is ample room for a diet that is less dependent on animal proteins and, therefore, attractive from a sustainability perspective.

Table 3 illustrates that the fish/seafood food group is responsible for the largest variation between countries. That Portugal is the top fish consuming nation (15.7 g/d of fish-derived protein) can be anticipated, but that Ireland is the second from the bottom (3.4 g/d) is most surprising for a country with such plentiful marine and freshwater resources. FAO data for other years indicated that this was no anomaly. In fact, it has been well-established that strong diet trends originating in deep-rooted differences between the classic (Roman and Greek) versus the Germanic and Anglo-Saxon cultures (Montanari, 1994) survived for many centuries. According to this historical work, the Venerable Bede (a British monk living 673-735 AD) wrote down "that the Anglo-Saxon pagans did not fish even though their seas and streams abounded in fish", explaining the low fish consumption of Ireland on a cultural basis, dating back to the Great Migration of Germanic Peoples (400-600 AD). The mere fact that such cultural preferences have remained intact across 1500 years clearly shows that making current consumers change their diets into a more sustainable direction will require considerably more effort than just education, or even gentle "nudging".

TABLE 3. MAIN SOURCES OF DAILY PROTEIN SUPPLY (G/CAPITA) IN EU-15 COUNTRIES:
LOWEST AND HIGHEST LEVEL PER CATEGORY IN 1999.

PROTEIN SOURCE	LOW LEVEL	COUNTRY	HIGH LEVEL	COUNTRY
Cereals	17,6	The Netherlands	35,5	Italy
Potatoes	1,6	Italy	5,5	Portugal
Pulses	←0,1	(4 countries)	3,7	Spain
Tree nuts	←0,1	(12 countries)	1,7	Greece
Oil crops	←0,1	(10 countries)	1,6	Germany
Vegetables	2,1	Finland	7,7	Greece
Fruit	1,0	Finland	2,5	Greece
Stimulants (coffee)	←0,1	Greece	2,6	Denmark
Alcoholic beverages	←0,1	(6 countries)	2,6	Ireland
Beef & Veal	4,6	Germany	10,4	Italy
Mutton & Goat	0,1	Finland	5,4	Greece
Pork	6,7	United Kingdom	22,7	Austria
Poultry	4,6	Germany	10,4	Italy
Offal	0,5	Denmark	9,6	Ireland
Milk (incl. cheese)	13,9	Spain	28,2	The Netherlands
Eggs	2,1	Ireland	5,0	France
Fish/Seafood	2,9	Austria	15,7	Portugal
Total plant protein	32,6	The Netherlands	53,3	Greece
Total animal protein	55,3	The United Kingdom	76,2	France
Total protein	95,8	Germany	118,9	Portugal

Source: de Boer et al. (2006).

Consumer communication and policy aspects

Food has become more affordable, as it is now less than half as expensive in real terms as it was in 1960. To a large extent this is a result of increases in yield per hectare. Even per capita, the world now produces 40% more food than forty years ago. However, in the next forty years another 70% more will be required. In addition, climate change and accompanying degradation of land and water resources are to intensify in future. Consequently, world market price projections of the International Food Policy Research Institute (IFPRI) show that world grain prices will increase 30-50% before 2050, and that meat prices will increase an additional 20-30% beyond current high levels (Msangi and Rosegrant, 2009). In their November 2010 Food Outlook (FAO, 2010) the FAO warned that food prices were likely to rise beyond the 2008 peak values. In January 2011, just a few months after publication, those predictions materialised and the end does not seem in sight yet. In fact, one of the authors of the Foresight report (Foresight, 2011), Lawrence Haddad, warned in an interview: "The last three to four years have seen alarming spikes in hunger. The price rises in 2007-8 were actually quite modest in a historical context but it led to 100 million more people going hungry. Bigger prices rises could wipe out the development gains of the last 20 years and promote violent conflict and migration." (Carrington and Vidal, 2011). Therefore, Western politicians, industry and consumers should be much more proactive, because if they don't, a transition towards less animal protein is likely to be brought about by rising prices, which will hurt the poor and increase hunger. A voluntary and timely drive towards more sustainability and equity is called for.

European countries such as the UK (DEFRA, 2009), Sweden (LV, 2009) and the Netherlands (LNV, 2009) have published policy reports addressing food security, sustainability and health (such as obesity, CVD, diabetes) combined. The food industry is focussing on health and increasingly on sustainability. In spite of the social status of meat, some European consumers are prepared to avoid meat (de Boer et al., 2009), but if they do, health issues provide much stronger incentives than environmental issues (Beardsworth and Bryman, 2004). Consequently, consumer communication is crucial, because their "framing" is fundamentally different from governmental and industrial policymakers (de Boer et al., 2011). There is no "one size fits all". Evidently, a huge range of differences exist between countries and between distinct groups of consumers within countries. In summary, making European consumers change their diets into a more sustainable direction will not be a piece of cake.

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Conclusions Scientific

Global food demand is increasing rapidly and so are the environmental impacts of production. Inevitably, the prices of food will rise also, primarily hurting the poor. To weather the storm, the goal can no longer be simply to maximize productivity, but to optimize across a far more complex landscape of production, environmental, and social justice outcomes (Godfray et al., 2010). Whether for environmental reasons, exploding prices, or - more likely - a combination, a trend reversal towards diets containing less animal protein in Western countries seems not just strongly recommendable, but inevitable. At least some consumers seem ready to play their parts (de Boer et al., 2009). The positive impacts on sustainability will largely depend on the extent of a diet shift. In actual reality, a new equilibrium between plant products and animal products is likely to be critically dependent on economic variables such as income and relative and absolute prices of the commodities under scrutiny, i.e. meat, fish, milk, eggs, cereals and soy.

References available on
www.alprofoundation.org