Environment: Science and Policy for Sustainable Development

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/venv20

The Sustainability Challenges of Our Meat and Dairy Diets

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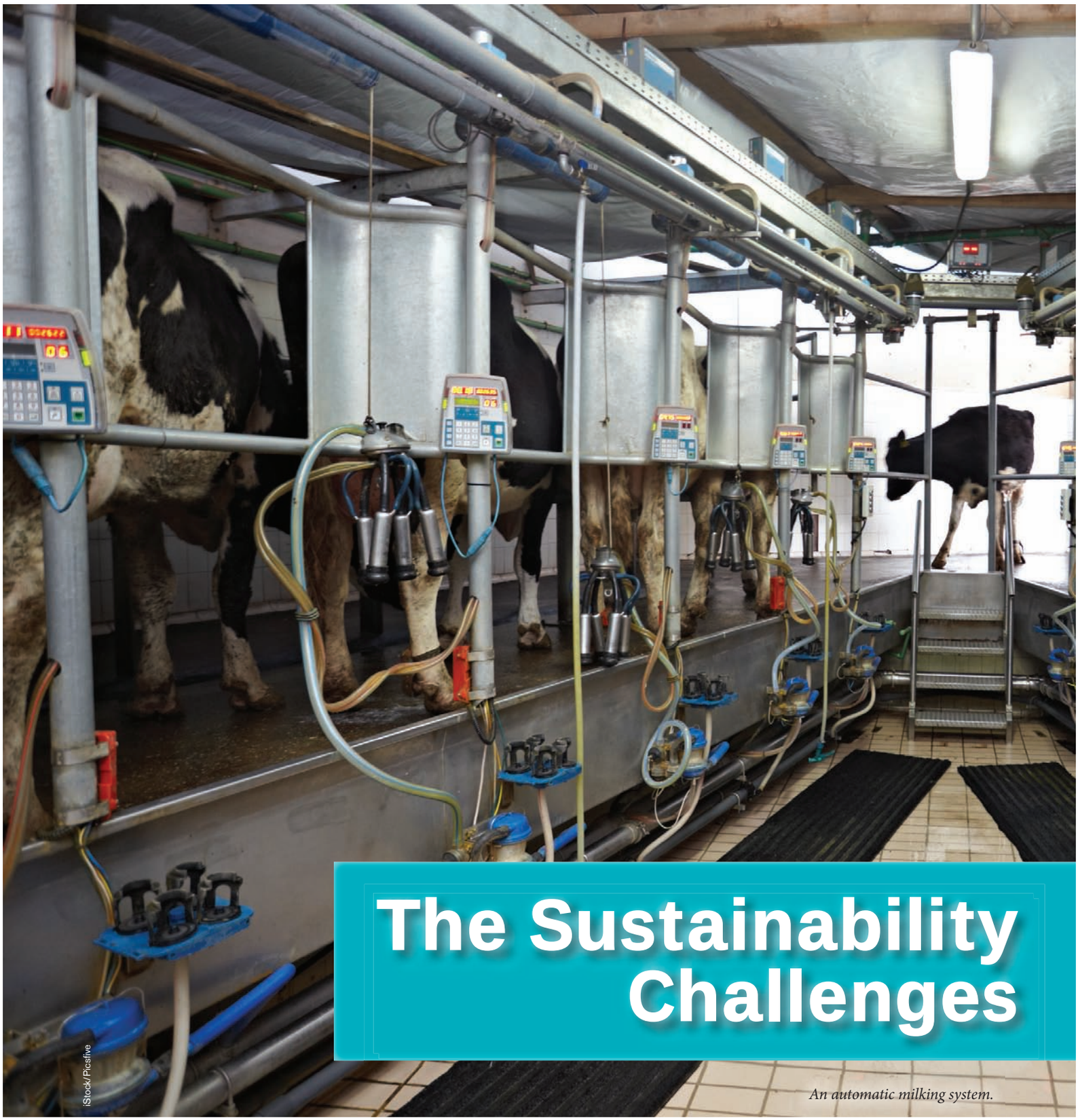
Published online: 23 Apr 2015.



The Sustainability Challenges

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An automatic milking system.

by
Susanne
Stoll-Kleemann
and Tim O'Riordan

Continuing high consumption of livestock products in nearly all developed countries, and increasing demand for livestock-based foods in large transition economies, are creating serious problems of prolonged and persistent environmental and social degradation. These problems are further exacerbated and affected by climate change and

# of Our Meat and Dairy Diets

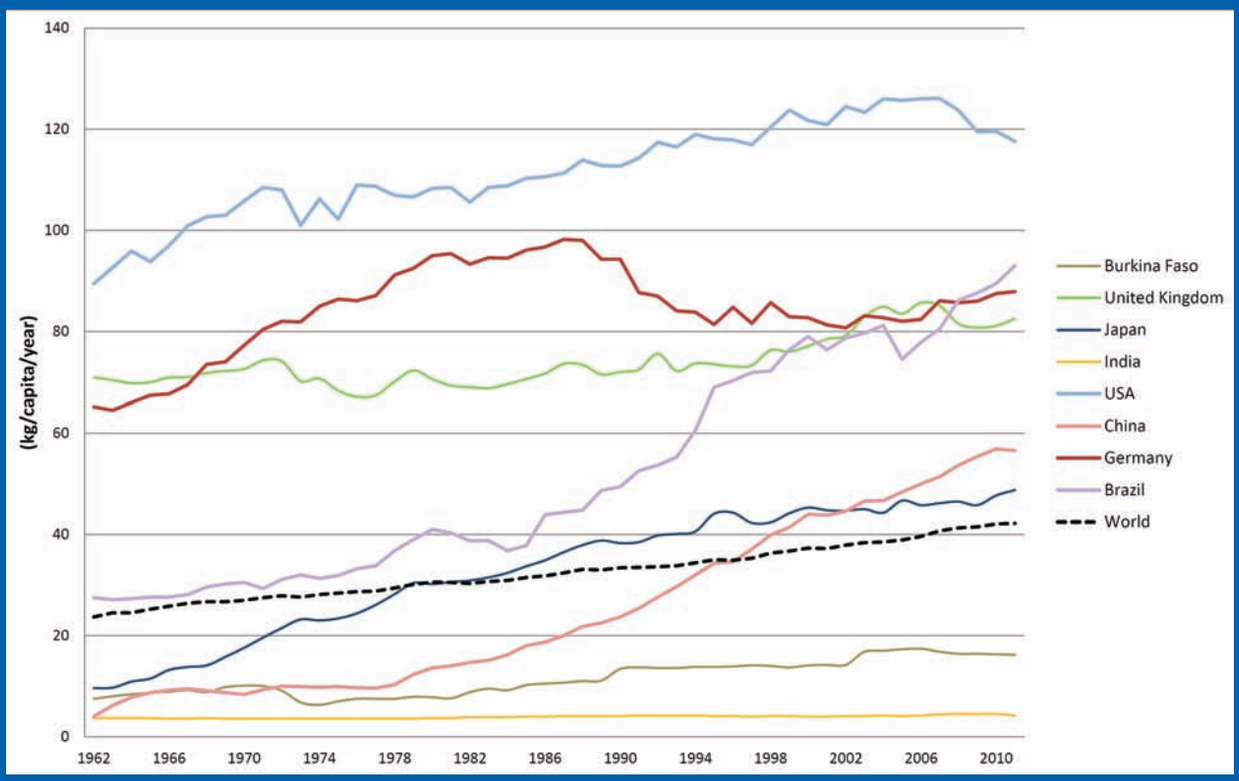
risks, biodiversity loss, water stress, and water pollution. How do the associated socioeconomic aspects such as food security and personal health, together with impoverishment and displacement of communities, associated with livestock production consumption figure into the challenges? And how can we change livestock production consumption to reduce future environmental destruction going forward?

> *"It is among the 21st century's greatest challenges to eat within planetary limits yet giving health, pleasure and cultural identity."*[1]

The Demand for Livestock-Based Diets

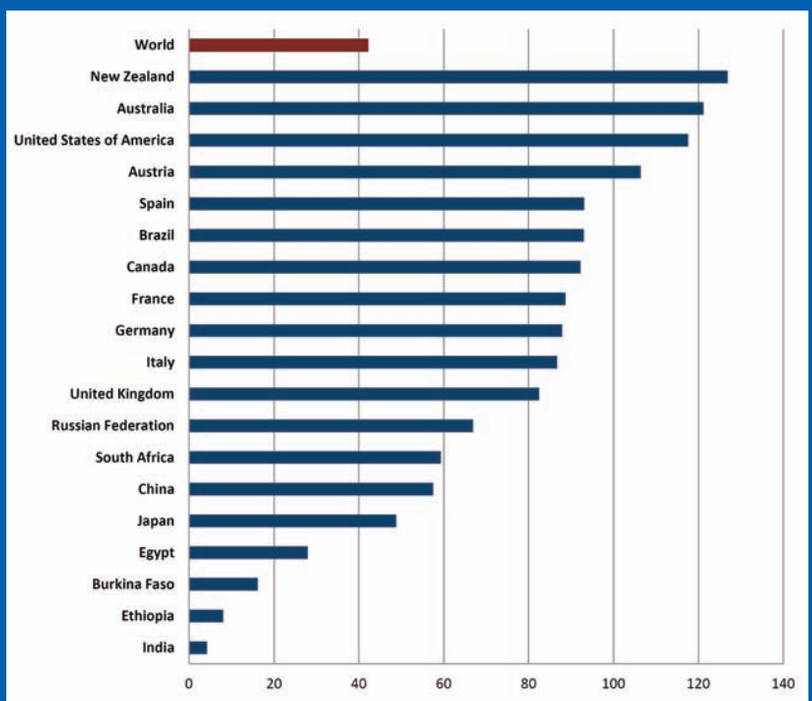
Worldwide meat production has tripled over the last four decades and expanded by 20% in the past decade.[2] According to the United Nations (UN) Food and Agriculture Organization, worldwide consumption of meat has increased from 23 kilograms to 42 kilograms per-capita between 1961 and 2009 (see Figure 1).[3] The current per-capita consumption in Germany of 88 kg per year is more than twice the global average. The U.S. per-capita annual meat consumption is around 117 kg; this is some 30 times higher than in India, with the lowest per-capita annual meat consumption of 4 kg (see Figures 2 and 3).[3] That people in developed countries are, on average, consuming nearly double the quantity of meat products compared to their counterparts in developing countries is due to lowering prices of meat and dairy products, competitive pricing wars and aggressive marketing by the supermarket chains, unsustainable eating habits, and unreflective attention to both the personal and ecological effects of diets in general. Global demand for meat (as well as dairy products) is expected to

Figure 1. Development of Meat Supply Over Time



Source: Uta Schmidt; FAOSTAT 2014

Figure 2. Meat Supply in 2011 (kg/Capita/Year)



Source: Uta Schmidt; FAOSTAT 2014

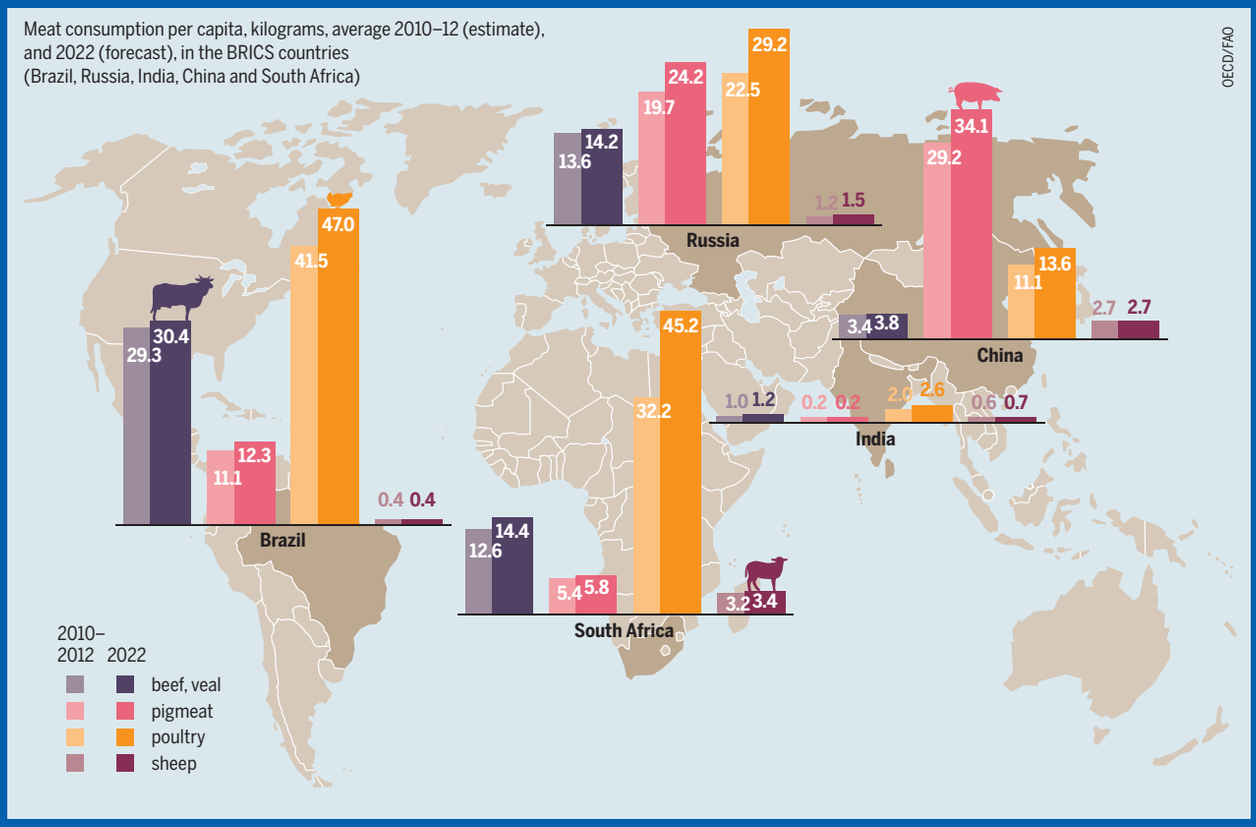
accelerate, if left unchecked, driven by rising incomes and rapid urbanization. The *Meat Atlas* points out that

> *The middle classes around the world eat too much meat. Not only in America and Europe but increasingly in China, India and other emerging countries as well. Consumption is rising mainly because city dwellers are eating more meat. Population growth plays a minor role.*[4 (p. 8)]

The Environmental Effects of Producing and Consuming Meat

Around 70% of agricultural land and 30% of the global land surface are used by animal production, though there are considerable regional variations. Livestock rearing has significant

Figure 3. Changes in Livestock Product Consumption in BRICS Countries 2010–2012 to 2022



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repercussions on virtually all aspects of environmental well-being.[5] We begin with the effects on biodiversity. Nowadays this is regarded as so extensive as to constitute one-sixth of global species loss.[6] Biodiversity losses may be socially as well as environmentally harmful; for example, the expansion of soybean production in former rain-forested areas in South America has led to widespread loss of local incomes.[7] We then turn to climate risk. Meat production is associated with 18% of global greenhouse gas emissions arising from methane linked to animal digestion, to deforestation of carbon rich trees, and to the vast amounts of artificial fertilizers required to feed cattle housed in highly concentrated numbers.[5] In addition, serious deterioration of water quality regionally is linked to the discharges of ammonia

Applying anhydrous ammonia: a major problem for soils and water.

and nitrous oxides connected with intensive cattle feeding. Displacement of indigenous ways of living and disruption of long settled property rights give rise to widespread poverty and social breakdown.

The Impacts of Meat Production and Consumption on Biodiversity

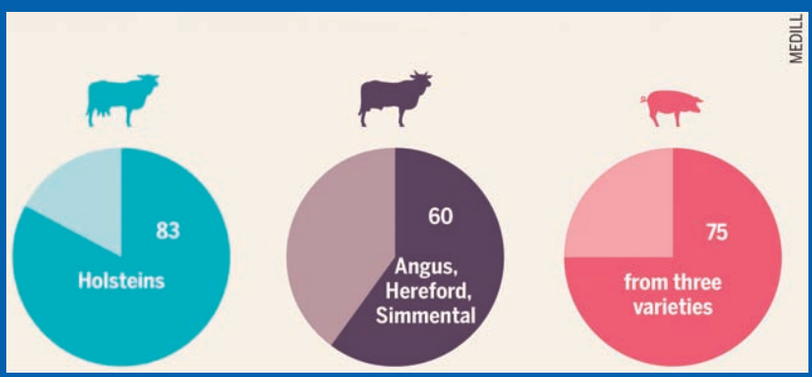
The livestock sector is the leading cause of reduction of biodiversity. A recent report by the Zoological Society of London, in concert with WWF International,[8] claims that in the past 40 years 52% of all the world's wildlife has disappeared, with agriculture, urban development, and food energy production identified as the major threats.

According to Westhoek et al.,[9] 30% of biodiversity loss is linked to livestock production, owing to its contribution to deforestation and land conversion, overgrazing and degradation of grassland, and desertification.[10] Much of this disturbance and degradation arises through unsustainable growing of animal feed based on monocultures. About half of birds worldwide are currently threatened by the destruction caused by these practices.

The UN Food and Agriculture Organization (FAO)[5 (p. xxiii)] states that increases in livestock production threaten some 306 of the 825 terrestrial ecoregions and 23 of 35 global biodiversity hotspots. A study from Australia demonstrates that the beef industry has the largest relative potential contribution to the impact on terrestrial biodiversity in Australia, by both the area covered and the nature of the impacts.[11] This includes the area of native vegetation cleared for grazing, the impacts of overgrazing and trampling, the amount of grain used in high-density feedlots, and the quantity of greenhouse gases emitted.

The reduction of farm animal breeds in favor of specially bred productive livestock add to global species losses. Nine percent of original farm animal breeds have already disappeared, and more than 20% of the remaining breeds are presently threatened with extinction[12] as they are replaced by more productive stock, as shown in Figure 4. Almost one-quarter of the 8,000 unique farm animal breeds are presently at risk, primarily due to the transition to a high-technology industrial livestock sector. A few high-yielding breeding strains also dominate the production of chickens, goats, pigs, and sheep.[13] This narrow genetic base of commercial animal breeds increases their vulnerability to pests and diseases. It also poses long-term risks for food security because this transition shuts out options for rearing adaptive species capable of responding to future environmental circumstances, market conditions, and societal needs, all of which are highly unpredictable. In the face of climate change, the long-term sustainability of livestock-maintaining communities, as well as industrialized livestock systems, is jeopardized by the loss of farm animal genetic diversity.[13]

Figure 4. Dominating the Livestock Industry: Market Share of Breeds for Milk, Beef, and Pork Production in the United States, by Percentage



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The Greenhouse Gas Footprint of Meat and Dairy Products

High meat and dairy product consumption also has serious implications for the future of the world's climate. Animal waste releases methane (most of that from enteric fermentation by ruminants) and nitrous oxide (mostly from manure), greenhouse gases that are 30 and 300 times, respectively, more potent than carbon dioxide. Emissions from meat production globally account for 2,836.8 million tons of CO_2 equivalent and those of milk production 1,419.1 million tons of CO_2 equivalent.[14] According to Foley et al., agriculture overall is responsible for 30–35% of global greenhouse gas emissions, largely from tropical deforestation and methane emissions. The estimated emissions attributable to livestock collectively are estimated at 18%.[5,15] The main sources of emissions are feed production and processing (45% of the total), outputs of greenhouse gases (GHGs) during digestion by cows (39%), and manure decomposition (10%). The remainder is attributable to the processing and transportation of animal products.[16] Livestock are also responsible for almost two-thirds (64%) of anthropogenic ammonia emissions, which contribute significantly to acid rain and acidification of ecosystems.[5]

Beef and dairy products are very emissions-intensive livestock products responsible for the most emissions, accounting for 65% of the total GHGs emitted by livestock.[10] Average global estimates suggest that, per unit of protein, GHG emissions from beef production are around 150 times those of soy products, by volume, and even the least emissions-intensive meat products—pork and chicken—produce 20–25 times more GHGs than plant-based foods (see Table 1).[17]

From this table we see that the production and consumption of animal-based foods is associated with higher GHG emissions than plant-based foods. Scarborough et al.[18] have calculated the difference in dietary GHG emissions between self-selected meat-eaters, fish-eaters, vegetarians, and vegans in the United Kingdom. The

Table 1. GHG Emissions From Food Production

Food types	g CO_2eq/kcal	g CO_2eq/g-protein
Ruminant meat	330	62
Recirc. aqua	160	39
Dairy	74	9.1
Pork	61	10
Poultry	52	10
Butter	33	n/a
Eggs	24	6.8
Rice	14	6.5
Vegetables	14	n/a
Tropical fruits	9.1	n/a
Temperate fruits	6.4	n/a
Oil crops	7.2	n/a
Wheat	5.2	1.2
Maize	3	1.2
Legumes	1.9	0.25

Source: Tilman and Clark (2014)[17]

A milk tanker truck.

iStock/Andygwve

Table 2. Total Water Footprint (WF) of Selected Food Products			
Food item	**m^3/ton**	**liter/kcal**	**liter/g protein**
Beef	15,415	10.19	112
Sheep/goat meat	8763	4.25	63
Pig meat	5988	2.15	57
Butter	7692	0.72	0
Chicken meat	1440	3.00	34
Eggs	3265	2.29	29
Milk	1020	1.82	31
Nuts	9063	3.63	139
Pulses	4055	1.19	19
Oil crops	2364	0.81	16
Cereals	1644	0.51	21
Fruits	962	2.09	180
Starchy roots	387	0.47	31
Vegetables	322	1.34	26
Source: Mekonnen and Hoekstra (2012)[21]			

results indicate that dietary GHG emissions per capita in self-selected meat-eaters are approximately twice as high as those in vegans.

Hedenus et al. conclude that dietary changes are crucial for meeting the 2°C target and that only by also assuming reduced meat and dairy consumption do we find agricultural emission levels that do not take more than half of the total emission space in 2070.[19 (p. 89)]

Meat Consumption and Water Stress

Meat production and consumption play an important role in depleting and polluting the world`s scarce freshwater resources. Agriculture in general accounts for 92% of the freshwater footprint of humanity.[20] In a recent global study, Mekonnen and Hoekstra show that animal products have a large water footprint relative to crop products and also account for some 29% of water pollution.[21] The major sources of water pollution are from animal wastes, antibiotics and hormones, chemicals from tanneries, fertilizers and pesticides used for feed crops, and sediments from eroded pastures.[21]

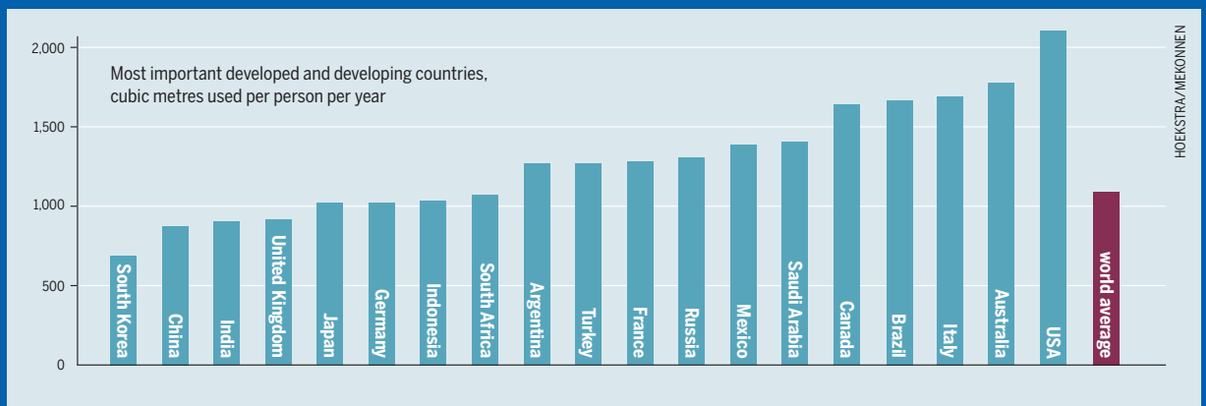
As described in Table 2 and Figure 5 (water used for meat production in G20 countries), the livestock sector is a key player in increasing water use, mostly because the water is needed for the irrigation of feed-crops. For example, it takes 15,415 liters (15.4 cubic meters) of water to produce just 1 kg of beef.

In the United States, livestock is responsible for an estimated 55% of erosion and sediment, 37% of pesticide use, 50% of antibiotic use, and one-third of the loads of nitrogen and phosphorus into freshwater resources. Livestock also affect the replenishment of freshwater by compacting soil, reducing infiltration, degrading the banks of watercourses, drying up floodplains, and lowering water tables. Livestock's contribution to deforestation also increases runoff and reduces dry-season flows.[5]

Meat Consumption, Hunger, and Food Insecurity

High meat consumption causes social conflicts and aggravates the prob-

Figure 5. Water Used for Meat Production in G20 Countries



Source: Heinrich-Böll Foundation 2014, Hoekstra/Mekonnen; CC-BY-SA Heinrich Böll Foundation, Friends of the Earth Europe

lem of hunger. Worldwide, 80% of the area of all agricultural land is used for fodder, with 44% of the world's grain harvest diverted to industrialized meat production.[22] In the European Union, two-thirds of the agricultural crop land is used for animal feed.[22] Competition for scarce land between "food and fodder" is proving to be dramatic for global nutrition. This is because plants that could be used for human consumption directly for nutrition are diverted to the (indirect) process of meat production. To produce 1 kg of animal protein, 6 kg of plant protein are necessary.[23] Eighty percent of the worldwide soy harvest is used for fodder.

West et al. conclude that "If current crop production used for animal feed and other nonfood uses (including biofuels) were targeted for direct consumption, some 70% more calories would become available, potentially providing enough calories to meet the basic needs of an additional 4 billion people (the 'diet gap')."[24 (p. 326)] The United States, China, Western Europe, and Brazil account for 26, 17, 11, and 6% of the global diet gap, respectively.

Tscharntke et al. point out in this context that global food security is not directly linked to global food production and argue instead that the predicted rise in meat consumption should be reduced via shifting diets so as to increase food security.[25]

A closely related social problem in this context is that of displacement. Small-scale farmers, for example, in Latin America, are expelled from their land, which is given to a large soy plantation to grow large amounts of animal feed to export to industrialized countries. In Paraguay, more than 100,000 small-scale farmers have, often forcibly, been expelled from their soy farms since 1990. Likewise, there are human and land property right infringements in Brazil, where already 1% of the population owns more than 46% of the land area. In Argentina, more than 50% of the soy plantations are owned by 2% of the companies. Fifty-seven percent of the companies possess 3% of the used area.[4,7]

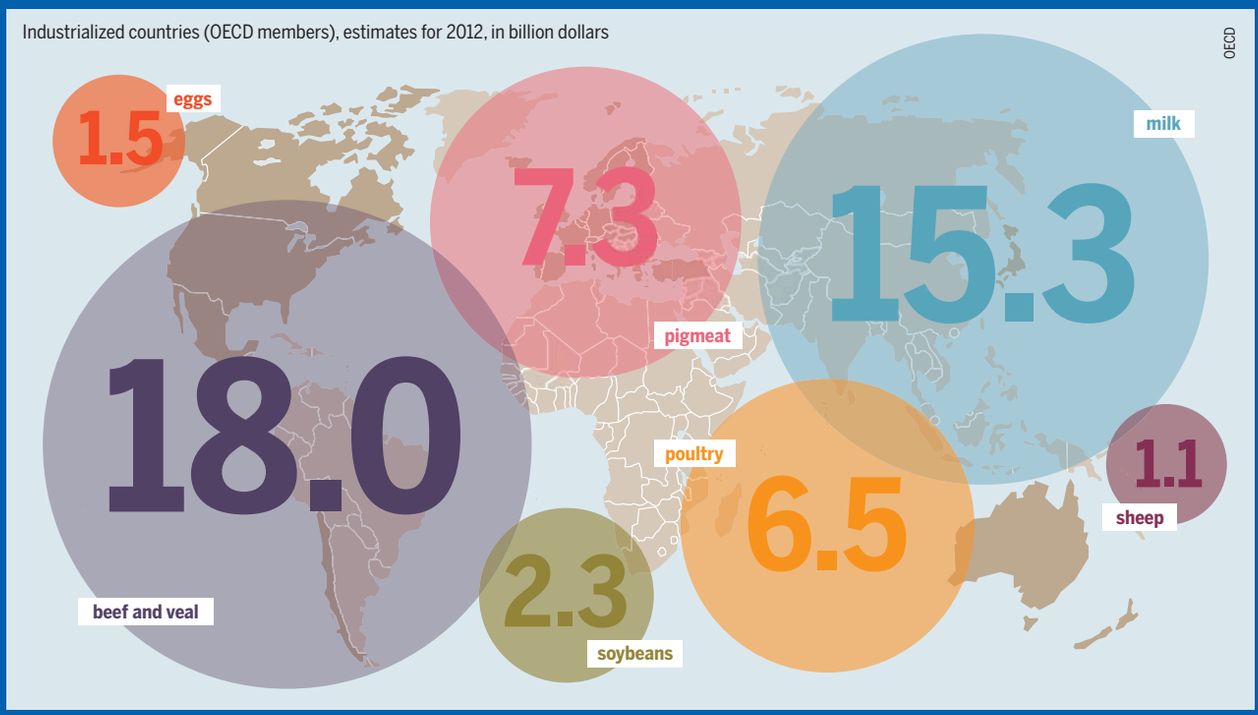
iStock/alffoto

A farmer organizes mass soybean harvesting at a farm in Campo Verde, Mato Grosso state, Brazil.

Since the entrance of African countries into the World Trade Organization (WTO), cheap meat exported from Europe has led to destruction of local markets of Africa. European poultry firms export frozen chicken pieces at a very low price because these pieces have less or low profitability in Europe, where chicken breast is preferred and the rest of the animal is regarded as "waste." Before export to Africa the feed industry used to take all this protein-rich material and use it to make feed. Following the ban because of the bovine spongiform encephalopathy (BSE) epidemic (the European Union [EU] restricted the use of meat and bone meal as animal feed in 1996), Africans were discovered as new customers. After covering the cost of shipping to West Africa the food can be sold for two-thirds less than the locally raised chickens.[26] Local producers cannot compete. The wholesale prices of imported chicken pieces are so low in Accra or Monrovia that they would cover only half of their production costs back in Europe. So far, no developing country has managed to impose a ban on such dumping practices through the World Trade Organization. In areas where the imports have not yet penetrated, poultry is a stable source of income for many small farmers, especially women. But in Ghana and Benin the local broiler industry has "all but died out."[26 (p. 45)]

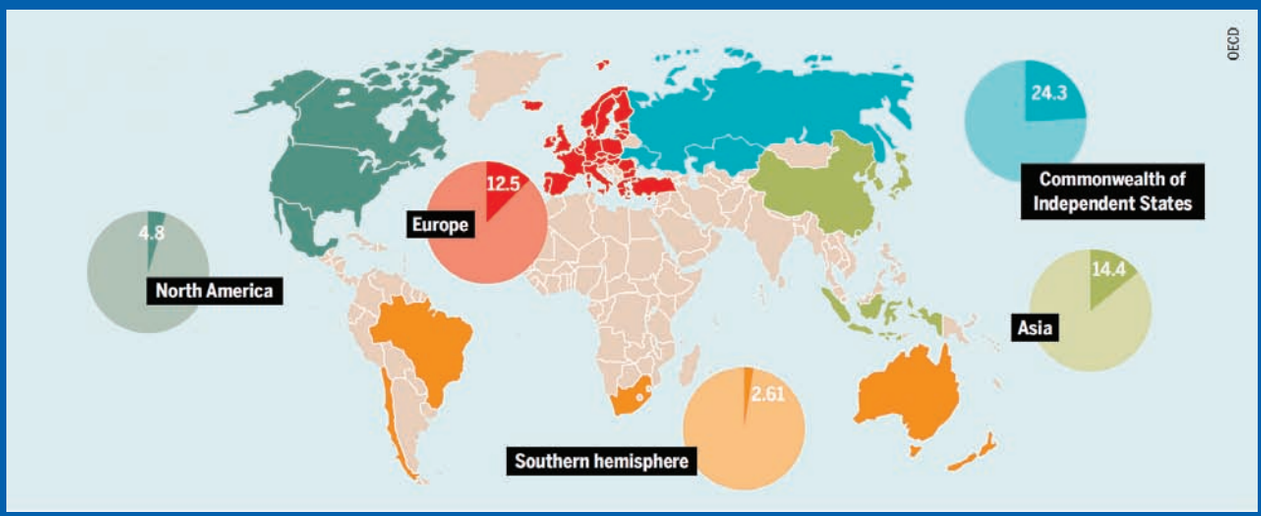
While around 1.3 billion people worldwide still depend upon animal husbandry, most of them in developing countries, the number of livestock graziers is falling.[27] The livestock sector is becoming industrialized and

Figure 6. Subsidies for Meat Production From Industrialized Countries (OECD Members), Estimates for 2012, in Billions of Dollars



Source: Heinrich-Böll Foundation 2014, OECD; CC-BY-SA Heinrich-Böll Foundation, Friends of the Earth Europe

Figure 7. Percentage of Gross Farm Receipts From Governments for Livestock, by Region, Classification by OECD, 2010–2012



Source: Heinrich-Böll Foundation 2014, OECD; CC-BY-SA Heinrich-Böll Foundation, Friends of the Earth Europe

Box 1. Meat Consumption and Human Health

High meat consumption has a proven record in harming human health. We only need 56 g/day (adult men) and 46 g/day (adult women).[39] This amounts to around 10–35% of the overall calorie intake in the United States of around 91 g/day (adults).[40] Meat and eggs are the main sources for protein in Americans diets.[39 (p. 38)] The American Dietetic Association acknowledges that plant protein can meet requirements when a variety of plant foods is consumed and energy needs are met.[41 (p. 749)] This is confirmed by Young and Pellet (1994), who found that "mixtures of plant proteins can serve as a complete and well-balanced source of amino acids for meeting human physiological requirements."[42 (p. 1203)]

Overall, diets with a high share of animal products (including meat and dairy products and eggs) can lead to overweight and obesity, coronary heart disease, hypertension, diabetes, gout, and cancer. Additionally, the consumption of meat from intensive livestock farming (more than 99%) results in antibiotic resistance and in the intake of pharmaceutical residues and stress hormones. Many scientific studies show that vegan and vegetarian diets not only contribute preventively to a healthy and longer life but also have a curative impact on many diseases.[43] Tilman and Clark[17 (p. 3)] summarize dietary comparisons between meat eating and non-meat eating. They conclude that switching to a non-meat diet can lead to a reduction in type 2 diabetes from 16 to 41%; in cancer from 7 to 13%; in coronary heart disease from 20 to 21%; and in overall illness from 0 to 18%.

Meat consumption increases health risks because of high saturated fat and cholesterol content; high energy density; carcinogenic compounds found in processed meat and formed during high-temperature cooking; a compound called L-carnitine in red meat that may promote plaque buildup in the arteries; and the lack of health-protective plant foods in high-meat diets.[44]

Negative health effects of meat consumption include antibiotic resistance for humans. The Worldwatch Institute (2013)[45] states that "antibiotics that are present in animal waste leach into the environment and contaminate water and food crops, posing a serious threat to public health." In 2011 more than 1,700 tons of antibiotics was delivered by pharmaceutical concerns to veterinarians in Germany, nearly twice as much as were used for human medicine (about 800 tonnes),[46] including antibiotics that are critically important for humans. As a consequence, mortality due to infections exceeds 25,000 deaths per year.[47]

meat-producing companies are expanding. The profits of these companies are the results of high direct and indirect subsidies, the direct ones from the state while the indirect ones are built on the environmental damage caused by factory farming and the use of livestock feed—costs that society pays instead of the companies.[27]

The European Union offers subsidies for fodder crops and reimburses up to 40% for new animal housing. Taxpayers also pay for the costs of transport infrastructure, such as ports needed to handle the feed trade. In many countries, meat is subject to a reduced level of value-added tax. In addition, low wages in abattoirs make it possible to produce meat cheaply.[27] Figure 6 estimates the subsidies for livestock based products paid by industrialized countries (Organization for Economic Cooperation and Development [OECD] Members). In sum, $52 billion is paid to subsidize fodder and animal products. Pig meat is supported by $7.3 billion and poultry by $6.5 billion. In Europe, 12.5% of the gross receipts of farms for livestock is paid by the government. The Commonwealth of Independent States even supports livestock farms by nearly one-fourth (24.3%) of their gross farm receipts. Asian livestock farmers still receive 14.4% of their gross receipts from their government. In Figure 7 these percentages of gross farm receipts from governments for livestock are depicted by region, as classified by the OECD, 2010–2012.

Box 1 shows the consequences of meat consumption on human health.

Overcoming Barriers

An important general lesson from this article is that the livestock sector has such deep and wide-ranging environmental and social impacts that the topic of shifting diets toward more vegetarian and vegan meals (coupled with reducing the 20–25% of food waste in the whole food chain) should rank as one of the leading focal themes for sustainability policy: Successful efforts here can produce large and multiple payoffs. Indeed, as societies continue to evolve, it is likely that severe local and global environmental considerations, along with human social and health issues, will become the dominant policy challenges. The *Meat Atlas* observes in this context, "Diet is not just a private

matter. Each meal has very real effects on the lives of people around the world, on the environment, biodiversity and the climate that are not taken into account when tucking into a piece of meat."[4]

Barriers to Changing Meat Consumption Toward Achieving More Sustainability

In light of the many social and environmental impacts of the production and consumption of livestock products, it is notable that governments seem unwilling to tackle the links between diet and sustainability.[10,28] Moreover, efforts to moderate meat and dairy consumption are largely absent from mitigation strategies and campaigns by major environmental groups to raise awareness of the planetary footprint of livestock products or encourage dietary change.[28]

One reason for not changing diets toward more sustainable foods may be *benign ignorance*. Tobler et al. in a large-scale survey found that meat consumption is regarded by many as least environmentally damaging.[29 (p. 68)] They found that the more frequently people consumed meat, the smaller they perceived the environmental benefit of reducing meat consumption to be.[29 (p. 678)]

A second reason is *deliberate ignorance*, or what psychologists call cognitive dissonance. According to Melanie Joy, in the case of meat consumption there is a disconnection between behavior and more universal values. People tend to view their preferences as rational and any deviation as offensive.[30] Joy also draws our attention to the "missing link" between meat on the table and its live animal source, which protects us from uncomfortable dissonance.[30 (p. 17)] Furthermore, she claims, people justify their behavior and deny any underlying moral positions related to meat consumption by arguing that meat eating is "normal" because it is exhibited by the majority.[30 (p. 105)]

A third barrier is the *cultural significance of meat* in many societies of the world. Food is highly symbolic and taste is largely acquired through culture.[30 (p. 16)] Lang perceives a culture that allows, "in the name of progress, choice and individual rights, to develop an approach to food policy which saw no limits. Thus the mismatch of human and environmental health is mediated by economics and culture. There is a push and a pull to this situation; people choose but do not want to accept the longer-term consequences."[1 (p. 21)]

A fourth barrier is the *economic dimension*: For example, in the United States, "animal agribusinesses is a $125 billion industry controlled by handful corporations, which include agro-chemical and seed companies, which produce pesticides, fertilizer, seeds and other products; processing companies that buy and process livestock; food manufactures that process the meat into specific products such as frozen entrees; food retailers, including supermarkets and restaurant chains; transportation systems, including railroads and shipping lines; pharmaceuticals; farm equipment such as tractors and irrigators."[30 (p. 38)]

Susanne Stoll-Kleemann

Vegan supermarket in Berlin, Germany.

Vegan restaurant in Berlin, Germany.

Politicians fear that attempts to reduce meat and dairy consumption would likely mobilize protest from these powerful interest groups.[10] Joy observes: "The power of animal agribusiness is such that the industry has become intertwined with government, blurring the boundary between private interests and public service."[30 (p. 89)] Food policy is inevitably a very sensitive political issue.[1]

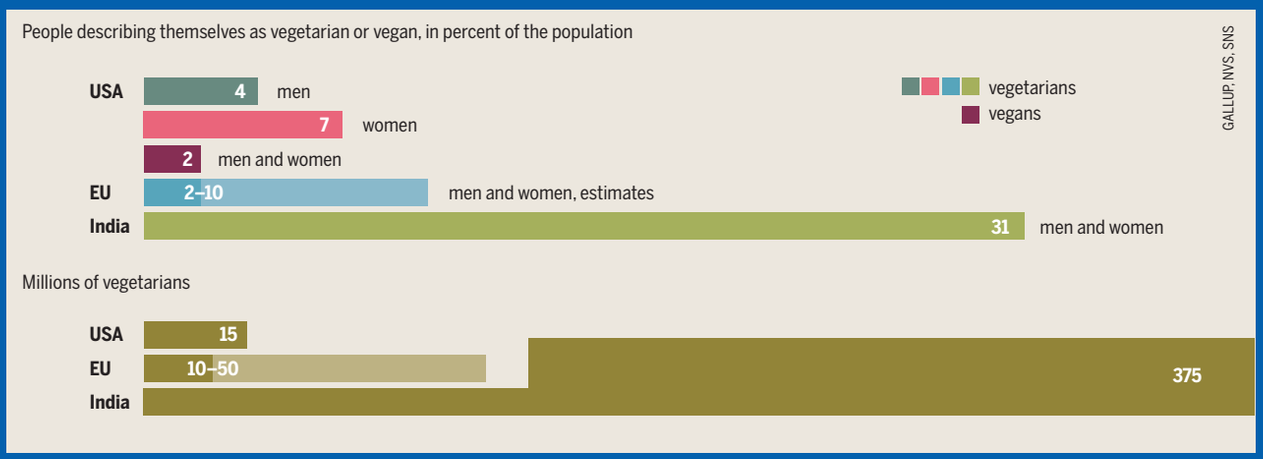
Ways Forward

A classic approach for reducing meat consumption from intensive livestock farming would be to increase prices by removing avoidably damaging subsidies. In sustainability terms, economic, social, and environmental externalities should be built into prices by selective taxing of and/or fees for resource use, inputs, and wastes.[31] We are entering an economic world where the notion of the "externality" is no longer valid.[32] The issue here is the strength and reliability of the scientific evidence and longer term prognoses for the well-being of people and the planet of continuing with such externalities.[33] Unless the case for raising the price of food to take into account the many costs outlined in this article is carefully made with strong proof, politically speaking, such a strategy would be dynamite. There would also be significant social justice repercussions, even though in principle the extra levies could be directed to low-income healthy diet shifts, which could prove to be of considerable benefit to many low-income households.

There is growing evidence that the cultural meaning of meat consumption during the 21st century is changing, at least among some groups of the population. There are studies for several European countries showing that young people of higher educational level prefer a vegetarian diet, with those who eat meat shifting to lower meat diets.[34] A new lifestyle is emerging in which a vegetarian and increasingly even a vegan diet is a central part of the social identity. The infrastructure is adapting itself to this new demand by vegan supermarkets and restaurants (see the photos on this page and the facing page). From a policy perspective this suggests more sensitive

Advertisement for vegan food, Berlin, Germany.

Figure 8. Vegetarians: A Growing Minority in the West, a Major Force in India



Source: CC-BY-SA Heinrich-Böll Foundation, Friends of the Earth Europe

targeting of environmental and health campaigns toward the very young—7 to 18 years old—who are increasingly predetermined to respond and to use social media to influence their friends and peers.[35]

Meat consumption strongly depends on sociodemographic variables where age, education, and gender are decisive. In India with its 375 million vegetarian/vegans, religion is an important factor (see Figure 8). Men consume twice as much meat as women and women are twice as often vegetarians as men.[34] Meanwhile, surveys in Germany show that high meat consumption is a phenomenon associated with the lower classes, so it can no longer be seen as prosperity indicator. This is confirmed on a global level by Leahy et al., who found out that vegetarianism slightly increases with income.[36] Yet in emerging economies, meat consumption is associated with revealing new levels of wealth, as is the case in China with its "growing, urbanizing and on average wealthier population, which increasingly demands more resource-intensive foods" like dairy and meat products.[37 (p. 9)]

Garnett observes that there has been too strong a focus on individual "conscious" behavior. She argues for a greater emphasis on social, economic, and technological influences on consumption along with more integrative and multidisciplinary approaches to influencing diets.[38 (p. 11)] Garnett continues, "Not all decisions may be conscious—habits, routines and external shaping influences play an important part. Attributes such as taste, convenience, "coolness" or price may well be prioritized over these other considerations."[38 (p. 12)]

Concluding Observations

What all of this adds up to is a paradox for sustainability science. One the one hand, the generic evidence of joint social and ecological degradation linked to meat and dairy production is overwhelming. On the other, there is huge structural resistance among the food corporations, the retailing outlets, and the regulators against addressing the connected approaches to information, moral guidance, price incentives, and health gains, linked to interfering with personal dietary behavior. Sustainability science thrives on the knowledge-brokering of partnerships, of widening the imagination, of strengthening moral certainties, and of encouraging leadership for change in the self and in valued others. Sustainability science is understandably cautious about taking on an advocacy role for justifiable fear of creating antagonism, particularly where deep-rooted habitual behavior is concerned, and where social identity is cherished.

What is at stake here is a deep conundrum. Diet is a function of habit, of social identity, of the history of personal relationships, and of the subtle manipulation of the advertising and food-linked industries over personal choices. What is particularly pernicious is the manner in which this manipulation is so pervasive and persuasive that it shapes values, behavior, and self-esteem. The consumer is anesthetized from the "wide and the long" repercussions of eating. In the context of these "dark forces," efforts to raise diet-altering awareness over the wider social and ecological repercussions of livestock production, particularly over the coming 25 years, for the most part have landed on stony social and moral ground. This conundrum is underscored by the tendency of researchers of global change not to change their own eating (and indeed air traveling) habits, so few provide the illumination of role models for colleagues and students.

Ingrained cultural habits die hard and lead to political headaches. The smoking controversy took 45 years (initiated by massive denial lobbying and science brokering by the tobacco industry) to reach the stage where regulations were put in place to require smokers to inhale out of doors and further away from public buildings. Attempts to provide healthy food in schools (e.g., the Food for Life Partnership in England, http://www.foodforlife.org.uk) failed completely to overcome huge parental resistance to create the conditions for more healthy food to be served in school cafeterias. Many schools did not have the catering facilities for fresh food preparation on site, so schools had to invest their very scarce budgets into transforming their catering facilities. Even today there is not agreed regulation over sustainable food production and catering (www.sacert.org/catering), let alone a "vegetarian first" catering policy.

The ultimate challenge of sustainability science is to grapple with these "dark forces" of interconnected self-replicating power and influence by bringing their moral and ecological dangers into the day-to-day public consciousness. This will involve engaging with the very forces that need to be "onside" for sustainability science to succeed. At the same time, sustainability science practitioners will have to learn to work with opinion formers, faith communities, educational leaders, and young people's role models slowly and purposefully to begin a process of moral reappraisal across the emerging citizenry of the planet. The potential tragedy is that the emergence of sustainability science is not in a position either to be recognized, or treated as legitimate or credible, just when its potential for success is most demanded. This is the oppositional setting for shifting diets, and for pursuing the editorial mission of *Environment Magazine*.

Healthy food in a school cafeteria.

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The authors would like to thank Uta Schmidt for encompassing logistic support and Dr. Bernhard Schmidt-Ruhe for fruitful discussions on several topics of the article.

NOTES

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2. In this article we focus on meat production and consumption for reasons of clarity because their sustainability consequences are complicated enough without considering other animal foods such as dairy products and eggs. But concerns about human nutrition do not end with the avoidance of meat products. From an environmental and social perspective nearly the same arguments apply: Egg-laying hens and milk-producing dairy cows need to be fed. Due to the high demand for animal products, fodder needs to be imported from countries where rain forests are cut to extend the area of production. As a consequence, biodiversity and the social and economic structures of local small-scale farmers are threatened. Greenhouse gases such as methane are also emitted during the digestion process in (dairy) cows. High levels of milk and egg consumption are harmful regarding human health. Excessive dairy consumption can cause obesity, prostate cancer, diabetes, and autoimmune diseases. A high consumption of eggs can lead to cardiovascular diseases (associated with elevated levels of cholesterol) as well as colon and breast cancer.

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