

Sirpa Sarlio

Towards Healthy and Sustainable Diets

Perspectives and
Policy to Promote the
Health of People and
the Planet



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Perspectives and Policy to Promote the Health of People and the Planet

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Chapter 1

“Sustainability Is More than Reducing Greenhouse Emissions”: Different Perspectives on Sustainability



1.1 History and Key Concepts

More and more studies on sustainable food production and diets have been published in recent years, even though many of the basic challenges and solutions to achieving them have been known for many decades. An early forerunner was Frances Moore Lappé's groundbreaking book *Diet for a Small Planet* published back in 1971. It pointed out that world hunger is caused not by a lack of food but by unfair and ineffective food policies that favor meat production over plant-based diets. Lappé advocated that people consume more food that was lower down the food chain and called for corporate and social responsibility to bring this about. She gave many practical examples of planning healthy meals for a small planet, calculated protein costs, estimated how to get sufficient protein with the least amount of calories, and showed how different plants could be combined to achieve good quality protein with an optimal combination of all the essential amino acids (Lappé 1971).

In 1986 Joan Gussow and Kate Clancy proposed that human diets should be based on environmental criteria as well as nutritional ones for which they coined the term “sustainable diet”. They argued that food choices should take into account not only their nutritional impact but also the long-term stability of the food system encompassing global justice, biological diversity, the efficient use of resources, avoiding fossil fuels, and using local, seasonal produce. Their guidelines for sustainable diets included eating a variety of foods; maintaining an ideal weight; avoiding too much fat, saturated fat, and cholesterol; eating foods with adequate starch and fiber; avoiding too much sugar and sodium; and drinking alcoholic beverages in moderation (Gussow and Clancy 1986). Most of this advice is still highly valid and recommended today.

The most commonly used definition of “sustainable development” is itself more than 30 years old. The frequently quoted definition comes from the report of the World Commission on Environment and Development, also known as the Brundtland Report (1987): “Sustainable development is development that meets the needs of

the present without compromising the ability of future generations to meet their own needs". The report emphasized that human action and the wider environment are inseparable. Many problems related to food production – food insecurity, overuse of soil and chemicals, unfair trading practices, and overuse of land – were identified as threats to sustainable development.

In 1988, a year after the Brundtland Report, the Food and Agriculture Organization (FAO) of the United Nations defined sustainable agricultural development as

management and conservation of the natural resource base, and the orientation of technological change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Sustainable agriculture conserves land, water, and planet and animal genetic, and is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable. (FAO 2014a)

Human health and nutrition are not explicitly mentioned in the FAO definition but are implicit in the reference to satisfying present human needs and those of future generations.

Subsequent guidance from FAO (2014a) on principles and approaches to sustainable food and agriculture regards agriculture as the primary interface between the world's natural and human systems. It describes agriculture as the mechanism that utilizes natural resources (land, water, biodiversity, forests, fish, nutrients, and energy) and environmental services so as to transform them into products (food, feed, fiber, and fuel) and associated economic and social services (food security, economic growth, poverty reduction, and health and cultural values). The guidance has a strong focus on maximizing productivity and production while minimizing agriculture's negative environmental footprint. Other potentially powerful approaches such as changing human consumption patterns towards more sustainable food choices are, unfortunately, not discussed.

Today, most definitions of sustainable dietary habits refer to diets that have low environmental impacts and that contribute to food and nutritional security and to healthy lives for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe, and healthy while optimizing natural and human resources (Burlingame and Dernini 2012).

One aspect common to almost all definitions of sustainability and sustainable diets is that the world is regarded as a system of interrelated elements, of relationships connected in time and space, in which knowledge is necessarily contextual. Foods and other products have a life cycle that has environmental impacts on other dimensions of human life such as the economy, social systems, and culture as well as on people's health and welfare. Such impacts, together with attempts to control them, affect socioeconomic groups differently. The sustainability of diets and food systems is therefore a broad and complex concept that can easily remain rather general or abstract; it seems understandable but is easily open to different interpretations.

Despite the many approaches to sustainability, it can be argued that environmental sustainability within planetary boundaries is the most important dimension because we all are dependent on the environment in which we live.

1.2 Acting Within Planetary Boundaries

The concept of planetary boundaries was first introduced in 2009 when a group of scientists identified and quantified nine planetary boundaries or “thresholds”; they estimated that humanity could continue to develop and thrive for generations to come as long as human activity stayed within them, but crossing the boundaries could generate abrupt or irreversible environmental changes (Rockström et al. 2009).

When the framework was updated in 2015, it stated that four of the nine boundaries had already been crossed. Climate change, biosphere integrity (including biodiversity loss and species extinctions), land use change, and altered biogeochemical cycles (of phosphorus and nitrogen) are considered to be at an increased or high risk of being irreversible. Moreover, two of them, climate change and biosphere integrity, are what scientists call “core boundaries”: significant alteration in either of them would drive the earth system into a new state (Steffen et al. 2015). These changes would more than likely have negative impacts on human health and well-being as well as on food security (Fig. 1.1).

By unsustainably exploiting non-human nature, we have been mortgaging, if not destroying, the health of future generations, if not their very existence. Environmental challenges such as climate change, ocean acidification, land degradation, water scarcity, overexploitation of fisheries, and biodiversity loss pose serious challenges to today’s human health as well as future planetary health (Whitmee et al. 2015).

The food system plays a crucial role in overstepping planetary boundaries. The mass production of meat and dairy products is a key driver of biodiversity loss, altered biochemical cycles, carbon cycle disruption, changes in land use, and the overuse of freshwater.

1.2.1 *Climate Change*

Climate change encompasses the long-term global warming of the Earth along with rising sea levels, faster ice melts, and changes in plant flowering times. Global warming – rapidly increasing average surface temperatures – is caused by human activities that increase atmospheric concentrations of “greenhouse gases”, particularly carbon dioxide, methane, and nitrous oxide, together with black carbon. The root of these activities is the extraction of fossil fuels, such as coal, oil, and gas from places where they have been buried for millennia, so as to burn them or turn into plastic. Higher global temperatures increase the likelihood of heatwaves, floods, droughts, and other extreme weather events.

Climate change and nutrition are closely linked. Prevalent systems of food production and consumption accelerate climate change, which in turn alters agricultural landscapes. Food systems account for an estimated 24% of greenhouse gas emissions (UNEP 2016). The main direct and indirect sources of greenhouse gases released through farming are from the conversion of land to agriculture, fertilized soils that

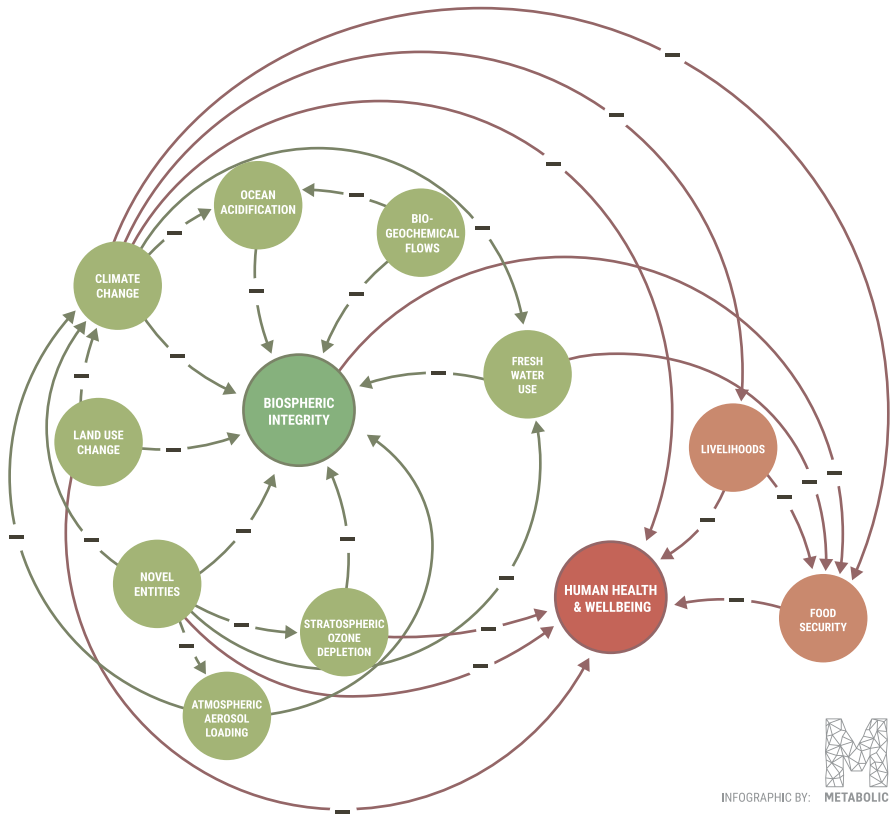


Fig. 1.1 Causal relationship between biophysical and humanitarian impacts (Source: Gladek et al. (2016). Reprinted by permission of the publisher)

produce nitrous oxide, cattle's digestive processes (enteric fermentation) that give off methane, biomass burning, and rice cultivation that yields methane (Reddy 2015).

Healthier diets, however, would be more climate-friendly. A study by Springmann et al. (2016a) suggests that eating more plant-based foods and less red meat could reduce food-related greenhouse gas emissions by 29–70%, as well as reducing global avoidable mortality by 6–10% because of fewer deaths due to coronary heart disease, stroke, cancers, and diabetes. The economic value of such health benefits is comparable to, if not in excess of, the environmental benefits. The greatest absolute health and environmental benefits would be in developing countries but the most per capita gains would be in more economically developed countries.

Conversely, however, climate change poses a serious threat to food production and human health. It affects all the basic, underlying, and immediate causes of undernutrition, adds to pressures on already food insecure regions, and is likely to influence both the quantity and quality of foods produced. It is difficult to estimate the magnitude of these effects but large declines in agricultural productivity are to be expected, leading to less food being available. Deaths associated with a lack of

fruit and vegetables because of climate change are predicted to be twice as common as deaths attributed to people being underweight. Most of these problems are projected to occur in south and east Asia. Adopting climate-stabilization pathways, however, could reduce climate-related deaths by 29–71% (Springmann et al. 2016b).

Climate change threatens food security indirectly as well by triggering increases in plant diseases caused by fungi, bacteria, and other microorganisms (Reddy 2015). Rising concentrations of carbon dioxide in the atmosphere may also reduce the nutritional quality of foods; the zinc, iron, and protein content of grain crops such as wheat and rice could be reduced as well as that of legumes like soybeans and peas (Myers et al. 2014).

1.2.2 Biodiversity

The number and variety of plants, animals, and other organisms that exist is known collectively as biodiversity or biological diversity. It refers to the variability among organisms living in terrestrial, marine, and other aquatic ecosystems and ecological complexes of which they are part. The term encompasses diversity within species, between species, and of ecosystems.

Loss of biodiversity is happening at unprecedented rates. It has been estimated that humans have used about 7000 different plant species since they started agriculture at least 10,000 years ago, but the world's agricultural landscape is dominated today by less than 100 species. Moreover, just three crops, namely rice, maize, and wheat, provide more than 50% of the plant-derived calories eaten by people. The diversity of livestock raised for food is similarly limited. Some 40 livestock species are reared today for food but 5 species alone account for 95% of the total. In aquaculture, an estimated 31 species provide 95% of global fish and shellfish production. Such figures tend not to include wild foods that may play an important role in local contexts. This means that data on food composition and consumption can certainly be used to document biodiversity but inherent difficulties in data collection mean that most studies are carried out at very aggregated levels (WHO 2015).

Dietary guidelines tend to emphasize eating a variety of foods but food and nutrition policies and research tend not to pay much attention to the benefits of biodiversity for planetary health and thus long-term human health. Although it is well-known that there are significant intraspecific differences in the nutrient content of most plant-based foods, tables collated in food composition studies include only a fraction of the world's edible biodiversity. Cooperation across the relevant sectors tends to be inadequate, including within the United Nations system whose various institutions – the Food and Agriculture Organization (FAO), the World Health Organization (WHO) and the Convention on Biological Diversity (CBD) – appear to have little cooperation horizontally with each other. The FAO's Second International Conference on Nutrition in 2014 failed to draw attention to diversity while the importance of biodiversity is not adequately reflected in sustainable development goals (Hunter et al. 2016).

Some direct drivers of biodiversity loss include overexploitation, changes in patterns of consumption and land-use, invasive species, pollution, and climate change. Such loss is not only a problem for diets and nutrition: biodiversity loss can destabilize ecosystems resulting in problems ranging from a lack of clean water, air and food to emerging natural disasters and the increased spread of infectious diseases (WHO 2015).

The exact contribution of food systems to biodiversity loss is impossible to quantify but it has been estimated that they are the single largest contributor globally to the loss of vertebrate biodiversity, which is a proxy for all biodiversity loss (Gladek et al. 2016).

1.2.3 Land Use Change

We live on one planet only that has a fixed or set acreage of land. The increasing speed with which forests, wetlands, and other vegetation types are being converted into land for direct human use is contributing to a loss of biodiversity, climate change, and other environmental problems. Vegetation and soils typically absorb carbon in the atmosphere; when land is disturbed, its stored carbon dioxide (and methane and nitrous oxide) are released, reentering the atmosphere and thereby contributing to climate change. Land clearing can also result in soil degradation, erosion, and the leaching of nutrients (Reddy 2015).

All over the planet, demand to use land for agriculture is increasing. Food production worldwide is responsible for about 75% of deforestation. Between 1980 and 2000 more than 55% of new agricultural land replaced intact forests (Reddy 2015). The growing consumption of meat and dairy products is a key driver accelerating this process. Raising livestock for human consumption accounts for some 70% of all agricultural land use and takes place on 30% of the planet's land surface. In Latin America in particular, the expansion of livestock rearing is a key factor in the continent's deforestation; about 70% of what was Amazonian forest is now pasture (Aiking 2011).

Another driver of changes in land use is increased promotion of biofuels derived from crops like maize in the United States, palm oil in Asia and sugarcane in Brazil. World biofuel production has increased five times in less than a decade. Many challenging issues are related to this trend, including the potential for biofuel production to drive both domestic and foreign large-scale investments in land, for instance in sub-Saharan Africa, which has been called "land grabbing" (HLPE 2013).

Agriculture now occupies roughly half the surface of our planet considered habitable for plants. But only 45% of arable land is used to produce food that is directly consumed by humans. Some 33% of arable land is used to produce food that is fed to animals, while about 12% is used to grow crops for purposes other than human or animal consumption, particularly biofuels (Gladek et al. 2016).

By eating plants and legumes lower down the food chain instead of feeding them to animals and by tapping other sources of energy than growing biofuels, humans could significantly reduce the escalating demand for land and problems associated with changes in land use.

1.2.4 Biogeochemical Cycles

The fourth planetary boundary or threshold that scientists believe has been crossed is that of biogeochemical cycles which have been altered as increased amounts of nitrogen and phosphorus flow from agriculture and industry to the biosphere and the oceans (Steffen et al. 2015). The unsustainable use in agriculture of fertilizers and feed containing nitrogen and phosphorus has been a key driver of this process.

Nitrogen and phosphorus are essential nutrients for both plants and animals to grow but they can take up or absorb just limited amounts of them. Only about 15–20% of these two chemical elements applied on fields as fertilizers or given as animal feed reach consumers' plates, implying significant loss and flows to the environment (UNEP 2016). In soils and manures, excess nitrogen can be converted into nitrous oxide, a greenhouse gas, transformed by microbes especially under wet conditions. If current trends in fertilizer use continue, nitrous oxide emissions from agricultural soils are projected to increase by one-third (34%) by the year 2030 from their 2005 level (Reddy 2015).

The run-off of excess nitrogen and phosphorus into water causes eutrophication of rivers and lakes and related problems that accelerate biodiversity loss and trigger changes in seafood availability especially in shallow waters. Eutrophication refers the explosive growth of plants and algae resulting initially an increase in plankton-eating fish and disturbances in the ecosystem. Later oxygen in the water is depleted resulting in the deaths of many aquatic animals. Reducing nutrient run-off is key to preventing eutrophication. Fish management practices such as raising mussels that filtrate water and removing excess fish have been shown to have at least short-term success (Jeppesen et al. 2012).

1.2.5 Other Environmental Challenges

In addition to the four planetary boundaries that have already been crossed, human food production and dietary habits are contributing to other environmental problems of soil erosion, chemical contamination, antimicrobial resistance, water scarcity, and ocean acidification.

Agriculture is not possible without a healthy soil. It is highly alarming, therefore, that an estimated one-third of soils are moderately or highly degraded because of erosion, nutrient depletion, acidification, salinization, compaction, and chemical pollution (UNEP 2016). The largest driver of soil erosion is grazing livestock, contributing to about 35% of soil erosion losses worldwide. Other drivers include deforestation, poor soil management practices, and intensive agriculture of annual monoculture plants instead of perennials. It has been predicted that world food production may well be depressed by as much as 30% in the next 50 years because of soil erosion and accompanying loss of soil fertility (Gladek et al. 2016). Intensive farming techniques accelerate soil degradation processes, increasing the likelihood that more and more people will experience food insecurity and nutritional problems.

Chemical contamination results from the use of agrochemicals including pesticides and veterinary drugs. Some systemic pesticides in particular, such as neonicotinoids and Fipronic, can cause significant damage to beneficial creatures including honeybees, birds, and earthworms. While the effects of chemical pesticides on human health have been extensively researched, direct causal relationships have been hard to establish conclusively (Gladek et al. 2016).

The use, misuse, and overuse of antibiotics in animal farming has boosted antibiotic resistance, posing a serious threat to human health. Antibiotics are used in many countries to promote animal growth and as a nonspecific generalized means of preventing and treating infections. Strains of microbes and other organisms that are resistant to antibiotics can be disseminated to the wider environment via animal wastes (Economou and Gousia 2015).

Good quality water is essential for humans and for agriculture. Food production accounts for more than 70% of fresh water use globally. The availability of water, however, is highly local – it is usually impractical to transport in quantity or over distance – with about one-third of people worldwide suffering from some level of insufficient availability (UNEP 2016). In addition, freshwater pollution and scarcity affects water availability and quality; an estimated 67% of the world's people will experience water scarcity by the year 2025 (Lovarelli et al. 2016). The amount of water an individual agricultural product uses – its water footprint – depends of cultivation methods, regional conditions, and agricultural management methods. Animal products generally have higher water footprints than plants although high values have been reported for some plant crops such as coffee, cocoa, almonds, and rice (Lovarelli et al. 2016). It has been estimated that producing 1 kg of animal protein requires 100 times more water than producing 1 kg of plant protein (Aiking 2011).

1.3 Supporting Healthy People and Communities Within Planetary Boundaries

It is crucial for present and future human and planetary health that food production and dietary habits are environmentally sustainable – but that is not enough. As an FAO report stresses (Burlingame and Dernini 2012), sustainable diets also need to be culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe, and healthy while optimizing natural and human resources.

Figure 1.2 shows the core dimensions of sustainable and healthy diets, placing people, plates, and the planet in the center. The food we eat off our plates should not only be good for the planet but also good for the people living on the planet. If planetary boundaries and thresholds are ignored, a diet might well be healthy for an individual but unsustainable in the longer term. If attention is not paid to people's needs and unacceptable, unsuitable or unhealthy food produced, food may be wasted and increased malnutrition develop. But without an adequate food supply, plates will be empty, resulting in food insecurities and imbalances. The upshot of

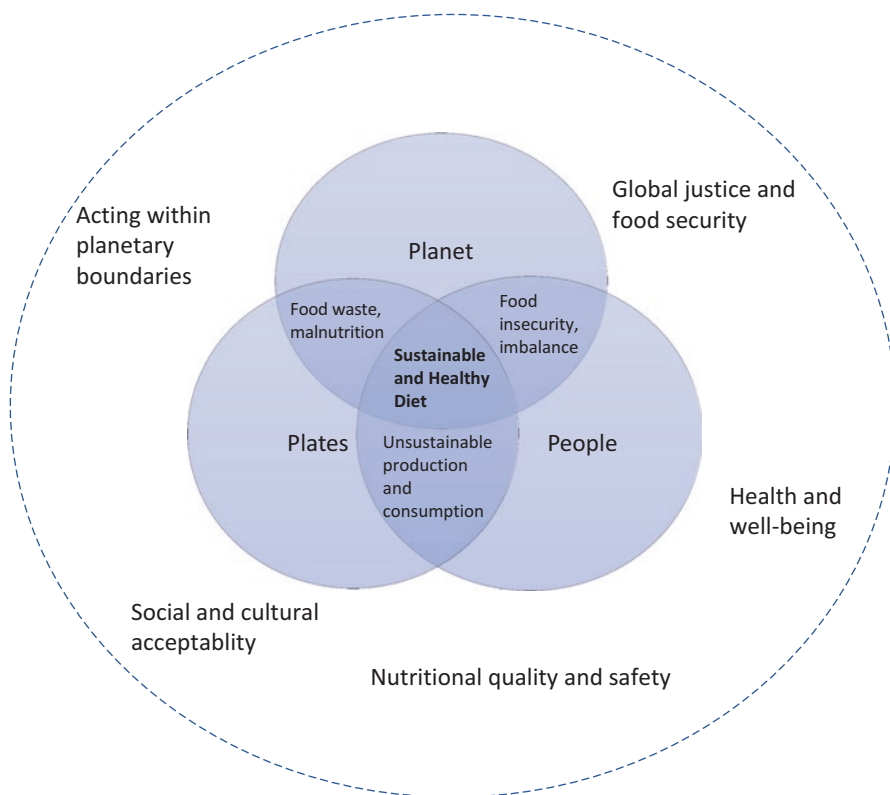


Fig. 1.2 Core dimensions of sustainable and healthy diets

these considerations is that the sustainable production and supply of food for human consumption requires not only acting within planetary boundaries but also attending to:

1. food's nutritional quality and human health and well-being;
2. food's cultural and social acceptability; and
3. food security and global justice.

1.3.1 Nutritional Quality, Human Health and Well-Being

Good nutrition is a cornerstone of people's health and well-being. To be sustainable in the long term, their foods and diet needs to be safe to eat, of good nutritional quality, and accessible to all, particularly potentially vulnerable groups with special nutritional needs such as pregnant women and children. Sustainability can be jeopardized by all forms of malnutrition ranging from undernutrition and

micronutrient deficiencies to obesity and the excess intake of certain nutrients such as salt, saturated fats and sugar. Most current diets fail to support people's health and well-being in the long term.

Poor diets contribute to poor health in all regions of the world. They increase not only morbidity and mortality but also reduce people's quality of life. In their extensive study of the global burden of disease, Forouzanfar et al. (2016) analyzed how different behavioral, environmental, occupational, and metabolic risks influence disability-adjusted life years (DALYs). They found that a poor diet quality was at the root of the biggest cluster of risk factors, accounting for 12.2% of all DALYs for men and 9.0% for women. Of individual dietary components, most risks were attributable to a high intake of salt and processed meat and a low intake of whole grains, fruit and vegetables, nuts and seeds, seafood, and omega-3 fatty acids. Other dietary habits such as eating red meat and drinking sugar-sweetened beverages played a less important role although their impact clearly increased in the decade 2005–2015. Between 1990 and 2015, childhood underweight and stunting decreased whereas the numbers of people with a high body-mass index (BMI) increased by more than 25%. The patterns in risk factor varied across regions and countries and with time. In sub-Saharan Africa, for example, a leading factor in DALYs was child and maternal malnutrition whereas a high BMI dominated in many other countries (Forouzanfar et al. 2016). Studies such as these confirm that the quality and quantity of what people eat needs to be improved all over the world to better match human needs.

All food production has environmental impacts, positive and negative, which has to be weighed against its role in providing nutritional and health benefits. Ideally people's dietary habits should support human health at the same time as being sustainable in the long term. But this is not easily achieved. Although there is plenty of data on the nutritional quality of foods and the health benefits of specific dietary habits, the data on sustainability is limited. Moreover, studies adopt different approaches to different dimensions of sustainability with different research designs, data sets, and methods. More recent studies on environmental impacts mostly focus on greenhouse gas (GHG) emissions and record much less data on other dimensions of sustainability. High nutritional quality has been associated with both high and low GHGs, while some unhealthy dietary patterns such as a high intake of candy and salted snacks have been shown to have a low environmental impact (*see* Auestad and Fulgoni 2015).

Yet existing studies show that diets high in animal products like meat and dairy have higher environmental impacts than more plant-based diets. In broad terms, balanced diets that follow common dietary guidelines are both healthy and environmentally sustainable (*see* Chap. 3).

1.3.2 Cultural and Social Acceptability

Our dietary habits are strongly shaped by the culture and society in which we live. What is on our plate is strongly determined by our preferences. We tend to eat what we like and we learn to like food to which we have become accustomed. Dietary habits are

shaped by the traditions, values, and beliefs of each society and are also linked to identity, status, and social norms. Any attempt to promote sustainable diets without paying attention to their cultural and social acceptability is likely to fail.

What any given culture regards as edible food tends to be much less than what food is available to eat. Humans are omnivores with the ability and need to eat a multitude of different foods, unlike many animals that are restricted to specific foods. This typically results in the omnivores' paradox, eating behaviors that oscillate between neophilia and neophobia. On the one hand, we are inclined towards trying new foods and favor their variety, diversity, and innovation; on the other, unknown foods can be a cause of concern and are easily rejected. Eating behaviors are absorbed from early childhood and are closely tied to family and cultural practices (Lupton 1996). We learn from other people what we should eat, when it is acceptable to eat, how to prepare foods, with whom to eat, and the cultural meanings of foods. Choosing foods and eating them is thus a highly social activity.

There are plenty of edible foods growing and living on our planet but people tend to eat only a few selected species. People could eat the flesh of almost all animals, for instance, but they tend not to eat animals that are raised as pets with given names such as cats, dogs, horses, and guinea pigs (Lupton 1996). Various taboos and religious and other beliefs limit some people's options; for example, religious Hindus do not eat cows, Jews and Arabs do not eat pigs while Muslims follow strict rules about not eating from dawn to sunset during the month of Ramadan. Conversely, some specific foods are eaten within some cultures that within others would be shunned. Half-formed bird, duck or chicken embryos are a popular street food in the Philippines called *balut*; many Chinese people eat bird nests; frogs' legs are a delicacy in France; Koreans eat dog meat; and there is a growing trend of encouraging mothers to eat their placenta after childbirth (Weil 2006).

In many Western cultures meat is regarded as the main part of the meal. It is valued as and associated with power, strength, energy, and masculinity whereas vegetables and fruit are seen as more feminine foods. But there has also long been a profound ambivalence and moral dilemma about meat going back to ancient Greek writings if not before because of the violence, aggression, and spilling of blood associated with it. Because meat comes from dead animals, it is also linked with pollution and rottenness more strongly than with any other food (Lupton 1996). Current concerns focus on animal welfare in the mass production of meat and dairy products.

Today, only the "flesh" of an animal is valued as meat; its internal organs and other parts – offal – are generally regarded as the low-value, waste products of meat production despite often being fit for human consumption and of good nutritional value. Although it was once part of many people's diets in Western countries, many consumers today find it difficult to eat offal. Henschion et al. (2016) have suggested various strategies to widen offal's public acceptance and consumption, such as campaigns to communicate its benefits, align it with cultural traditions, and encourage social support. This would contribute to sustainability given that about half a cow's body weight comprises non-flesh components.

What is considered a delicacy in one culture, however, can be a source of revulsion and disgust in another. People from Western countries may feel that some of the

foods eaten in Asia, for instance, are unappealing – but the same holds true the other way around. Just as attitudes towards food depend on culture (Lupton 1996), so too what is regarded as sustainable is influenced by cultural, ethical, and political values and beliefs. In this context, environmental, social, and economic sustainability has been described as an ethical ideal aiming at inter-generational justice and an ethical relationship between human and non-human nature (Nielsen 2014).

1.3.3 Food Security and Global Justice

Food needs to be available and accessible to everyone. Food systems that guarantee food security for everybody in an economically and socially fair and just way are essential for a good society. The UN's Committee on Food Security (CFS) has defined food security as a condition where all people at all times have physical, social, and economic access to sufficient, safe, and nutritious foods to meet their dietary needs and food preferences for an active and healthy life. It regards the four pillars of food security as availability, access, utilization, and stability. Nutrition is also integral to the concept of food security (CFS 2016). Food systems should deliver food security and nutrition so that the economic, social, and environmental bases to generate food security and nutrition for future generations are not compromised.

Currently our food systems are badly out of balance. More than enough food is produced to feed all the world's population and more, yet over 795 million people remain undernourished. It is critical to address the imbalance of power that creates this food imbalance; producing more food will not tackle it. The agro-food sector is the world's largest economic sector. Half of the global workforce is employed in agriculture. The majority of the world's poorest people are subsistence farmers and fisherfolk who do not always receive their due benefits from their work. Many of them work in unacceptable conditions, do not receive adequate compensation or do not have access to healthy food. Policymaking is strongly influenced by large, wealthy corporations that have disproportionate power over political decision-making. Small players in the food system are marginalized both economically and politically (Gladek et al. 2016). It is obvious that these problems need to be addressed and structural changes made to bring about more resilient and fair food systems in the future.

Realizing the goals of sustainable development would end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. This requires, among other things, an improvement in agricultural productivity globally and in the incomes of small-scale food producers. Calls have been made to invest more in rural infrastructure, correct and prevent trade restrictions and distortions, and adopt measures to ensure the proper functioning of agricultural markets. The UN has adopted a goal of ending all forms of malnutrition and hunger by the year 2030 and ensuring all people, particularly the poor and more vulnerable including infants, have access to safe, nutritious, and sufficient food all year around (United Nations General Assembly 2015). This is a serious commitment and a global challenge.

Ensuring good nutrition and health for all requires action on the determinants of dietary habits and nutrition. Baseline analysis of health-related sustainable development goals in 188 countries has highlighted the importance of socioeconomic, demographic, and political factors in driving health improvements. Intersectoral activities, education and higher incomes are associated with health-related development. Some nutrition goals were set at the end of the twentieth century as part of the Millennium Development Goals including eliminating stunting and wasting in children under 5 years of age; by the turn of the century at least 16.5% of countries had reached this target while others showed some progress. Since then, however, childhood obesity has worsened with no country reaching the set target; about one-fifth (23.1%) of 2–4 year olds worldwide are now considered to be overweight (Lim et al. 2016). Without a comprehensive, intersectoral approach funded with adequate resources, ambitious sustainable development targets are clearly hard to reach.

1.4 Measuring and Evaluating Sustainability

Measuring and evaluating sustainability in relation to nutrition and health is critical, as the results provide the basis for evidence-informed decision-making and help to design policies, improve the performance of food systems, and augment healthier and more sustainable consumer choices. In addition, measurement can itself be regarded as an intervention: measuring something makes it more visible and is likely to generate interest, awareness, and reactions.

Nonetheless, measuring and evaluating the sustainability of foods, diets, and food systems has proved to be very sensitive and challenging. Ideally, all dimensions of sustainability should be captured including its environmental, social and economic aspects and the impact of different activities on sustainability parameters. At a minimum, nutritional adequacy, food safety, impact on human health, environmental impacts, food and nutrition security, biodiversity, cultural acceptability, and economic issues should be evaluated. Sustainability should be analyzed at different levels ranging from individual foods and meals to dietary habits and patterns. The performance of individual farmers, communities, and larger enterprises should be assessed and, ultimately, the health of the planet. All these considerations indicate that we are only just beginning to capture the complexity of measuring and evaluating food sustainability.

1.4.1 *Life Cycle Analysis*

Life Cycle Analysis (LCA) is probably the most common method used to estimate long-term impacts, especially environmental ones. It provides a systematic set of procedures for compiling and examining the inputs and outputs of materials, energy, and associated impacts attributable to a product or service throughout its existence

from cradle to grave. LCA always starts with defining the goal and scope of the study, including technical details to guide the assessment such as functional units, system boundaries, allocation methods, and specific impacts. Next comes a life cycle inventory of flows from and to nature for a particular product, followed by impact assessments.

Although LCA has been used since the 1970s and its escalating use over the past decade is revealed in a tenfold increase in published studies, there is in fact limited data for full LCA of individual foods. Most studies assess climate impacts only while assessment of the social dimensions of sustainability is particularly weak. Studies often focus only on the agricultural phase of a food, highlighting potential improvements just in farming and related activities. Far less studied are food processing and what happens after the point of sale such as home transportation, chilling, cooking, and leftovers and waste. A comprehensive sustainability assessment should also consider food security, nutrition, and health. This can be done in LCA by using functional units that relate to health such as serving size, energy content, protein content or composite nutrient score (Nemecek et al. 2016).

Life Cycle Assessment is extensively used in agri-food systems but there are many challenges, as reviewed by Notarnicola et al. (2017). Analysis of the same food can yield different results depending on how and where the food is produced because farming methods, management practices, soil types, weather conditions, and other factors all influence the outcomes. Current LCA methods do not comprehensively assess some factors that are critical for long-term sustainable food production such as soil quality, fertility, and erosion; ecosystem service; and biodiversity. Global influences on agriculture such as climate change and ozone depletion need to be taken into account while spatially differentiated models for the regional impacts of acidification, eutrophication and toxicity, are essential. There is a clearly a need to widen and improve not only Life Cycle Assessments but also interpretation of their results so as to make the technique a more robust tool in decision-making.

1.4.2 From Nations to Companies

The complex and broad nature of sustainability is reflected in the Sustainable Development Goals (SDG) 2030 adopted by the United Nations General Assembly in 2015. Proposals to measure and evaluate the attainment by the year 2030 of the SDGs include a list of 230 individual indicators covering 17 jointly accepted goals and 169 targets calling for action for people, planet, and prosperity (Report of the Inter-Agency and Expert Group 2016).

Several goals and targets in the SDG 2030 are related to food, indicating the crucial role that food and diets play in sustainable development (see Fig. 1.3). Goal 2 is to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture; challenging targets have been set to end all forms of malnutrition and to improve agricultural productivity, equal access to land, sustainable food production systems, resilient agricultural practices, genetic diversity, trade mea-

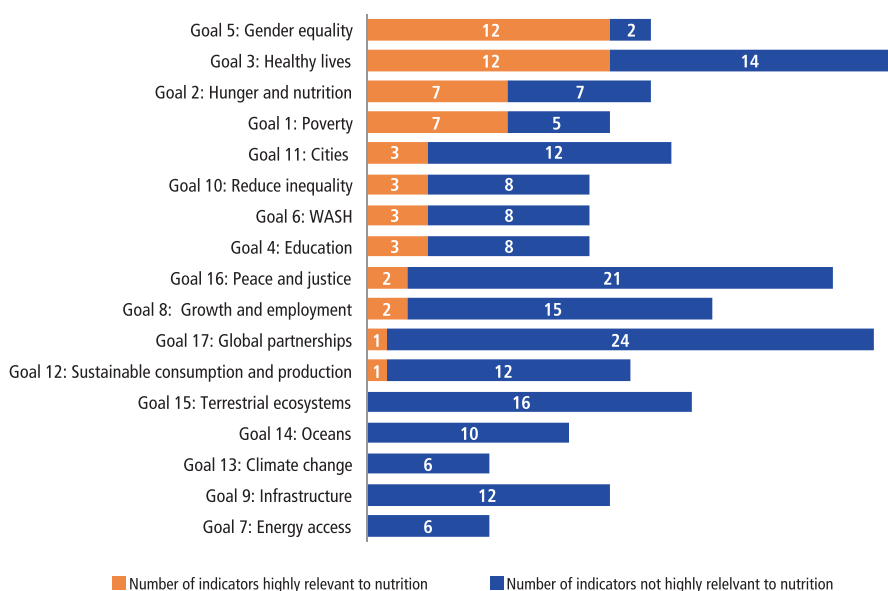


Fig. 1.3 Number of indicators in each Sustainable Development Goal highly relevant to nutrition

tures, and the proper functioning of food commodity markets. Goal 3 focuses on ensuring healthy lives and promoting well-being for all of all ages; nutrition is clearly related to child health (target 3.2) and a reduction of mortality from non-communicable diseases (target 3.4). Goal 12 aims to ensure sustainable consumption and production patterns and calls for the sustainable management and efficient use of natural resources, reductions in food waste and losses from harvest to consumer, and promotion of sustainable procurement patterns. Goal 14 seeks to conserve oceans, seas and marine resources and thus calls for ways of preventing nutrient pollution (target 14.1) and ending overfishing and other destructive fishing practices (target 14.4).

Although SDG 2030s Goal 2 specifically targets hunger, food security, improved nutrition, and sustainability, no indicators have been included on healthy and sustainable diets. Nutritional status is covered only by the prevalence of undernourishment and a few selected indicators (wasting, stunting, underweight) only for children under 5 years of age. Nothing is mentioned about other population groups or dietary habits, and very little said about consumption in general. On the plus side, however, many national level indicators of poverty, equity, waste management, and sustainability governance have been included.

Nonetheless, other potentially useful indicators can be employed to measure and evaluate the sustainability of our diet and food systems. The Economist Intelligence Unit (2016) has drawn up a Food Sustainability Index of 58 indicators to measure sustainability across three pillars: nutritional challenges; sustainable agriculture; and food loss and waste. The indicators for nutritional challenges cover prevalence

of undernutrition, micronutrient deficiencies, obesity, health care expenditure, and life expectancy as well as the amount of sugar in a diet, the purchasing power for fresh food, and the nutritional density of fast food. This index has been used to rank 25 countries including the G20 largest economies.

To assess the sustainability along food and agriculture value chains, FAO (2014b) has established a Sustainability Assessment of Food and Agriculture (SAFA) framework of four dimensions: good governance; environmental integrity; economic resilience; and social well-being. Within this framework are 21 themes and 58 sub-themes with performance indicators. The SAFA framework assesses companies and other enterprises involved in food production, not individual products or processes. Examples of assessing human health and safety, for instance, which are an integral part of social well-being, include health and safety training, safety in the workplace, health coverage, and public health. Its default indicator for public health is that company takes measures “to avoid polluting or contaminating the local community and contribute to the health of the local community”. Unfortunately nutritional indicators or working towards supplying healthier foods are not included. Nutritional standards are mentioned only as part of overall food quality.

1.4.3 Dietary Patterns and Foods

Various initiatives have been launched to measure the sustainability of dietary patterns. One group of experts, for instance, has proposed indicators to assess the sustainability of the Mediterranean diet. Environmental indicators include water, carbon and nitrogen footprints, and biodiversity. Economic indicators include a cost of living index related to food expenditure, food sufficiency, food loss and waste, and nitrogen fertilizer use in the agricultural sector. Indicators related to society and culture include the proportion of meals consumed outside the home, of ready-made meals and of meals comprising traditional products as well as the proportion of mass media initiatives dedicated to increasing knowledge and awareness of the background of foods with cultural value (Meybeck et al. 2015).

Proposed nutritional indicators include vegetable/animal protein ratios, energy adequacy, energy density, nutrient density, fruit and vegetable consumption, dietary diversity, food biodiversity composition and consumption, percentage of local/seasonal foods and seasonality, percentage of eco-friendly food production and/or consumption, physical activity/inactivity prevalence, adherence to a Mediterranean dietary pattern, diet-related morbidity/mortality statistics, and nutritional anthropometry (Donini et al. 2016). Given the very long list of indicators for which data is not necessarily available or has not been presented, it remains to be seen from future studies whether these innovative approaches and proposals will be useful.

Attempts have also been made to develop composite indicators quantifying the synergy between environmentally sustainable and healthy food into one single indicator that could be used to assess individual foods or meals. Lukas et al. (2016) have developed a “nutritional footprint” indicator combining nutritional and environ-

mental dimensions – information on energy, salt, fiber, and saturated fat content together with land use, carbon, material, and water – into a single figure and tested the indicator on different types of meals. A system of communicating this information for individual foods or meals via color codes that indicate low, medium, and high levels of each dimension has also been developed.

Van Dooren et al. (2017) have proposed a “sustainable nutrient rich foods index” that assesses energy density, saturated fat, sodium, added sugars, plant proteins, essential fatty acids, and dietary fiber. This index correlates with greenhouse gas emissions and can be used in ranking individual products or base components in the “traffic light” labelling system. In this study recommended “green” products are vegetables, fruit, legumes, nuts, mushrooms, and vegetable oils; intermediate “yellow” foods are fish, eggs, milk, lean meats, bread, and potatoes; while “red” foods that should be limited are red and processed meats, cheese, butter, and full-fat dairy. This index is an interesting tool but unfortunately does not capture the whole complexity of sustainability and has not yet been widely used or tested.

A cursory analysis of research data on sustainability clearly reveals the different approaches to sustainability regarding research design parameters, data sets, and methods. A lack of good quality data, common indicators, and databases pose significant challenges. Methods of Life Cycle Analysis assessments differ with various system boundaries and provide limited data for individual foods. Studies on environmental impacts mostly focus on greenhouse gas emissions and provide less data on other dimensions of sustainability such as biodiversity, land use, and water footprints. The different functional units that studies use have implications for comparing and interpreting the results and findings. Nutritional quality is usually only partially analyzed using methodologies that vary greatly from simple approaches such as food replacements to more comprehensive methods using dietary guidelines, quality scores or modeling techniques (*see* Auestad and Fulgoni 2015; Mertens et al. 2016; Perignon et al. 2017).

1.5 From Trade-Offs to Balance

Ideally sustainable development should take into account all dimensions of sustainability equally, without prioritizing or ignoring one aspect more than another. In reality, however, initiatives to establish sustainability in one component usually involve trade-offs in another. Food production, for instance, may be sustainable in terms of providing enough healthy food for everyone while supporting a local community, but such production may not be environmentally sustainable. Trade-offs may also be made within the same dimension of the sustainability concept. For example, a particular production method can be sustainable in terms of protecting biological diversity but unsustainable in terms of its energy output and contribution to anthropogenic (human-induced) climate change. These complexities represent a challenge to governance; to tackle it, interactions, benefits and trade-offs need to be identified and balanced with each other.

Three types of trade-offs in ensuring sustainable food production are common:

1. between human and natural systems;
2. within human systems and natural systems; and
3. between and/or within human and natural systems over a period of time.

The first type of trade-off between human and natural systems includes human activities depleting natural resources leading to disrupted ecosystems, climate change, and biodiversity loss. An example of the second type of trade-off within the human system is the allocation of rights, resources, and related activities. For instance, policies that favor access to land or fishing rights being concentrated in the hands of a few large operators may improve production efficiency but risk undermining the livelihoods of smallholders and social stability. Trade-offs within the natural system include reducing the amount of land used while still maintaining output through intensification at the cost of increased water use, or choosing between production of food or biofuel. The third type involves trade-offs in any of the above scenarios occurring over time as immediate benefits are prioritized over later costs. Natural resources and ecosystem services may be depleted over several decades, for instance (FAO [2014b](#)).

Competing perspectives of sustainability create further complexities. The most commonly used approach is to conceptualize sustainability as a food production challenge; the main focus is on improving production methods and efficiencies by means of technological innovations, better farming practices, and managerial changes. Another perspective is to focus on consumption patterns, particularly on consumption of foods that have a high environmental impact, for which the solution is a call for people to change their dietary habits. This approach links health and environmental agendas, often viewing relationships between the two as synergistic. A third approach focuses on current food systems, especially imbalances and injustices that give rise to the coexisting socioeconomic problems of excess and insufficiency as well as environmental and health problems. All these different perspectives clearly have their own merits (Garnett [2013](#)). A combination of different measures targeting both production and consumption is needed to meet climate targets (Audsley et al. [2009](#); Bryngelsson et al. [2016](#)).

Audsley et al. ([2009](#)) have calculated how an estimated 70% reduction in greenhouse gas emissions from the food system in the UK might be achieved by the year 2050. Their results show clearly that a combination of measures covering both production and consumption is needed, and that significant changes in the food system are essential. Their suggested measures range from the decarbonisation of energy carriers in food production to increased farm efficiencies and reduced methane emissions by deploying new technologies. As the largest single source of greenhouse gas emissions within the food system is in the livestock sector, changes in food consumption are crucial. Any overall benefits, however, will depend on how consumers compensate for their lower intakes of meat and dairy products.

Indeed, promoting sustainability requires a shift in wider thinking about food; it needs an inclusive approach reflecting the multidisciplinary determinants of sustainable diets and food systems encompassing agricultural, health, and environmen-

tal aspects as well as sociocultural and socioeconomic determinants. The complex web of determinants makes the task especially challenging. Better tools to assess the impact of various determinants on the sustainability of particular diets as well as of the trade-offs associated with attempts or recommendations to increase the sustainability of diets are urgently needed (Johnston et al. 2014).

To address sustainability challenges and improve planetary health, multidisciplinary and intersectoral approaches involving all stakeholders are indispensable. Quick action is required because urbanization and rising incomes for some people are currently driving a global dietary transition in which more traditional diets are replaced by those high in meat, oil, and sugar. Tilman and Clark (2014) have estimated that by the year 2050 these dietary changes would include human consumption of 61% more “empty calories”, 58% more dairy and egg products, and 23% more pork and chicken, all of which would be a major contributor to an estimated 80% increase in agricultural greenhouse gas emissions globally.

Solutions to this diet-environment-health trilemma are of great environmental and public health importance. This book will now consider the imbalances in our food systems (Chap. 2), the environmental and health impacts of dietary choices (Chap. 3) and the policies needed to promote sustainable and healthy diets (Chap. 4).

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Chapter 2

“When Enough Is Not Enough”: Our Food Systems Are Badly Out of Balance



2.1 Unequal Distribution and Access to Foods

Today's agricultural system now produces more than enough food globally to feed everyone on the planet. Global yields have been significantly increasing since the 1950s such that more food is produced per person than ever before. Both calories and grams of protein have steadily risen, amounting to a 31% increase per person over 50 years between 1961 and 2011 (Gladek et al. 2016). Food balance sheets from 176 countries reveal that on average global diets are well balanced with energy, protein, and fat intake together with fruit and vegetable consumption meeting WHO recommendations for a healthy diet. There are, however, great differences between countries: 102 countries need to reduce their per capita mean energy intake by 199 kcal daily while 72 countries need to increase such intakes by 121 kcal (Jalava et al. 2014). Mean values reveal the huge problem of unequal distribution and access to foods. Clearly our food system is badly out of balance.

In addition, the world's population is growing. FAO has estimated that under a business-as-usual scenario food output needs to increase by 60% by the year 2050 to feed more people. Whereas intensification and specialization have until now been key drivers in agricultural processes, they will not be sufficient in the future to produce more food. New solutions and a structural transformation of food systems towards a more sustainable and resilient state are needed to ensure the health of people and planet in coming decades (Gladek et al. 2016).

There is a broad consensus among policymakers and others about the importance of addressing current and future food crises worldwide but no agreement as to how best to meet this challenge. Instead, debate on how to handle risks to food security has descended into a policy stalemate as different actors propound their very different views on how best to tackle the problem. Suggested approaches include adopting new technologies to increase food production, ensuring equitable food distribution, implementing policies to reduce pollution and food waste, and encouraging local community action to promote sovereign food systems.

More constructive interactions between different actors who promote different approaches are essential if food systems are to become more sustainable. No single solution or pathway will be successful in every instance. Blended strategies are needed such that the strengths and weaknesses of different approaches can support and balance each other (Fraser et al. 2016).

In the meantime, global estimates suggest that hunger is decreasing globally while food security is improving (Global Food Security Index 2016). Nonetheless, access to a healthy and balanced diet is very uneven across the globe: about one-third of people suffer because of poor quality diets, a lack of food or excess consumption, while malnutrition in its many forms exists in all countries.

2.1.1 Double Burden of Malnutrition

Globally about 800 million people suffer from caloric deficiency while nearly two billion adults are overweight or obese because they are consuming more calories than they need. In addition, an estimated two billion people suffer from micronutrient malnutrition indicating their poor quality diets (Global Nutrition Report 2016).

Diet quality varies substantially by region and is influenced by socio-demographic factors such as age, gender, and income. Unfortunately unhealthy patterns of eating – consuming sugar-sweetened beverages, processed and unprocessed meats, and foods high in saturated fats, trans fats, cholesterol, and sodium – are outpacing increases in healthy patterns across most of the world’s regions. In particular, younger adults and men have worse diets than older adults and women (Imamura et al. 2015).

Indeed, one in three people today are malnourished in one form or another. Malnutrition is especially harmful if it occurs early in life. Of the 667 million children aged under five worldwide, about 159 million are too short for their age (stunted), 50 million do not weigh enough for their height (wasted) and 41 million are overweight. There has been some progress in reducing wasting and stunting in children but many countries are still failing to meet global nutrition targets or even follow and promote optimal nutritional activities such as breastfeeding as Figure 2.1 shows (Global Nutrition Report 2016).

One of the biggest nutritional problems is adults being obese and overweight which is linked to other problems such as raised blood glucose. Indeed, the diet-related health burden due to non-communicable chronic diseases now surpasses undernutrition in nearly every region of the world (Imamura et al. 2015). The double burden of malnutrition – the coexistence of people being undernourished with those being overweight and obese – is thus a real challenge.

The staggering figures of malnutrition threaten future sustainable development. Moreover, although food security has improved, especially in middle-income and emerging market countries, nutritional problems are increasing in low-income countries which often lack basic infrastructure and in which low individual incomes hampers their citizens’ access to healthy foods. All these problems will be exacerbated by future climate change as countries with low food security tend to

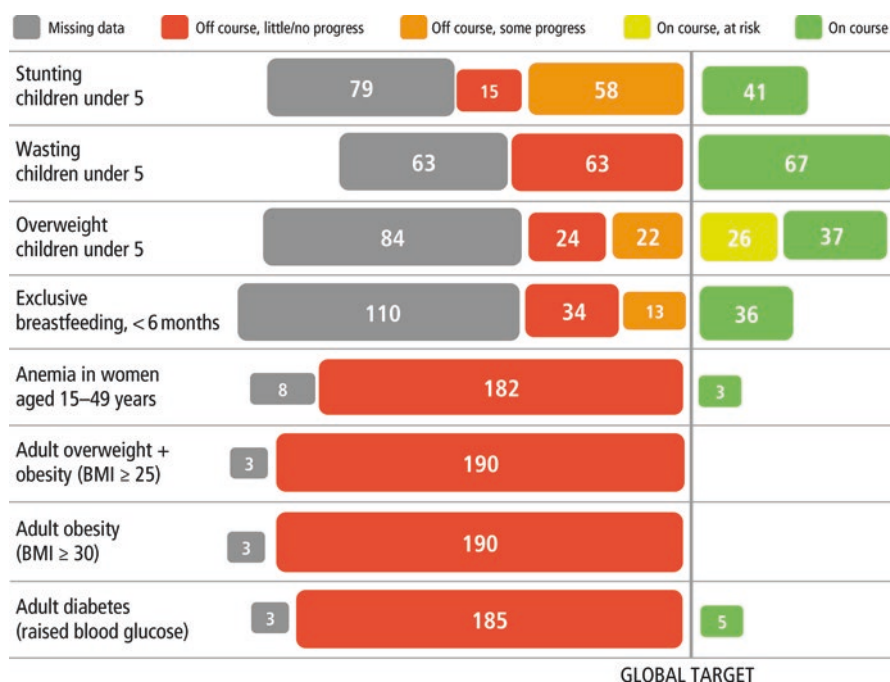


Fig. 2.1 Number of countries at various stages of progress against the global targets on nutrition (Source: Global Nutrition Report (IFPRI 2016) Used with permission from the International Food Policy Research Institute)

be those most affected by changing weather patterns such as increasing rainfall, flooding, and drought. World Bank estimates suggest that without putting in place effective mitigation and adaptation measures, about 100 million people could fall into extreme poverty by the year 2030. Even if adaptive measures are adopted, extreme weather events related to climate change could still lead to crop yield losses as high as 5% by the year 2030, driving up food prices (Global Food Security Index 2016). Given that many richer countries import many of their foods, it is in effect poorer countries that are feeding the richer.

Many measures are needed to tackle food insecurity in a sustainable way and the power imbalance between rich and poor. They should include adopting a comprehensive twin-track approach covering immediate action among the most vulnerable as well as medium- and long-term action to eliminate the root causes of poverty and hunger. Priorities should be plans that have been initiated, developed and adopted by countries themselves, multisectoral cooperation, and strategic coordination and commitments. There is also an urgent need to integrate climate change concerns into food security policies and programs (CFS 2016).

Indeed, food security, nutrition, and sustainability are closely interlinked. Sustainability should be regarded as an integral part of food security planning, monitoring, and evaluation in determining the long-term viability of food system chains.

Without integrating sustainability as an explicit dimension of food security, today’s policies and programs could easily become the very cause of increased food security in the future (Berry et al. 2015).

2.1.2 Resources for Food, Feed and Biofuels

Currently only 45% of all arable land across our planet (0.67 billion hectares) is used to produce food that is directly consumed by humans. About 33% of arable land (0.49 billion hectares) is used to produce animal feed while some 3.4 billion hectares are used as animal pasture. A further 12% of arable land worldwide is used to grow food crops that are not intended for human or animal consumption; the majority of such crops are grown as biofuels (Gladek et al. 2016).

Biofuel crops are rapidly changing agricultural landscapes in many countries. In less than a decade, annual world biofuel production has increased five times from less than 20 billion liters in 2001 to over 100 billion liters in 2011. More than 50 countries have adopted biofuel policies with different incentives and policy tools (HLPE 2013). Based on current policy commitments and subsidy programs, the production of biofuels is expected to more than double between 2011 and 2021, with most expansion taking place in Latin America and Asia (Gladek et al. 2016).

The first generation of biofuels were derived from food crops. Producing bioethanol from sugar has a long history starting as a response to oil crisis in the 1970s; today about 18% of the sugarcane grown worldwide is used to produce bioethanol, mostly in Brazil. In the United States, biofuels were initially promoted during energy crisis in the 1970s in corn-producing regions where ethanol was a co-product of corn syrup; today about 5.7% of global corn production is channeled towards producing ethanol. In the EU environmental concerns have been additional driver in biofuel policy. Biodiesel made from vegetable oils and EU’s dependence on imports of oilcrops has triggered the biofuel and feedstock market becoming increasingly global. In 2008 about 10% of global vegetable oil production went into biodiesel with China growing cassava, sweet potato, and sweet sorghum for it while India and some African countries use sugarcane and molasses (HLPE 2013).

The by-products of biofuel production, however, can be used as animal feed while some biofuels are increasingly derived from non-edible crops and from agricultural and food waste. Any fatty acid can be used to prepare biodiesel, including oils used for frying food and fat from slaughterhouses that is regarded as waste. Industrial starchy waste can be fermented to butanol (Giroto et al. 2015). In 2015, these second generation biofuels accounted for 13% of all renewable fuels based on US production data and were projected to exceed first generation biofuels by 2022 (Fraser et al. 2016).

It is obvious that food security policies cannot be considered separate from biofuel policies. Biofuel production may compete with food production for limited land, water, and other resources, and may increase food prices. Governments should adapt a coordinated food security and energy security strategy, while the right to food and food security should be the priority concerns of any biofuel policy.

2.2 Unconsumed Food From Farm to Fork

About one-third of all food intended for human consumption, amounting to some 1.3 billion tons each year, is never eaten, largely because it was subsequently discharged, lost, degraded or contaminated. In low-income countries most food loss occurs at the production and post-harvest stages whereas in middle- and high-income countries most food loss and waste occurs at the distribution and consumption stages. This high degree of inefficiency exacerbates food insecurity and malnutrition, and also has significant environmental, social and economic impacts (HLPE 2014).

It has been estimated that food losses and food waste are responsible for about 8% of global greenhouse gas emissions; this equates to a quantity of food that would have needed cropland the size of China and that would have used about one-quarter of all water directed towards agricultural purposes. If just one quarter of the food currently lost or wasted globally could be saved, it would be enough to feed 870 million hungry people in the world (Council of the European Union 2016).

Prevention of food loss and waste together with the development of sustainable solutions to manage food loss is difficult but could bring environmental, social, and economic benefits. Such prevention could reduce food prices and the amount of money spent on food at the household level, improve productivity and profits in the food chain, and reduce pressure on natural resources (HLPE 2014). Reducing food waste also tends to be a more acceptable and easier way for many consumers and stakeholders to embrace sustainability than reducing meat consumption or instigating more fundamental changes to food production.

Once again, however, there are many challenges. Simply evaluating, measuring, and comparing food loss and waste is difficult because of a lack of standards, different definitions, many metrics, and diverse measurement protocols that differ between disciplines. Studies adopting an environmental approach to food waste tend to include all food-related material, including non-edible foods and crops, and show thus higher food losses and waste than studies focusing only on edible crops. Most definitions of “food loss” refer to a decrease in the amount of food available at all stages of the food chain before it reaches the consumer; those of “food waste” tend to refer to food that is appropriate for human consumption but that has been discarded or left to spoil at the sales or consumer level – but definitions vary and have different meanings in different languages. Food loss and waste can be measured as food mass or by considering the nutritional or monetary value of lost or wasted food. These differences have prompted strong calls to develop global protocols to measure food loss and waste so as to improve reliability, comparability, and transparency (HLPE 2014).

Identifying and understanding causes of food loss and waste is not easy because the wide-ranging causes – biological, microbiological, chemical, biochemical, mechanical, physical, physiological, psychological, behavioral, logistical, and organizational – are diverse yet interrelated. At root, food losses and waste are consequences of the way food systems function technically, culturally, and economically (HLPE 2014). Although wasting food to many people feels ethically wrong and can be regarded as symbolic of human injustice, food thrown away in an affluent

Western household can hardly be given to those worse off in other places far away (Gjerris and Gaiani 2014). Yet as consumers are encouraged to prefer “fresh” products and choose products with “best before” dates that are furthest away in the future, the likelihood of more food waste grows still further.

In a Westernized culture of affluence where a large selection of high-quality foods is now regarded as the norm and where food supply exceeds individual energy intake needs, food waste could be regarded as a market-driven necessity. If investors and managers of food retailers have decided that shops need to be overstocked with a wide variety of products in oversized packages, that products must look cosmetically perfect, and that best-before periods are short while the desired or aspirational eating culture favors feasts and offers excess food, food waste is hard to avoid. In households, overstocking fridges and serving a variety of foods in large portions can be construed as an indicator of affection and being a good parent or caretaker of household members. Moreover, experiences of past food insecurity can increase the likelihood of people overstocking food as a precautionary measure (Porpino et al. 2016).

While reducing food loss and waste is important for long-term sustainability and future of all life on earth, human health should not be jeopardized in the process. Food must always be fit for human consumption, although the borderline between edible and inedible may sometimes be difficult to determine. Almost all food is biological material that eventually putrefies and becomes inedible for humans. Nutritional quality tends to decrease over time whereas the risk of microbiological growth increases. Although it is often perfectly safe to consume food after its “use by” or “best before” dates, its quality does deteriorate after these dates, creating increased risks of food-borne diseases, especially among vulnerable groups such as pregnant women and the elderly. Moreover, eating excess food simply to avoid throwing it away may cause other problems such as excess energy intake, which is currently a huge problem.

2.3 Metabolic Food Waste

Excess food may end up in the waste or compost bin, but many people tend to eat their plate clean even after their physiological needs for nutrients have been met. Excess food entering the human body can result in problems such as increasing waistlines and obesity. Indeed, the prevalence of people being obese and overweight is increasing in every region of the world and in nearly every country. In 2014 about 39% of adults worldwide were overweight while 12% were obese with a prevalence ranging from 67% in Northern America to 30% in Asia (Global Nutrition Report 2016). This means that about two billion adults in the world have been consuming more energy and energy-yielding nutrients than they need for their basic metabolism, physical activity, and growth. This excess energy is stored in their bodies, mostly in fat tissue leading to weight gain. Many people are also over consuming other nutrients especially in developed countries.

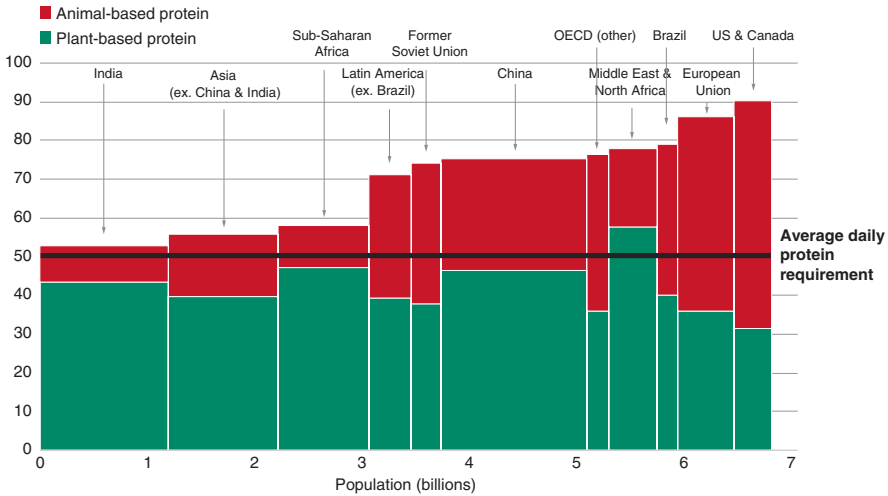


Fig. 2.2 Protein consumption exceeds average estimated daily requirements in all the worlds regions and is highest in developed countries (Source: Ranganathan et al. (2016). World Resources Institute. Reprinted by permission of the publisher)

Of all the energy-yielding nutrients – carbohydrates, fats, protein and alcohol – protein is especially problematic from an environmental perspective. Reducing the current global overconsumption of protein is one way of reducing the food system’s negative environmental impacts. Protein is an essential macronutrient and about 10–15% of the energy a person needs should come from protein. But contrary to popular belief, excess protein intake is not beneficial and may be associated with health problems. The global per capita availability of protein, mostly animal-based, has grown steadily over the past few decades. Animal-based protein intake increased 59% over the period 1961–2009 while plant-based protein intake rose just 14%. An “average person” in more than 90% of the world’s countries and territories consumed more protein than they needed during this time frame with the US, Canada and the countries of the European Union showing the highest intakes (*see* Fig. 2.2).

The World Resources Institute has modelled various scenarios with examples of different diets in high-protein intake countries with a view to calculating the environmental impacts of limiting protein intake and reducing or eliminating obesity. A reduction in human intake of animal-based proteins resulted in the largest reductions in greenhouse gas emissions and land use (Ranganathan et al. 2016).

By far the biggest problem from a human health perspective is excess body weight which is less sustainable for the individual and their society than being within the range of a normal body weight. Increasing body mass raises an individual’s basal metabolic rate during rest as well as their energy needs during physical activity. Overweight and obese people require more energy from food and drink than their leaner counterparts carrying out similar levels of physical activity.

This phenomenon has been known for decades, if not centuries. It was suggested by US nutritionists Gussow and Clancy back in 1986 that maintaining an ideal body weight should be part of sustainable food choices, and that food eaten above physiological needs, which manifests itself as obesity, should be considered the same as food waste – overconsuming food can be deemed equal to wasting food. Serafini and Toti (2016) subsequently developed this idea further by drawing up a “metabolic food waste” indicator which links the amount of food that leads to excess body fat to its impact on the environment expressed as its carbon, water, and land footprint.

The growing number of overweight and obese people is having a profound environmental impact worldwide. A heavy person needs more energy than their normal weight counterpart, stimulating more food to be produced, processed, and transported. Calculations from an observational study in Italy suggests that for each excess kilogram body weight, an overweight person has consumed about 3.7 kg extra food (fruit and vegetables were excluded from the calculations). The average metabolic food waste corresponding to excess body fat was about 63.1 kg food per person for overweight people and 127.2 kg per person for those who were obese. The study also found that animal products consumed in excess were the highest contributor to environmental impact expressed as carbon, water and land footprint (Serafini and Toti 2016).

Obese people need more energy than those of a normal weight range to maintain their body weight. Using population data from the UK, it has been estimated that, compared to people of a normal healthy mean body mass index (BMI) of 24.5 kg/m², those with a mean BMI of 29.0 kg/m² require 19% more energy from food as part of their total energy expenditure (Edwards and Roberts 2009). Another calculation indicates that if everyone in the world had as high a BMI as the average US American adult, their individual energy requirement would increase by 261 kcal/day, totaling the equivalent energy requirement of 473 million adults of a healthy weight. Such estimates clearly show that tackling obesity is critical for food security as well as ecological sustainability (Waipole et al. 2012). Moreover, transporting people with a higher BMI requires more fuel energy, indicating that achieving and maintaining a healthy BMI for everyone would have environmental benefits in terms of lower greenhouse gas emissions from transportation (Edwards and Roberts 2009).

Reducing the prevalence of obesity would mean that less energy-dense foods that are high in energy-yielding nutrients, namely fat, alcohol, carbohydrates, and protein, would be consumed, which is in line with dietary guidelines. Epidemiological studies on the environmental impacts of diets suggest that reducing people’s energy intake could be a primary factor in reducing greenhouse gas emissions, given the strong relationship between total energy intake and diet-related greenhouse gas emissions. In sum, people who consume more energy have a greater environmental impact. Attention is rarely paid to this relationship, and advice to eat less is often not well received (Perignon et al. 2017). Moreover, food advertising, availability and promoting don’t support less consumption.

Non-energy yielding nutrients such as vitamins, minerals, and fiber are essential for human health, but eating an excess of them brings no benefits. To maintain optimal levels within the human body, many nutrients are subject to the body’s homeostatic regulation which adapts absorptive, excretory, and metabolic

processes so as to provide a measure of protection against higher than usual intakes from a balanced diet. Any excess intake of water-soluble vitamins, for instance, is simply excreted in urine. Nonetheless a high level of these nutrients can have adverse effects (*see* EFSA 2006), especially when high intakes come from food supplements and fortified foods. Safe levels of non-energy yielding nutrients at an individual level are difficult to define but a balanced and diversified diet is usually the best safeguard against too low or too high intakes, and is also beneficial from a sustainability perspective.

2.4 Reducing Food Loss and Waste

Reducing food loss and waste is currently high on the global agenda. Political leaders, non-governmental groups and the private sector have all made commitments to act. The most important global target, target 12.3 of the United Nations 2030 Agenda for Sustainable Development, is to halve current levels of per capita global food waste at retail and consumer levels and to reduce food losses along production and supply chains, including post-harvest losses, by the year 2030.

EU countries have adopted the EU's Council Conclusions on Food Losses and Food Waste. These call on member states to scale up action with monitoring, sharing best practices, implementing various actions, supporting education and awareness-raising, and promoting cooperation on reducing food losses and waste. An EU Platform of Food Losses and Food Waste brings member states together with all actors in the food chain. The EU Commission has been requested to support member states in these activities by lifting legal and practical barriers to reduce food loss and waste, reinforcing cooperation between EU and international organizations, and assessing from 2018 onwards progress made (Council of the European Union 2016).

Action to prevent and manage food loss and waste can be presented as a hierarchy of potential solutions (*see* Fig. 2.3). The most preferable option is to prevent food waste in the first place, followed by redistributing excess food to other people or for animal feed. Recycling food waste and recovering energy from it are less desirable yet better than simply disposing of it, such as incinerating waste without recovering energy, sending it to landfill, or pouring food and drink down the drain into sewers (UNEP 2014). The first step in tackling food waste should be tackling the food surplus, which means tackling over-production.

2.4.1 *Reduction and Prevention of Food Waste*

Avoiding the loss of food and the generation of waste would ideally be obtained by maintaining an equilibrium between the production, consumption, and distribution of food. This ideal is very far from being attained but there is increasing awareness of its importance and many examples of successful strategies.

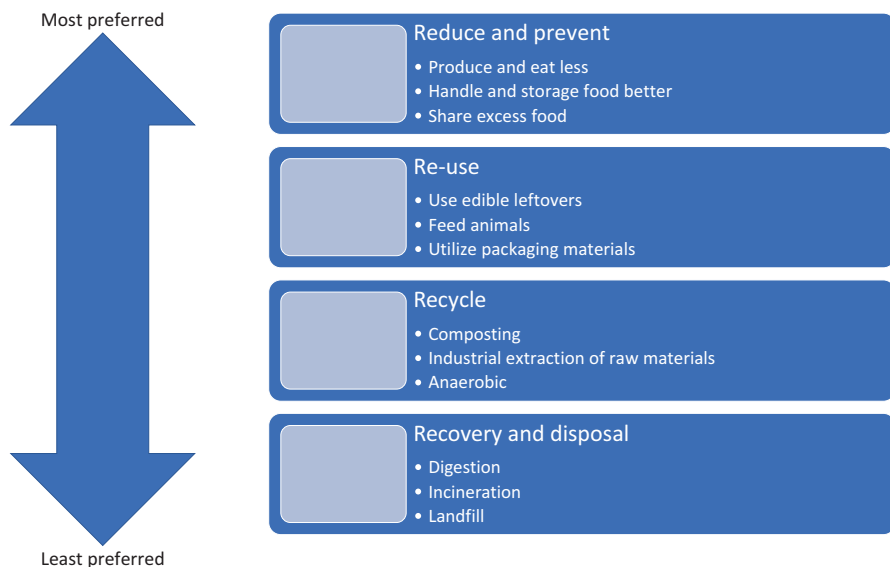


Fig. 2.3 Hierarchy model of food waste

The reduction and prevention of food waste can be achieved either by decreasing demand for excess food or by diverting safe edible excess food to other consumers. At the individual consumer level avoiding overconsumption can be achieved in many ways such as planning meals in advance, checking existing stock before buying new products, making and following shopping lists, using appropriate packaging and storage, eating up left-overs, and paying attention to date labels.

Food donation is a well-established food waste prevention measure that has been implemented worldwide. European Federation food banks were established back in 1984; today there are about 247 food banks in Europe. In the USA there are more than 200 food banks operating across all 50 states (Giroto et al. 2015). Some countries have social supermarkets that sell at reduced prices food that is no longer considered saleable in ordinary retail stores. Some charity organizations provide prepared meals for disadvantaged people cooked from donated ingredients. But while redistributing surplus food provides immediate help and relief to food insecure people, there is no evidence that doing so provide long-term benefits. On the contrary, these practices can undermine actions to reduce food waste and to address the upstream drivers of food insecurity. Donated food may be of low nutritional quality that does not match the dietary needs and preferences of recipients (Caraher and Furey 2017). Thus directing excess food to alternative consumers such as food insecure people appears a sensible option but can have unwanted side effects.

To counteract potential safety and health problems, guidelines have been drawn up for handling and distributing surplus food. EU draft guidelines on food donation (2016) emphasize that all consumers must be equally protected by the same safety standards. EU rules on food hygiene are applicable to all food business

operators, including those running social restaurants or distributing surplus food. The redistribution of animal origin foods including meat, fish, dairy, and eggs to other establishments requires formal approval because of the higher microbiological risks associated with improper transport, handling, and storage.

UNEP (2014) has developed guidance on preventing and reducing food waste with specific tools for governments, local authorities, businesses, and others. The guidance has four modules providing options for:

1. mapping and measuring;
2. developing national or regional policies and measures;
3. developing and implementing programs for household food and drink waste; and
4. preventing and reducing food waste in the food and drink supply chain business including within retail, manufacturing, hospitality, and food service.

Whatever options are adopted, the guidance emphasizes that health and food safety must not be compromised in any way. Any strategy must be developed in partnership with food safety authorities.

2.4.2 New Innovative Approaches

More recently many new and innovative ways to use excess food have emerged, turning a social service strategy targeted at poorer people into a popular approach among trendy and environmentally conscious consumers. These include innovative commercial solutions such as preorders in catering and restaurants, restaurants preparing meals from left-over food, shops avoiding excess packaging material, online websites selling surplus food, and mobile applications matching food surplus from retailers and restaurants to end-users, all complemented by awareness-raising campaigns aimed at increasing the public acceptability of imperfect foods (Caraher and Furey 2017).

Activists such as freegans find alternative ways of living that limit their participation in the conventional economy and consume minimal resources. Freegans take foods that would otherwise go to waste and use them to prepare meals, often sharing such meals in public places with anyone who wishes to eat them. Techniques such as “urban foraging” or “dumpster diving” involve rummaging through the garbage of retailers, residences, offices, and other facilities for useful goods including food that has been discarded. This lifestyle requires some knowledge about food safety. Freegans recommend avoiding foods that carry a high risk of food poisoning or being contaminated such as seafood, meat, eggs, dairy, sprouts, cut melon, cider, half-eaten food, bulging cans, and moldy breads. They have developed ways of safely handling waste food, including trimming moldy vegetables and fruit. Freegan websites give special attention to groups vulnerable to food poisoning including young children, pregnant women, and elderly adults but also those with existing health problems such as cancer, diabetes, HIV/AIDS, alcoholism, and decreased stomach acidity (see <http://freegan.info>).

If wasting food cannot be prevented or reduced, there are still other options. Agro-industrial residues and household food waste can be used as feedstock to produce biofuels and bioplastics while high-value components can be extracted from them. Although there are practical and technological challenges arising from organizing the proper collection and segregation of food waste, there are many promising opportunities for the future. Any source of fatty acid can be used to prepare biodiesel including frying oils that have already been used. In the United States alone, an estimated five million liters of diesel fuel could be replaced annually if oils and fats from restaurants were collected and converted to biodiesel. Bioethanol can be produced from rotten and sub-quality fruit and peel. Inedible dough, bread, and batter liquid can be fermented into butanol. Whey and expired yogurts can be used to produce lactic acid. Anaerobic digestion of food manufacturing residues and many types of food waste can produce a biogas (Giroto et al. 2015).

2.5 Globalization Is Changing Food Systems

Industrialized agriculture and what have become standard food systems are geared towards production models requiring efficiency to be maximized by increasing output and production while lowering costs. Food production and processing may move to areas of lower labor and other costs where environmental and health regulations are less strict. The globalization of the food trade has contributed to a loss of traditional food systems such as loss of local food markets and increased dependence on store-bought foods, and had profound impacts on food habits and cultures, and people's health.

Hawkes et al. (2009) have described how international trade, transnational supermarkets, and foreign direct investments have profoundly changed our food environment. Food prices in many developed countries are now lower, and there is a wider variety of foods available, particularly of fruit and vegetables all year round, not just when they are in season. Large multinational supermarket chains have replaced many local shops, foreign investments typically focus on highly processed food, and imported foods are changing traditional dietary patterns. Western diets are increasing replacing local foods in developing countries.

Liberal trade agreements between countries tend to limit public health measures being enacted, often jeopardizing both health and sustainability. Pacific Island countries, for instance, have experienced the “dumping” of high-fat meat cuts, particularly mutton flaps from Australia and New Zealand, and turkey tails from United States. In India, palm oil and soybean oils have replaced traditional oils. Fast food companies have been proliferating even in Africa, their success propelled by advertising and promotion. Increasing sales of processed foods including soft drinks, snacks, and dairy products has followed the rise of foreign-based large supermarkets in Mexico. But linking such changes in nutrition directly to the globalization of the food system is difficult because a number of factors – urbanization, agrarian reforms, and changes in relative income – also contribute to them (Hawkes et al. 2009). Nonetheless, the outcome is clear: poor quality diets are increasingly a global problem.

Despite increased globalization, liberalized trade between countries and the increasing dominance of large multinational food companies, most of the food produced worldwide is still eaten within the same country. International trade in food and food products accounts for only about 14% of the total volume of food that travels across countries. Europe is the most involved in international food trade: 30% of the world's cross-border food trade takes place entirely within this region. Large food companies dominate the market in Europe with more than half of all global food sales now purchased through supermarkets and hypermarkets (Gladek et al. 2016).

Many people in developed countries are increasingly discontented about the prevalent food systems that fail to provide healthy and sustainable food for all. People have also become disconnected from food production, while divergent views proliferate on how best to feed a growing world population in the future. Some of the key issues under discussion focus on what food should be produced and how, where, and by whom. Some approaches to these issues are discussed briefly below.

2.5.1 Local and Seasonal Food

Locally produced and/or seasonal foods are often perceived more sustainable and healthier than foods produced by big companies and global actors. Many discerning consumers are keen to know the origins of foods before buying them, and to connect with food producers while many are also willing to pay a higher price for locally and sustainably produced food. What constitutes local food has not been strictly defined but the term generally refers to food produced in the locality of the consumer; many regional and national initiatives aim to promote local products. While existing research does not in fact support claims that local and seasonal food is universally superior to non-local foods in terms of dietary quality or environmental impacts, it does potentially provide socio-economic and cultural benefits by supporting local communities, cultures, and economies.

Local food is closely related to the concept of “food miles”: the distance a food has travelled between its original place of production and its final consumption. It is commonly believed that higher food miles equate to higher levels of greenhouse gas emissions. But transportation is only a relatively minor part of the food system, and production processes tend to account for far more emissions and thus have more of an impact on the climate (Macdiarmid 2014). Tomatoes and lettuces grown in heated glasshouses in the UK, for example, account for higher GHG emissions than similar products imported from Spain where average air temperatures are warmer. Sugar and lamb shipped to European consumers from other countries have lower GHGs than the same products produced within Europe. It has been estimated that if the UK were to become self-sufficient in food, its average carbon footprint would be higher than it is today. However, fresh local produce such as fruit and vegetables eaten in season probably has lower or comparable carbon footprints than non-local counterparts available at the same time (Edwards-Jones 2010).

Current evidence therefore suggests no clear advantage or disadvantage for advocating consumption only of local seasonal foods when such foods are categorized as

those that are both produced and consumed in the same climate zone without requiring a significant amount of energy either to modify the climate in which they grow or to store them. It is theoretically possible to meet nutrient requirements by eating only local seasonal foods, even in winter in Northern countries, but doing so would reduce their overall fruit and vegetable intake and would be considered unacceptable by many in today’s societies. Moreover, eating only local seasonal food would be a high-risk strategy as crop harvests are so vulnerable to the weather. There could be negative consequences for a country’s economic stability as well with high seasonal variations in labor requirements. There would seem to be no clear environmental benefits either from consuming only local seasonal foods, given that global seasonal foods – that is, foods produced during their natural season but not consumed locally – can have similar or even lower GHG emissions to local food (Macdiarmid 2014).

While there are differences between local and global actors in the world’s food supply, there is no clear-cut answer as to whether a local or global system is better from a sustainability perspective. Brunori et al. (2016) analyzed the economic, social, health, environmental, and ethical dimensions of sustainability in 39 different types of food supply chains in 12 European countries. Their results show that it is impossible to establish which is better or worse because each depends on context and the assessment method. For example, biodiversity and added value at the local level seem to be better addressed by local food supply chains while global actors are better at achieving efficiency including in their use of resources. Rather than considering “local” and “global” as opposing alternatives to each other, it would be more productive to evaluate the different sustainability dimensions of various food supply chains. This could include identifying best practices, critical points, and benchmarks so as to develop more sustainable food supply systems in the future.

The promotion of local food is not only a question of food miles and food origins but is also closely linked in many countries to movements aiming at food sovereignty – a collection of ideas centering on the notion that consumers and producers need political, economic, and social power to shape the food systems they depend on if they are to be food secure. The 2007 Declaration of Nyéléni defined food sovereignty as “the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture system”. Food sovereignty thus places a strong emphasis on social justice and participation as they relate to local food. Indeed, the concept was originally developed as an alternative to today’s global transnational agribusiness and largely rejects the productionist framework that focuses mostly on increasing food supply. It shares similarities with other “place-based” approaches such as food democracy and community food security (Sonnino et al. 2016).

All these different approaches highlight the need to take local food habits, action, needs, and preferences seriously. Food is an important part of everybody’s everyday life everywhere. Any promotion of sustainable and healthy diets that neglects food’s social and cultural dimensions is likely to fail.

2.5.2 *Organic Farming*

Organic farming is usually presented and promoted as a sustainable method of producing food that has more positive effects, such as maintaining a better soil quality and greater biodiversity, than conventional farming. Diversified crop rotation and restrictions on chemical pesticides, herbicides, and fast-release fertilizers can have positive effects on species diversity, and the abundance of flora and fauna. Organic soil management leads to soils that are highly fertile because of their higher organic matter and biomass, have improved water filtration and retention capacities, and are less susceptible to being eroded by water and wind. Soils under organic management also make more efficient use of nitrogen, are better adapted to climate change, and also have a higher potential for better yields in future. Recent research has identified several examples of best practice and innovation (Niggli 2015).

Although organic agriculture is growing, only about 1% of the world's total agricultural land has currently been adapted to it while increased consumer demand for organic food in developed countries has spurred most organic crops to be grown in highly intensive monocultures (Gladek et al. 2016).

Organic agriculture is usually described as being more sustainable than the far more prevalent chemical agriculture but there are still controversies. Farms using organic methods tend to have lower crop yields and would thus require more land than non-organic farms to produce the same amount of food. Seufert et al. (2012) compared yields of certified or standardized organic farms with conventional ones using 66 studies of 34 crop species. Their results suggest that organic farms yields are on average 25% less although with great crop variation. Yields were especially low for vegetables (33% less) and cereals (26% less) whereas yields for fruit, oil-seeds, and legumes were comparable to farms using chemical methods. Vegetables and cereals require nitrogen to grow but the release of mineral nitrogen from organic sources to be available to plants is slow. Organic farming performed relatively better in variable moisture conditions in rain fed systems.

The environmental impact of organic produce depends on the particular food product and impact being studied. All food products grown under conventional methods make better use of land whereas organic foods are less ecotoxic in all food categories. For other environmental impacts, however, the picture is quite mixed. Conventionally produced beef, chicken, and eggs appear to have lower greenhouse gas emissions, lower acidification potential, and lower nitrogen losses than organically produced products whereas organically produced soybeans and potatoes have lower greenhouse gas emissions and acidification potential than conventional ones (Saxe 2014).

As organic farming restricts the use of synthetic chemical pesticides, herbicides, and fertilizers, the food it produces is therefore perceived to be safer to eat than conventional food. Nevertheless, studies reveal contradictory results. Some but not all studies have reported somewhat lower levels of pesticides and nitrates in organic foods while the differences in such residues between conventional and organic produce are generally very small. Levels of mycotoxins are similar but organic vegetables and animal products have had somewhat higher levels of foodborne pathogens.

Toxic contamination data is contradictory, and levels of environmentally transmitted organic pollutants are similar in both conventional and organic foods. Researchers have concluded that a food’s microbiological safety and contaminants are mainly influenced by factors other than the farming method that produces it (Garcia and Teixeira 2017).

There is no evidence that organic foods have significant nutritional or health advantages over conventionally produced foods. However, many consumers now prefer organic foods and are convinced that they are better even when the evidence is contradictory. Olson (2017) have analyzed readers’ responses to articles writing about Stanford University’s year 2012 meta-analysis of 237 studies published over four decades. This meta-analysis found no meaningful difference in vitamin or mineral levels between organic and non-organic food. It did find somewhat higher contaminant levels in conventional foods but the amounts were still below allowable safety standards. Nevertheless, the overwhelming reader response to articles was pro-organic with 86% of reader comments defending organic food. Many rationalized their continuing organic preference by citing the potential benefits of avoiding long-term exposure to synthetic chemicals and genetically modified organisms, or by offering anecdotal evidence of better health. It seems that research evidence does not change the minds of those who prefer organic food, and health-related benefits continue to be the most common justification for their continuing to eat organic food.

There are also other alternative agricultural systems to the prevalent farming system based on monocultures and synthetic inputs. Some of them, such as biodynamic agriculture and permaculture, implement some of the same principles as organic farming. Long-term soil productivity can also be improved by following conservation agriculture and crop management principles that rely on crop rotation, residue retention, and no-till agriculture. Integrated farming aims to produce food in ways that are better for the environment by optimizing various practices depending on the number of conditions that have been systemically analyzed. Studies have shown that energy use and greenhouse gas emissions per unit of food produced in integrated farming are lower than in either organic or conventional agriculture (Gladek et al. 2016). These and other studies indicate that there are many potential ways to improve agriculture’s sustainability.

2.5.3 Regional Healthy and Sustainable Dietary Habits

One approach to analyzing sustainable healthy diets is to look at regional healthy dietary habits and eating cultures that incorporate the environmental, social, and economic dimensions of sustainability.

A Mediterranean diet was already considered a model for a healthy diet back in the 1960s. It is characterized by a high intake of vegetables, pulses, fruit and unrefined cereals, a low to moderate intake of fish and dairy, a low intake of saturated fats and

meat, and a modest intake of wine. A study ranking the ecological footprint of various foods concludes that foods recommended for health reasons in the Mediterranean diet generally have lower environmental impacts as well (van Dooren and Aiking 2016).

More recently, the New Nordic Diet has been presented as a regional healthy and sustainable alternative to a Mediterranean diet. Guidelines for a healthy and sustainable Nordic Diet are presented every 8 years in the Nordic Nutrition Recommendations (NNR2012), the main reference point for dietary advice given by the authorities in Denmark, Finland, Iceland, Norway and Sweden. The Nordic Diet can potentially reduce the burden of chronic diseases such as cardiovascular disease, diabetes, and certain forms of cancer, mainly due to a higher consumption of fruit and vegetables and reduced consumption of meat and sugary drinks (Jensen et al. 2015).

The New Nordic Diet has been characterized by eating foods such as local vegetables including potatoes, berries, cabbage, root vegetables, legumes, wild mushrooms, whole grains, nuts, fish, fresh herbs, and rapeseed oil. A study conducted in Denmark shows that more people changing their eating patterns towards the New Nordic Diet results in food having a lower environmental impact. But substituting conventionally produced foods with a high proportion (84%) of organic foods lost many environmental improvements because of organic agriculture's lower crop productivity. Other changes like consuming less meat and excluding most long-distance imports resulted in significant environmental benefits (Saxe 2014).

With a higher intake of locally and organically produced fruit, vegetables, and seafood, the New Nordic Diet is about 16% more expensive than a conventional diet. The higher costs have the biggest impact on low-income households while the most favorable cost-effectiveness ratios are in medium-income households. But a significant part of the additional costs are because of organic production methods; the calculations assume that 75% of the food consumed is organic. Accepting more conventionally produced foods would significantly reduce the direct cost to a consumer without affecting the health benefits (Jensen et al. 2015).

In The Netherlands, nutritional scientists van Dooren and Aiking (2016) wanted to develop a healthy, environmentally friendly, and culturally acceptable regional diet for the Rhine-Meuse delta in the south-west of the country with its Dutch-speaking culture, and devised what they called the Low Lands diet. Its composition was determined by gathering information on both historical and current dietary habits to which they applied linear programming methods. The optimized Low Lands diet is higher in vegetables, fruit, fish, and fiber but lower in salt and saturated fat than current diet. It ranked as being more environmentally friendly than either a New Nordic Diet or a Mediterranean diet, while its health score was similar to that of a Mediterranean diet but lower than that of a New Nordic Diet.

There are many similarities in these three regional healthy diets such as a high consumption of vegetables, fruit, and seafood and a preference for fish. But there are some differences (*see* van Dooren and Aiking 2016) related to access, traditions, and preferences. The New Nordic Diet recommends the highest intake of fish and dairy; the Low Land diet is highest in porridges and potatoes, the Nordic in berries and the

Mediterranean in pasta. The Mediterranean diet uses olive oil whereas the Nordic diet suggests rapeseed oil. The Mediterranean diet includes a daily glass of red wine, the Low Land diet allows a daily bottle of beer but alcohol is not part of the Nordic diet. The Mediterranean diet mentions a general preference for wholegrains whereas the Nordic and Low Land diets specifically mention wholegrain rye bread.

These examples suggest that more regional diets combining health and environmental aspects with social and cultural dimensions could easily be developed in the future.

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Chapter 3

“Insects, Aquaculture and Mycoproteins Instead of Beef?”: Choosing Healthy and Sustainable Meals



3.1 Combining Health and Sustainability on the Plate

Guidelines on the recommended intake of nutrients and foods for various population groups to improve or maintain their health have a long history. The ancient Greek physician Hippocrates (460–377 BC) was known to give dietary advice in treating his patients. The importance of individual essential nutrients has been known for more than 100 years. Ensuring that all population groups have an adequate intake of nutrients is still valid advice today in dietary guidelines, but attention is increasingly given to their appropriate balance and quality because a substantial part of today's disease burden is caused by unbalanced poor quality diets.

Compared to the long history of advice being given to eat healthily, guidance on sustainable food choices that are good for the planet is relatively new, although there were some forerunners in the 1970s and 1980s. Sustainability needs to be incorporated into dietary guidelines because human dietary habits, food systems, and planetary boundaries are deeply interconnected (*see* Chap. 1). Nonetheless, providing guidance on healthy sustainable diets is no easy task. It requires combining different research traditions, using the best available evidence while tolerating uncertainties, setting priorities, dealing with powerful lobbyists and interested parties, and involving key stakeholders to formulate what should be implemented.

3.1.1 Guidance on Healthy Diets

Healthy diets should promote and maintain human health. They should protect us from diet-related diseases by containing adequate amounts of all the essential nutrients that are a precondition for a healthy body and healthy living but limited, if not minimal, amounts of nutrients and substances that can be detrimental to health.

Essential nutrients are indispensable for a human body's metabolic processes and the proper physiological functioning of tissues and organs. They must be obtained from food because they cannot be synthesized by the body. Essential nutrients for humans include certain amino acids (isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine, and histidine), two fatty acids (alpha-linolenic acid and linoleic acid), 13 vitamins (A, B₆, B₁₂, C, D, E, K, thiamin, riboflavin, niacin, folate, biotin, and pantothenic acid) and several minerals (calcium, phosphorus, magnesium, sodium, potassium, iron, zinc, iodine, selenium, copper, chromium, manganese, molybdenum, and fluoride). In addition people need energy, water, and dietary fiber, the amounts depending on an individual's age, sex, body size, and metabolic status. An optimal range of many nutrients can be identified. For some nutrients such as sodium (commonly found as salt), saturated fats, trans fats and sugars, maximum levels are set to minimize adverse health effects (Nordic Nutrition Recommendations 2014).

Nutrition research has tended to carry out studies on the health impacts of single nutrients and has strived to identify their specific mechanism. Most foods, however, contain many nutrients as well as other bioactive constituents that can interact with each other and affect bioavailability, uptake, metabolic responses and, ultimately, health. An association between single factors and chronic diseases can therefore be difficult to identify and interpret. As a consequence, studies on dietary patterns that aim to capture the combined effects of all nutrients and food components consumed are increasingly important. This approach was used in developing the latest Nordic Nutrition Recommendations (2014) in which traditional nutrient-based studies were supplemented with studies on dietary patterns and health.

Studies on dietary patterns and food-based guidelines are also important when drawing up nutrition recommendations. After all, people do not eat individual nutrients, but enjoy foods and combination of foods and tend to have little knowledge about nutrients per se. Therefore food-based dietary guidance is useful in showing people how they can put together a healthy diet for themselves. It can also pinpoint potential problems in our foods or diets such as too high an intake of sugar, salt or saturated fat. Healthy diets help to protect against all forms of malnutrition ranging from undernutrition and micronutrient deficiencies to being overweight and having diet-related non-communicable diseases and conditions including diabetes, stroke, heart disease, and cancer.

According to WHO (2015) the basic principles of what constitutes a healthy diet are similar all over the world although the exact make-up of a healthy diet varies depending on individual needs, cultural context, locally available foods, and dietary customs. A healthy diet includes vegetables and fruit, legumes (such as beans and lentils), wholegrains (such as unprocessed wheat, oats, brown rice and rye), and nuts. Daily consumption of at least 400 g or five portions of fruit and vegetables is recommended. Consumption of sugars should be limited including honey, syrups, fruit juices, and fruit juice concentrates. Fat intake, particularly of saturated fat and trans fats, should also be limited to prevent weight gain and to reduce the risks of developing non-communicable diseases. Dairy and processed foods are mentioned

as potential sources of saturated and trans fats. Salt intake should be low to prevent hypertension and to reduce the risk of heart disease and stroke. Processed meats, ready meals, and bread are given as examples of foods that contribute to a high salt intake. Unfortunately WHO's dietary guidelines do not address sustainability.

3.1.2 Studies on Healthy and Sustainable Diet

Research on healthy and sustainable diets has increased rapidly over the last few decades but the scope of the studies carried out remains limited. Such studies should ideally evaluate all the dimensions of a sustainable and healthy diet such as nutritional quality and health, environmental impact including the optimal use of natural resources and biodiversity, cultural acceptability, affordability, accessibility, and economic fairness. Instead such studies tend to focus on diets' environmental impacts, particularly greenhouse gas emissions and occasionally land use or water footprints. Nutritional adequacy is only rarely or partially addressed as are other dimensions of sustainable diets such as food prices.

Despite their narrow scope and lack of information, existing studies report broadly similar results in suggesting the benefits of more plant-based diets. A systematic review of 63 studies showed that reducing animal-based consumption is the most effective way of reducing ecological footprints with vegan diets indicating the greatest reductions in greenhouse gas emissions and land use. Analyses of the health benefits are limited but all existing studies suggest the health benefits of sustainable diets (Aleksandrowicz et al. 2016). The choice of which foods might replace meat, however, is critical because some otherwise healthy foods may be more expensive or may increase greenhouse gas emissions.

Relatively minor affordable and acceptable changes in diets can both improve nutrition and reduce food's environmental impact (*see* Horgan et al. 2016; Macdiarmid et al. 2012; Perignon et al. 2017). Moreover, Horgan et al. (2016) illustrated in their modeling study based on dietary data from the UK the many ways of improving the healthiness of current diets and reducing their greenhouse gas emissions. These improvements require reducing portion sizes and the frequency of eating certain foods while introducing some new foods, but rarely require completely removing foods from diets. Consumed in moderation, almost anything can be part of a healthy and sustainable diet. But healthier diets seem to be easier to achieve than sustainable diets requiring more changes to current dietary habits.

There are synergies between dietary guidelines for health and those for environmental sustainability. Healthy eating guidelines usually have a positive effect on the environment. But the benefits of healthy eating guidelines are greater for health than for the environment. There are also controversies. A complex area is a guideline about sugar: decreasing sugar intake is beneficial for health but it may be negative for environment if calories from sugar are replaced by other foods that have higher environmental footprint than sugar (Irz et al. 2016).

3.1.3 Food-Based Dietary Guidelines on Healthy and Sustainable Diets

Food-based dietary guidelines on how people should eat are usually developed by scientific expert groups, governments, or official bodies. They are typically tools to promote healthy diets and can serve as the basis for developing a country's food and agriculture policies. Dietary guidelines can thus be seen as a key component of a coherent food policy.

Fischer and Garnett (2016) have reported that only 83 of the 215 countries they studied have official food-based dietary guidelines, the majority of them in high-income or upper-middle-income countries. The most common recommendations included in the guidelines are reducing salt intake (96%), increasing fruit and vegetable consumption (94%), reducing fat or improving fat quality (93%), and reducing sugar intake (86%). Just 24% of the guidelines recommended reducing or limiting meat consumption.

The authors were able to find only four countries (Germany, Brazil, Sweden, and Qatar) that had official guidelines on sustainability. Four others (The Netherlands, Estonia, United Kingdom, and France) and the Nordic Nutrition Recommendations for the five Nordic countries have quasi-official guides while there are also some non-official guidelines such as the LiveWell, Barilla double pyramid and Food Climate Research Network guidelines. Fischer and Garnett recognized, however, that because of their limited cultural and linguistic capacity they covered only Spanish, French, German, Italian, Swedish, and Estonian guidelines, so may not have included other guidelines (Fisher and Garnett 2016). Indeed they do not mention the Finnish nutrition recommendations although sustainability has been part of the Finnish recommendations since January 2015. Table 3.1 summarizes the Finnish recommendations for food choices with their key health and environmental impacts.

The Finnish guidelines on sustainable and healthy diets are in line with other guidelines on sustainability. Indeed, Fischer and Garnett (2016) point out that all the official national guidelines that include sustainability say broadly similar things despite some differences in emphasis and the level of detailed guidance provided. All highlight more consumption of largely plant-based foods and less consumption of meat, especially red and processed meat. Sweden provides more detailed advice about using vegetables and recommends eating slightly more fish albeit from sustainable sources. The Brazilian and Qatari guidelines stress avoiding processed or ultra-processed foods. Germany and Brazil give advice on cooking methods and skills: Germany recommends using fresh ingredients to reduce unnecessary packing waste, while Brazil emphasizes the social and economic aspects of sustainability with seasonal, locally grown products.

Food-based dietary guidelines use different models and graphic representations of healthy and sustainable diets, including various pyramid models and plates. For example, the FINUT healthy lifestyles guide developed by the Iberoamerican Nutrition Foundation (FINUT) employs a three-dimensional pyramid to promote adequate nutrition and living an active healthy lifestyle in a sustainable way. The pyramid is

Table 3.1 Guidelines for sustainable and healthy food choices with health and environmental impacts

Change	Positive health impacts	Positive environmental impacts in the whole food consumption chain
Meat and meat products		
Less red meat and meat products	Lower risk of cancer and, possibly, type II diabetes Less saturated fat, lower energy density	Smaller carbon footprint Less eutrophication
Milk and milk products		
Less fatty milk products	Less saturated fat	Carbon footprint and eutrophication impact can be reduced, in particular, by selectively restricting cheese consumption.
Fish and crustaceans		
More fish	More unsaturated fatty acids, vitamin D, selenium and iodine	Footprint is smaller when using wild and farmed fish. Use of wild fish reduces eutrophication. Underutilised fish from the Baltic Sea region can be used as feed for fish raised in open water, thus compensating for the high eutrophication impact of fish farming. Use of fish farmed in recirculation systems moderates the eutrophication impact. Fish farmers have access to a method for comparing the eutrophication impact of different types of production.
Vegetables, berries and fruit		
More fruit and berries	More dietary fibre More water soluble vitamins and various minerals More other useful compounds not classified as nutrients	Smaller carbon footprint. Lower eutrophication impact. When using wild berries climate impacts and eutrophication are due to the collection and processing only, and the impact is very low. The use of local products allows a local selection of foods and diversification of economic activities.
More root plants and vegetables	More dietary fibre More water soluble vitamins and various minerals More other useful compounds not classified as nutrients	Carbon footprint smaller especially when using seasonal products. Carbon footprint of greenhouse vegetables varies a great deal depending on the production technology and season. The most advanced technologies allow to achieve about the same carbon footprint as in production in the open field. Greenhouse producers have access to a carbon footprint calculator for comparing alternative production technologies and products. Because of the closed systems the eutrophication impact of greenhouse products is small. Risks to the environment associated with the use of pesticides can be avoided by using domestic greenhouse products. Use of locally produced root plants and vegetables contributes to the diversification of cultivation, product selection and local economic activities.

(continued)

Table 3.1 (continued)

Change	Positive health impacts	Positive environmental impacts in the whole food consumption chain
More leguminous plants	More plant protein More dietary fibre More water soluble vitamins and various minerals	As nitrogen-fixing plants valuable in crop rotation. Uncertainty associated with the environmental impacts of raw materials of foreign origin can be avoided by using domestic products. Use of locally produced leguminous plant products contributes to the diversification of cultivation, product selection and local economic activities.
More nuts and seeds	More unsaturated fat and plant protein More dietary fibre More water soluble vitamins and various minerals	
Cereal products		
More whole grain products	More dietary fibre More water soluble vitamins and various minerals More other useful compounds not classified as nutrients	Smaller carbon footprint (except for rice). Use of local varieties and processing operations located in the nearby areas contributes to the diversification of cultivation, product selection and local economic activities.
Dietary fats		
More vegetable oils and vegetable oil based margarines	More unsaturated fat	Small carbon footprint. Turnip rape oil production suitable for crop rotation. Use of locally produced special crops or varieties and processing operations located in the nearby areas contributes to the diversification of cultivation, product selection and local economic activities.
Spreadable fats with less butter and milk fat	Less saturated fat	Smaller carbon sink and eutrophication impact.

Source: National Nutrition Council (2014)

addressed to the general population of all ages and aims to decrease the burden of non-communicable chronic diseases around the world but particularly in Latin America. One of the pyramid's three sides focuses on food and nutrition. Half of the triangle on this side illustrates and describes the recommended foods to consume. The half triangle is divided into seven horizontal layers; the layer at the pyramid's base is the longest, illustrating its proportional importance in a diet in contrast to the smallest layer at the top of the pyramid. From the bottom up, the pyramid's layers are:

1. water, drinks and liquid foods;
2. cereals and cereal products, half of which should be wholegrain;
3. fruit and vegetables;

4. milk and dairy products;
5. olive oil and other healthy unsaturated oils;
6. pulses, nuts, fish, seafood, white meat, eggs;
7. animal fats, red meat, cakes and sweets.

The FINUT pyramid recommends consuming foods from layers one to six daily but only occasionally those in the top seventh layer. The other half of the triangle details three groups of habits and behaviors favoring environmental sustainability and healthy living: biodiversity, animal welfare, sustainable agriculture, and live-stock; eating local and seasonal products and fair pay; and food safety, home cooking, eating with others, and breastfeeding. The education and hygiene face of the pyramid mentions recycling, using energy efficiently, using and consuming water responsibly, keeping emissions to minimum, and food safety (Gil et al. 2014).

The Barilla Center for Food and Nutrition (2016) has developed a Double Pyramid model that uses two single-face adjacent triangles: the food pyramid on the left is based on the Mediterranean diet with the highest recommended foods at the bottom, while the inverted environmental pyramid next to it on the right depicts the environmental impact of foods with the most damaging at the top. Each pyramid is divided into six color-coded layers of varying widths. From the base upwards, the Barilla food pyramid depicts:

1. fruit and vegetables;
2. bread, pasta, rice, potatoes and legumes/pulses;
3. oils and nuts;
4. milk and yoghurt;
5. cheese, fish, eggs, cookies and poultry;
6. red meat and cakes/puddings.

The inverted environmental pyramid depicts foods with the lowest environmental impact calculated in terms of ecological footprints at its bottom tip; those depicted in each layer above have progressively more impact. From the bottom tip upwards, the layers of environmental impact are:

1. vegetables, fruit and potatoes;
2. bread, rice, milk, cookies and pasta;
3. legumes/pulses, dried fruit, cakes, yogurt and eggs;
4. olive oil, pork and poultry;
5. fish and cheese;
6. beef and other red meat.

By placing these two triangles adjacent to each other, the Double Pyramid clearly communicates the inverse relationship between nutritionally recommended foods and their environmental impact, and can be used to calculate the environmental impact of different dietary regimes from omnivore to vegan (Ruini et al. 2015).

The Worldwide Fund for Nature (WWF) together with UK-based consultants has developed LiveWell Plates for adults, adolescents, the elderly, and vegans. They used modeling to find a range of food products that are as close as possible to what people

currently eat while also meeting the nutritional requirements of the given groups and respecting various environmental constraints, such as limiting carbon footprints and land use. The various recommended plates contain less meat, particularly lamb and beef, sugar and confectionery than current diets but more meat replacers, legumes, nuts, oilseed, fats, vegetables, and farmed fish. The price of each recommended plate is slightly higher than current diets mainly because of an increased amount of healthy products such as vegetables and fish (Kramer et al. 2017).

Developing all these dietary guidelines requires extensive scientific work which can be carried out in different ways. For example, in the Nordic Countries the guidelines are commissioned by the Nordic Council of Ministers, an official inter-governmental body for formal cooperation between Denmark, Finland, Iceland, Norway, and Sweden. The guidelines are written by independent scientists and form the basis for each country's national guidelines. The latest fifth edition of the Nordic Nutrition Recommendations (2014) recommend limiting consumption of processed meat, red meat, alcohol, salt, and beverages and food that have added sugar. They suggest exchanging refined cereals for wholegrain ones, high-fat dairy for low-fat dairy, and butter and butter-based spreads for vegetable oils and vegetable oil-based spreads. They recommend eating more vegetables, pulses, fruit and berries, fish and seafood, and nuts and seeds. A separate chapter on sustainability emphasizes the importance of plant-based diets and identifies the most sustainable options such as eating more dried beans, peas, lentils, and cereals, choosing mainly field vegetables, root vegetables, and perishable products when in season, and minimizing food waste.

The US Department of Agriculture Dietary Advisory Committee (2015) evaluated the inter-relatedness between human health and food sustainability, with a focus on dietary patterns for its 2015 national dietary guidelines. It reviewed 15 primarily Life Cycle Assessment modeling studies or land use studies from highly developed countries. The Committee concluded that evidence consistently indicates that, in general, a dietary pattern higher in plant-based foods (vegetables, fruit, whole grains, legumes, nuts, and seeds) and lower in animal-based ones is more health-promoting and is associated with a lesser environmental impact (GHG emissions, and energy, land, and water use) than the current average US diet. It concluded that a more environmentally sustainable diet could be achieved without excluding any food group. However, sustainability was not included in the final guidelines) (*see* Chap. 4).

These examples of food-based dietary guidelines suggest that guidelines combining both health and sustainability are possible and it could – and should – be developed for all regions and countries.

3.2 Choosing From and Within Different Food Groups

One of the challenges in putting together a healthy sustainable diet is that many foods are nutritionally similar but with different impacts from a sustainability perspective. For example, all types of fish have broadly similar nutritional benefits but

their environmental, social, and economic impact vary depending on the amount of fish caught or raised, the methods of fishing, and the role that fish play in a local food system.

Moreover, when considering just a single dimension such as climate impact, the conclusions of studies and reviews show a great variation between the same individual food items. Studies and reviews also use slightly different methods and system boundaries. For example, Clune et al. (2016) conducted a systematic review of greenhouse gas emissions associated with 168 fresh food items from 369 studies, focusing on emissions from farm to regional distribution centers. Hartikainen and Pulkkinen (2016), meanwhile, used 80 indicator foods to assess emissions from 151 food categories from agricultural production all the way through to processing; they included storage and home cooking in their calculations but excluded other activities such as food transportation and consumer travel.

Despite different approaches there is a clear hierarchy across food categories with grains, fruit, and vegetables having the lowest impact on GHG emissions and meat from ruminants such as beef and lamb having the highest (Clune et al. 2016, Hartikainen and Pulkkinen 2016). Table 3.2 summarizes the key findings of greenhouse gas emissions across different (ready-to-eat) food categories followed by more detailed discussion below.

3.2.1 *Meat and Dairy*

Meat and dairy products are an important part of the diet of most people. They provide a high amount of protein as well as many vitamins and minerals. Milk and milk products are good sources of essential nutrients including vitamins A, riboflavin, and B₁₂, and the minerals calcium and iodine, while meat and meat products provide vitamins B₆ and B₁₂ as well as the minerals iron, zinc, and selenium.

On the negative side, however, meat and dairy are also major sources of saturated fatty acids while many processed products containing meat and dairy have a high salt content which increases the risk of someone consuming them developing non-communicable illnesses such as type 2 diabetes, cardio-vascular diseases, and cancer. Red and processed meats in particular increase the risk of developing colorectal cancer; most recommendations are to limit their consumption to an average weekly intake of 500 g. Many guidelines recommend switching from eating high-fat dairy and meat options to low-fat versions and low-salt options so as to improve health and reduce the risk of developing non-communicable diseases (Nordic Nutrition Recommendations 2014). Indeed, it has been estimated that 5.1 million premature deaths would be prevented and greenhouse gas emissions two-thirds lower by the year 2050 compared to expected levels on current trends if these health guidelines on meat consumption were followed worldwide. Industrial animal farming has also contributed to the rise of antibiotic resistance and pandemic threats (Weathers and Hermanns 2017).

Table 3.2 Average greenhouse gas emissions (CO₂ –eq/kg) from different foods

	Low ≤ 1 CO ₂ –eq/kg	Medium 1–4 CO ₂ –eq/kg	High 4–15 CO ₂ –eq/kg	Very high >15 CO ₂ –eq/kg
Animal-based foods		Most fish, eggs, milk, yoghurt, honey, insects	Pork, poultry, rabbit, kangaroo, sausages, shrimps, mussels, cheese, cream, butter, octopus, trout, swordfish	Beef, lamb, buffalo, lobsters, sole
Fruits, vegetables and nuts	Field grown vegetables, fresh fruits like apples, citrus fruits, bananas and berries	Legumes, nuts, dried fruits, cultivated mushrooms, avocados, asparagus, greenhouse vegetables		
Cereals	Grains, bread	Rice, quinoa, pasta, breakfast cereals		
Miscellaneous foods	Water, sugar, tea, coffee, plant-based milk substitutes like soya and almond milk	Jams, chocolate, vegetable oils, tofu, margarine, wine, spirits, herbs and spices	Mycoprotein based meat substitute	Laboratory grown meat substitute

The environmental impacts of foods vary but by far the highest source of greenhouse gas emissions from a food group is meat and dairy. It has been estimated that livestock is responsible for nearly 80% of all agricultural emissions. Most livestock emissions are of methane (CH₄) and nitrous oxide (N₂O), both potent greenhouse gases with a high warming potential. The main sources of methane are as a by-product of ruminant animals' enteric fermentation – their digestion of carbohydrates – and stored manure with also emits N₂O. Livestock's urine accounts for 64% of anthropogenic ammonia emissions, which contribute significantly to acid rain and the acidification of ecosystems (UNEP 2012). Moreover, rearing animals for human consumption needs plenty of water: about 100 times more water is needed to produce 1 kg of animal protein than plant protein. In addition, meat and dairy disproportionately contribute to biodiversity loss and changes in land use through deforestation (Aiking 2011).

Studies on dietary patterns show a similar story. Diets that contain more animal products, especially beef, require more water, energy, fertilizers, and pesticides than diets with less animal products (Marlow et al. 2015). To produce 1 kg protein from beef requires 18 times more land, 12 times more fertilizer, 10 times more water, 10 times more pesticide, and 9 times more fuel than 1 kg of protein from kidney beans (Sabate et al. 2014). Omnivore diets containing meat and dairy have 2–3 times higher environmental impacts than lacto-ovo-vegetarian diets, while the lowest impact is from vegan diets (Ruini et al. 2015).

Sustainability can be improved, however, without completely eliminating meat or dairy. Based on databases of existing UK dietary habits, Macdiarmid et al. (2012) created a sustainable and healthy diet with 36% lower greenhouse gas emissions. This weekly diet contains 372 g of meat, of which 190 g was red meat. The amount of dairy was similar to current consumption but with a shift towards more milk and less high-fat dairy products like ice cream, cream, and butter. Horgan et al. (2016) showed that while there was a clear need to reduce meat intake, especially to achieve lower greenhouse gas emissions, a small number of people could even increase their intake of unprocessed meat to optimize the nutritional composition of their diet.

When looking at individual foods, ruminant meat such as beef and lamb have significantly higher greenhouse emissions than other meats like pork or chicken. Among dairy products milk and yoghurt are more climate-friendly than cream or cheese. The lowest values for climate impact are recorded for plant-based milk substitutes like soy milk (Clune et al. 2016; Hartikainen and Pulkkinen 2016). There is some variation between areas, however. Beef from South America and lamb from the EU have the highest greenhouse gas emissions whereas the highest dairy emissions seem to be in Asia and Africa (Clune et al. 2016). The level of food processing involved is also important: hard cheese requiring more milk has higher GHG emissions than soft or semi-hard cheese (Hartikainen and Pulkkinen 2016).

Reducing consumption of animal products would also reduce global use water although with large variations between countries (Jalava et al. 2014) because the amount of water needed to produce meat and dairy depends on local conditions such as farming methods, climate, and technologies. There are also differences between different types of meat. Globally, an average of 15,500 m³ of water is needed to produce 1000 kg of beef, 4900 m³ for 1000 kg of pork and 3900 m³ for 1000 kg of chicken (Lovarelli et al. 2016). One Brazilian study suggests that organic milk has a higher water footprint than non-organic milk, apparently because organic cows produce less milk and inefficiencies in nutritional management result in greater amounts of polluted water (Palhares and Pezzopane 2015).

There are several ways of reducing the environmental impacts of meat and dairy production. Mitigation techniques offer some possibilities of reducing the climatic impact of raising animals; these include carbon sequestration processes to capture atmospheric CO₂ and store it in soils, improved feedstock efficiencies and animal diets, reduced food waste, and improved manure management. Another option is for people to switch from eating meat from ruminant animals to that from pigs and poultry. The most powerful change would be for people in developed countries to reduce their high meat consumption and for any growth in demand to be constrained. To keep greenhouse gas emissions at levels in the year 2000, the world's projected nine billion inhabitants by the year 2050 should consume no more than 70–90 g of meat a day (UNEP 2012).

But there are many challenges to reducing the greenhouse gas emissions that result from rearing animals for human consumption. Many consumers are not aware or do not understand the high impact of meat and dairy on greenhouse gas emissions. A UK study reveals that only 18% of respondents agreed that climate change could be reduced if they consumed less meat, dairy, and eggs. In contrast,

animal welfare was important to 89% of respondents while more than half were very concerned about the origins of meat, mostly wanting to buy that obtained from locally reared animals (Clonan et al. 2015). Similar results have been recorded in other studies and from other countries. A recent review of 33 studies by Hartmann and Siegrist (2017) confirms that people are reluctant to reduce their meat consumption, significantly underestimate the environmental impact of meat production, and are more concerned with issues such as packaging and locality that have less environmental impact.

3.2.2 *Fish and Seafood*

Fish and seafood are healthier alternatives to meat and recommended in many dietary guidelines. All fish has high-quality protein while fatty fish such as salmon, mackerel and sardines have a high content of beneficial omega-3 polyunsaturated fatty acids. Fish contains vitamin B₁₂, iodine, and selenium while fatty fish are a major source of vitamin D. But fish and seafood can also contain environmental toxins such as methyl mercury or organic pollutants. While some vulnerable population groups like children and women of fertile age need specific advice on whether or not to eat certain fish types, fish consumption in general reduces the risk of developing non-communicable diseases (Nordic Nutrition Recommendations 2014). Increasing people's fish consumption, particularly of both oily and white fish, is one of the major changes needed to improve the healthiness of diets and to reduce greenhouse gas emissions (Horgan et al. 2016).

From a sustainability perspective, however, fish can be potentially problematic. The world's global fish stocks have been poorly managed for decades. The top ten species that human eat account for about 30% of the world's marine stocks. More than half the stocks of these ten species are fully exploited, one third is overexploited and only 15% could potentially withstand increased capture. The general scientific consensus is that significantly more fish cannot be taken from wild fish populations. An increasing demand for fish therefore needs to be met by increasing sustainable aquaculture production or increasing the catch and consumption of other fish species (Toppe et al. 2012). Selective fishing of currently neglected fish species could also improve water quality and combat eutrophication but the challenge is to develop innovative ways of using them for food or feed.

Greenhouse gas emissions from fish are on average fairly similar to those from raising chickens. There is, however, a high variability with seafood in particular showing higher greenhouse gas emissions (Clune et al. 2016; Hartikainen and Pulkkinen 2016). For wild fish, emissions largely come from fuel consumption and refrigeration during the catch; trawlers and others catching offshore fish incur significantly higher fuel consumption than coastal fishing fleets. Within different types of fish the lowest values are reported for pilchards, herring, pollock, carp, mackerel, and tuna; medium values for seabass, salmon, cod, eel, and trout; and the highest values for hake, mako shark, anglerfish, swordfish, and turbot as well as seafoods such as prawns, shrimp, mussels, and lobster (Clune et al. 2016).

There are many strategies and tools to encourage sustainable aquaculture and to help consumers choose sustainable sources of fish. These include various codes of conduct for responsible fisheries, guidelines, agreements, standards, labels, and certification programs (Toppe et al. 2012). Probably the best known is the Marine Stewardship Council's blue MSC certificate that can be awarded to any fishery that uses only sustainable fish stocks, minimizes its environmental impact, and has effective management (see <https://www.msc.org>). In addition, groups such as WWF and Greenpeace keep local or global lists of fish and seafood that should be avoided and those that can be consumed.

Unfortunately a plethora of parallel lists and systems make choosing what fish to eat more complex. A study from the UK shows that consumers find it difficult to understand the sustainability messages relating to fish. Almost half the respondents reported that they were confused as to which type of fish they should eat so as to protect fish stocks, while only 27% actively sought to purchase fish from a sustainable source. More than half the participants were aware of the health benefits of eating fish, yet consumed only 1.4 portions a week (Clonan et al. 2011).

3.2.3 *Vegetables, Fruit and Berries*

Most dietary experts recommend eating plenty of fruit, vegetables, legumes, nuts, and seeds. WHO (2015) recommends daily consumption of at least 400 g (five portions) of fruit and vegetables. Potatoes, sweet potatoes, and other starchy roots are important staples in many diets but are not classified as fruit or vegetables. Vegetables, fruit, and berries usually contain plenty of dietary fiber, vitamins (C, E, K, folate), carotenoids (pre-Vitamin A) and minerals such as potassium and magnesium. Except for vitamin B₁₂, legumes are good source of B vitamins, protein, minerals (iron, zinc, magnesium, potassium), dietary fiber, and starch. Nuts and seeds contain high amounts of useful unsaturated fatty acids, proteins, vitamins (E, B₁₂, niacin) and minerals (magnesium, zinc, potassium, copper). All plant foods contain a wide variety of phytochemicals and other potentially useful compounds (Nordic Nutrition Recommendations 2014).

Vegetables, legumes, and fruit tend to have much lower greenhouse gas emissions than animal-based products making them an ideal component of a sustainable diet. This applies to both epidemiological studies of diets (Perignon et al. 2017) as well as studies of individual food items. All field-grown vegetables and fruits have on average very low levels of greenhouse gas emissions, while emissions from produce grown in heated greenhouses are more than double because of the heating fuel required. Emissions from pulses and legumes lie somewhere between the two (Clune et al. 2016).

Despite the health benefits of eating more fruit and vegetables, some studies suggest that doing so incurs higher costs. Some studies indicate that isocaloric substitution of meat with fruit and vegetables resulted in slight increases in greenhouse gas emissions (Perignon et al. 2017). Greenhouse gas emissions per kilocalorie of

processed fruit and vegetables are high due to their processing, transportation, packaging, and storage (Drewnowski et al. 2015).

Nonetheless, increasing the mean consumption of vegetables, fruit, nuts, and seeds is the most frequently recommended strategy to increase the healthiness and sustainability of diets, a strategy that is more important from a health perspective although it also brings significant sustainability benefits. Guidance to increase intake of fruit, vegetables, nuts, and seeds is valid at the population level but reduced consumption by individuals already eating above the recommended intakes could lower greenhouse gas emissions (Horgan et al. 2016).

Vegetables have a low water footprint (about 300 m³/t) but fruit growing requires more water (1000 m³/t). High values have been reported for pulses, spices, and nuts ranging from between 4000 and 9000 m³/t, although there are differences between studies depending on the methods used and regional conditions. Tomatoes grown in an open field, for instance, have a lower water footprint in general but other factors such as conditions in the fields, fertilizer and pesticide use, and irrigation methods can influence outcomes (Lovarelli et al. 2016).

3.2.4 *Staple Carbohydrate Foods and Sugar*

Starchy roots like pasta, bread, rice, and potato are staple foods in many diets. Together with sugar they are significant sources of carbohydrates, but the nutritional quality of different staple carbohydrates varies. Whole grains provide dietary fiber, minerals (iron, zinc, phosphorus, magnesium) and vitamins (vitamin E, thiamine, riboflavin, niacin, vitamin B6). Because these are mostly found in the germ and bran fractions of grains, refined cereal products contain less beneficial nutrients. Dietary guidelines emphasize the benefits of choosing unrefined wholegrain products that are high in dietary fiber and nutrients. Prospective cohort studies indicate significant inverse associations between wholegrain intake and a risk of developing cardiovascular diseases, stroke, and diabetes (Nordic Nutrition Recommendations 2014).

Staple carbohydrate foods generally have a low environmental impact. Horgan et al. (2016) have estimated from UK data that more potatoes, cereals, rice, and pasta could be on average consumed to reduce greenhouse gas emissions and improve the healthiness of current diets but the changes needed depend on an individual's diet.

Greenhouse gas emissions associated with staples and cereals are mostly very low although quinoa and rice have somewhat higher emissions (Clune et al. 2016). About 10% of the total agricultural GHG emissions are associated with rice cultivation because the anaerobic decomposition of soil organic matter by methanogenic bacteria in rice fields under water produces methane. (Reddy 2015).

The water footprint of different staples varies: growing potatoes requires much less water than growing rice or wheat for pasta. There are also differences between species: growing durum wheat (*triticum durum*) for pasta requires more water than growing bread wheat (*triticum aestivum*) (Lovarelli et al. 2016).

Foods containing refined sugar carbohydrates like soft drinks, syrups, candy, chocolate, snacks, chips, and cakes have lower GHG emissions per 100 g or per

calorie than other food groups. Despite their low environmental impact, they cannot be viewed as sustainable foods, however, because sustainability encompasses population health and well-being (Drewnowski et al. 2015).

3.2.5 *Fats and Oils*

Vegetable oils, spreads, and butter contain energy and vitamins A, D, E and K. Vegetable oils and spreads are also key sources of essential fatty acids of varying composition depending on the vegetable source and its processing. Soybean, maize, and sunflower seed oils are high in polyunsaturated fatty acids whereas olive oil and rapeseed oil are high in monounsaturated fatty acids. Butter, palm oil, and coconut oil are high in saturated fatty acids. Butter also contains cholesterol and transfatty acids. A high intake of saturated and trans fats is considered a risk factor for developing cardiovascular diseases (Nordic Nutrition Recommendations 2014).

WHO recommends (2015) using unsaturated fats (such as those found in fish, avocado, nuts, sunflower, canola, and olive oil) and avoiding saturated fats (for example, those found in fatty meat, butter, palm and coconut oil, cream, cheese, ghee, and lard). Trans fats are not part of a healthy diet.

Most saturated fats come from animal-based products such as meat and dairy. Yet not all vegetable oils are beneficial. Palm oil tends not to be recommended because of its high content of saturated fats (WHO 2015). Its production also raises serious sustainability issues. Highly valuable tropical forests in Indonesia and Malaysia have been destroyed in order to plant palm oil trees; these two countries produce about 81% of the world's palm oil and have about 11% of the world's remaining tropical forest considered to be global diversity hotspots. A range of government and industry initiatives aim to reduce deforestation and improve sustainability (*see* Ivancic and Koh 2016), but cannot change the fact that palm oils are not recommended from a health perspective.

Animal fats like butter have higher greenhouse gas emissions whereas vegetable oils, margarine, and similar products produce on average medium level greenhouse gas emissions (Hartikainen and Pulkkinen 2016).

To reduce greenhouse gas emissions and improve the healthiness of their current diet, many individuals could start using smaller quantities of full-fat oils and spreads, and reducing their consumption of low-fat alternatives and butter. Their energy requirements would still be met without increasing their salt intake (Horgan et al. 2016).

3.3 Novel Approaches

Most people's eating habits are shaped by tradition, habits, beliefs, and personal preferences. We eat only a small number of the many edible foods available around the world. Our diets could be broadened, however, by adopting novel approaches that employ technological innovations and by eating a wider range of specific local and traditional foods.

3.3.1 Plant-Based Substitutes for Meat

Many plant-based products can be eaten as alternatives to meat, some of them based on centuries- old recipes. Plants such as soybean and other legumes, cereals, fungi, and oilseeds all contain high-quality proteins that are suitable to produce meat analogs – also called mock meat, meat substitute, imitation meat or faux meat – that approximate to the qualities of meat. Textured vegetable proteins can be used in meat analogs to improve their texture, appearance, and how they feel in the mouth.

There is a rapidly growing market for plant-based processed foods to replace meat. A variety of meat substitutes are now available, each with different benefits and limitations. Soy is a versatile ingredient that has been used for centuries in products like tofu and tempeh and is also the key source for texturized protein. Quorn is made from mycoproteins but contains egg white as a binder, making it unacceptable for vegans. Seitan is made from wheat flour that is washed until the starch dissolves. Because it contains gluten, however, it is not suitable for those who are gluten-sensitive including people with celiac disease. Wheat gluten can also be texturized and used in combination with soy to produce meat extenders (Malav et al. 2015). Other products use new versatile ingredients like pulled oats, fava beans, and other similar innovations.

New technologies are also being developed to produce meat in the laboratory and selectively manipulate its composition. Existing methods involve either using suitable stem cells or explant from an animal's muscle that is then proliferated in a nutrient medium. This cultured meat could have 78–96% lower greenhouse gas emissions, 99% lower land use and 82–96% lower water use. But there are many challenges ahead before it will be on consumers' plates ranging from technical solutions to regulatory issues to consumer acceptance and appeal including the need to improve its composition and sensory properties (Sharma et al. 2015). Perceived naturalness is usually an important factor in consumer acceptance of food; cultured meat being regarded as unnatural will be a barrier to its consumption (Hartmann and Siegrist 2017).

Moreover, there may not always be significant environmental benefits from switching to meat analogs. A UK study has estimated that swapping meat and milk for highly refined livestock analogues such as Quorn, tofu or soymilk could even increase the quantity of arable land needed to supply the foods. This suggests that a broad-based switch to plant-based products achieved simply by increasing the intake of cereals and vegetables would be more sustainable than eating these specially processed products. In the future processing techniques that use less energy and other crops such as oats are anticipated to offer more sustainable options (Audsley et al. 2009).

A comprehensive “cradle-to-plate” Life Cycle Assessment of meat alternatives encompassing different types of environmental impacts has revealed that mycoprotein-based meat analogs and laboratory-grown meat that use a significant amount of energy and a medium amount of cultivated land have higher environmental impacts than chicken, dairy or gluten-based substitutes. The best products with the lowest impact were soy-meal-based substitutes and insects. Lab-grown meat had the highest impact in most categories except for agricultural land use. Gluten-based analogs and

chicken had the highest impact on land use, while dairy-based substitutes had high impacts in the categories of ozone layer depletion, terrestrial acidification, and agricultural land occupation (Smetana et al. 2015).

3.3.2 *Insects and Seaweed*

Introducing and adopting alternative, environmentally friendly sources of protein and other nutrients from different food cultures is another option that might improve Western diets. Insects and seaweed are two options.

Insects have been suggested as a meat alternative because of their low environmental impact (Smetana et al. 2015) and because they could address global food and feed insecurity, and meet and increasing global demand for protein for growing population. While entomophagy – eating insects – is a novelty in the Western world, it has been part of the traditional diets of at least two billion people around the world. Globally more than 1900 insect species are eaten as food, the most consumed being beetles (31%), caterpillars (18%), bees, wasps and ants (14%), and crickets, grasshoppers and locusts (13%). Insects have a high conversion efficiency – they yield a high amount of protein when consumed in comparison with their own energy intake. Crickets, for example, require only 2 kg of feed for every kg of bodyweight gain. Insects also emit less greenhouse gases and ammonia, and use less land or water than livestock. (Huis et al. 2013).

The nutritional composition of insects is highly variable, even within the same species group, although in general, the nutritional quality of insects is very promising. For example, the composition of unsaturated fatty acids in mealworms is comparable to that of fish (Huis et al. 2013). Payne et al. (2015) compared the nutritional composition of six commercially available insect species to that of beef, pork, chicken, and offal. They found bigger differences in energy-yielding nutrients between the insects than between the meats. The protein content varied from 10 g (palm weevil larvae) to 35 g (mopane caterpillar), fat content from 3.6 g (honeybee) to 25 g (palm weevil), and saturated fat content from 2.3 g (cricket) to 9.8 g (palm weevil). Insects tended to have higher micronutrient levels than all three meats. All insects had higher levels of calcium and riboflavin than any of the meats or offal. The iron content of crickets and honeybees was higher than that of meat (Payne et al. 2015). Moreover, it seems that grasshoppers, crickets, and mealworms have high levels of chemically available micronutrients including iron, calcium, zinc, magnesium, and manganese (Latude-Dada et al. 2016).

While insects clearly have the potential to be good nutritional substitutes for meat, research on the environmental impact of farmed insects is still in infancy. About 16 different insect species are today farmed on a commercial basis, but a 2016 Life Cycle Analysis was limited to only three insect species: mealworms (*Tenebrio molitor*), superworms (*Zophobas morio*), and black soldier flies (*Hermetia illucens*). Other studies reveal a great variation in life cycle assessment methods used while the environmental impact of farmed insects depends on many factors including feed

quality, species and metamorphic state. More research using harmonized methods is indispensable before the environmental impact of commercially available insects can be determined (Halloran et al. 2016).

Seaweeds are macroalgae found in all coastal areas around the world. Many types of seaweed are edible and have a good nutritional quality with high levels of protein, essential fatty acids, minerals, and dietary fiber. Seaweeds are popular in Asia but have also been eaten elsewhere.

Dulse (*Palmaria palmate*) has been used as animal feed in England and as a condiment with bread and butter in Ireland and Iceland. In Wales purple laver (*Porphyra umbilicalis*) has been a “survival food” in the past, recommended by doctors as a good source of iron and high-energy nutrition for malnourished women and children. The Inuit in Greenland have traditionally eaten cooked winged kelp (*Alaria esculenta*), bladder wrack, dulse, knotted wrack, and sugar kelp (*Saccharina latissima*). In recent years the popularity of foods containing seaweed has increased including the use of seaweed in processed foods (Mahadevan 2015).

From a sustainability perspective, seaweeds have many benefits. They can be profitably cultivated without artificial fertilizers; they do not compete for agricultural land; they require relatively simple farming technology; and they have minimal environmental impact. Wider consumption of these “sea vegetables” outside Asia, however, would require research and innovation to make them desirable to consumers and to address challenges such as the variability in nutritional composition and safety (Mahadevan 2015).

Seaweeds can also be used as thickening agents in the food processing industry, as an ingredient in animal feed, and as a soil conditioner and fertilizer in agriculture. They can also potentially be used in wastewater treatment because some seaweeds can absorb heavy metal ions like cadmium and zinc from polluted waters (McHugh 2003).

Despite their potential benefits, Western consumer acceptance of novel foods such as meat substitutes, insects and seaweeds is a significant challenge. Novel foods tend not to be easily accepted unless they fit in with cultural traditions and preferences. Most people living in Western countries are not accustomed to eating insects or seaweed; several studies (*see* Hartmann and Siegrist 2017) indicate their low understanding of sustainability and low acceptance of novel foods such as insects or meat substitutes. Acceptability, however, is influenced by product type, familiarity, taste, and cultural background. Food products in which insects are not visible, cricket flour for instance, tend to be more acceptable than unprocessed insects, although people are also more willing to eat insects in future after they have tasted them. Dissemination of information about the benefits of cultured meat may increase its acceptance (Hartmann and Siegrist 2017). Food habits and preferences are also influenced by fashion and trends, so novel foods could well become staples in the future.

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Chapter 4

“Serving Sustainable and Healthy Food to Consumers and Decision Makers”: From Commitments to Action



4.1 Struggling for Sustainable Diets

Bringing sustainability into food and nutrition policy and implementing it is not easy. The first attempts to promote sustainable diets among nutrition educators were met with criticism as questions were raised about the feasibility, objectivity, and advocacy of doing so. Even the term “sustainable diets” was reportedly confusing and even threatening (Gussow 1999).

Sustainable diets are still a difficult concept to promote. The importance of improving the sustainability of diets and food systems is recognized, and many NGOs and other activists are pushing the agenda forward, but the political response from governmental bodies and representatives has so far been inadequate. Challenges include understanding complex multidisciplinary research and a lack of knowledge about good policy practices that are effective (Sedlacko et al. 2013). Powerful actors in the for-profit private sector and elsewhere have hampered the process. Putting health and sustainability onto the agenda of decision makers ranging from consumers to political leaders requires not only the will to do so and an understanding of their importance but also multisectoral cooperation, policy coherence, and practical tools for policy implementation. It also requires courage to say that some foods are better than others, although in small quantities all foods can be part of a healthy sustainable diet. This is clearly not an easy task.

There are also many obstacles, not least from powerful corporate and political interests that have the potential to impede progress. Such challenges have existed for many decades. For example, in January 1977 when government authorities in the USA first published the dietary goal of reducing people’s meat intake, the food industry protested heavily at the guidance. Under intense pressure the authorities published a revised version later that year in which the statement “reduce consumption of meat” was replaced by “choose meat, poultry, and fish which will reduce saturated fat intake” (Nestlé 2007).

More recently, problems occurred when the US Department of Agriculture Dietary Advisory Committee (2015) proposed the inclusion of sustainability into Dietary Guidelines for Americans; it was accused of overstepping its statutory rights. Political and other pressures were brought to bear as well because the food and beverage industry did not want individual foods disparaged, while the inclusion of sustainability would have required current policies to be changed (Merrigan et al. 2015). Ultimately the proposal was rejected. US Department of Agriculture Secretary Tom Vilsack and Secretary of Health and Human Services Sylvia Burwell wrote in a joint statement that the Dietary Guidelines for Americans would remain within the scope of the mandate in the 1990 National Nutrition Monitoring and Related Research Act, which is to provide “nutritional and dietary information and guidelines”. They stated that the 2015 Dietary Guidelines were not the appropriate vehicle for a policy conversation about sustainability (Vilsack and Burwell 2015). Yet one legal analysis (Simon 2015) argues that nothing in the mandate or Act precludes the inclusion of sustainability in the Dietary Guidelines.

In Australia, statements about the importance of ecological sustainable development were made as part of food and nutrition policy back in 1992. But its implementation received little support because agricultural interests dominated state food policy initiatives. In 2010 a fresh commitment to develop a new integrated National Food Plan was initiated, but during the process of consultation and stakeholder involvement powerful food industry groups managed to effectively sideline nutrition and sustainability (Carey et al. 2015). Despite some 65% stakeholders supporting the inclusion of environmental sustainability, the final plan positioned sustainability only in the context of maximizing food production efficiency for economic sustainability with limited attention to either consumption or equity (Ridgway et al. 2015).

In 2009 Sweden developed guidelines for environmentally effective food choices and submitted their proposals to the EU Commission. Their recommendations included:

- eating less meat and choosing locally produced meat, beef and lamb, preferably from animals that had grazed on natural grassland;
- choosing locally grown vegetables, potatoes, fruit and berries;
- choosing sustainable fish;
- avoiding bottled water and palm oil;
- consuming pesticide-free or organic products; and
- limiting rice consumption (Livsmedelsverket 2009).

The guidelines were subsequently withdrawn, however, when the Commission determined that recommendations to eat more locally produced food contravened free trade rules (Dahlback 2010).

Although including sustainability within dietary guidelines is still rare, some countries have managed to do so (*see* Chap. 3). Ministries of health tend to play a key role in developing guidelines with other ministries becoming involved when the guidelines impact on their policies or activities. Although processes differ widely, an overall commitment from government seems crucial, especially to withstand opposition from the food industry and other interest groups (Fisher and Garnett 2016).

Opposition from industry is understandable because many of the recommended changes threaten parts of the agricultural and food processing industry. Cost-benefit analysis from the LiveWell project shows that if recommended dietary habits were to be adopted, agricultural revenues related to the production of vegetables, eggs, and pulses would significantly increase, but not sufficiently to compensate for losses in the meat and dairy industry, while the total income earned by the agriculture and food processing industry overall would decrease. Nevertheless, such financial losses could be outweighed by the environmental and health benefits that would follow including a reduced prevalence of obesity and less greenhouse gases (Alleweldt et al. 2014).

Including sustainability within dietary guidelines has a clear potential to move dietary guidance more towards individual foods and to shift it from giving advice on food groups to making choices about individual foods within food groups (Merrigan et al. 2015). This could favor some parts of the food industry over the others and offer new market opportunities.

4.2 Current Commitments and Policies

Calls to include sustainability into food and nutrition policies have been increasing in recent years. Different actors have made commitments to promote sustainable food systems and healthy sustainable diets at global, regional and local levels.

On 19 November 2014 the UN Food and Agriculture Organization's Second International Conference on Nutrition (ICN2) endorsed the Rome Declaration on Nutrition and its accompanying Framework for Action to guide implementation. More than 2200 participants from 162 member states and many stakeholders from civil society attended the Conference. The Rome Declaration highlights that current food systems are increasingly challenged by climate change, resource scarcity, and unsustainable production and consumption patterns, and that difficulties in providing healthy, safe, and nutrient rich food for all are increasing. Those endorsing the Declaration made a commitment to "enhance sustainable food systems by developing coherent public policies from production to consumption and across relevant sectors to provide year-round access to food that meets peoples' nutrition needs and promote safe and diversified healthy diets".

But although sustainability is mentioned in the ICN2 documents several times, there are very few concrete proposals to align sustainability with health. Several statements and positions made during the meeting reveal tensions including those from the food industry emphasizing the important role that meat and animal products play in nutrition (Report of the Joint FAO/WHO Secretariat 2014). These tensions were also present during very difficult negotiations before the ICN2 Conference itself on outcome documents. Some countries like Finland made proposals to have stronger wording about sustainability and healthy diets in the final commitments but were attacked by food industry lobbyists and received little support from other countries. After lengthy negotiations about the Rome Declaration, the Framework for Action was finalized without proper discussion

among all participants. Brinsden and Lang (2015) have stated that ICN2 can be regarded as a missed opportunity to have a more ecological approach to diet and nutrition.

More positively, the process is not over yet. The Rome Declaration proposed that the United Nations General Assembly consider declaring a Decade of Nutrition Action from 2016 until the year 2025 with existing structures and resources, a proposal to which United Nations General Assembly (2016) agreed. It also calls on FAO and WHO to lead implementation of the UN Decade of Nutrition Action and develop a work program based on the Rome Declaration and its Framework for Action. This work programme (2017) includes developing sustainable resilient food systems for healthy diets as one of the six action areas that refer both to sustainable consumption and production as well as developing commitments and establishing action networks. More than 90 countries have already adopted improved practices in their food systems, 27 countries have activities to reduce food waste, 146 have inter-sectoral coordination mechanisms, and a growing number of countries are considering including sustainability in their food-based dietary guidelines (WHA 2017).

In addition to these global commitments, regional and local commitments have been made by various actors and stakeholders. For example, 133 city mayors and representatives of local governments from all over the world signed the Milan Urban Food Policy Pact (2015) committing themselves to work towards developing sustainable food systems that are inclusive, safe, resilient, and diverse, that provide healthy and affordable food for all people within a human-rights-based framework, and that minimize waste and conserve biodiversity while adapting to and mitigating the impacts of climate change. The Pact calls for cross-sectoral collaboration and policy coherence, and contains a voluntary framework for action with 37 specific areas.

Other similar initiatives within city regions or local areas have been launched such as the C40 Food Systems Network of the world's megacities committed to addressing climate change, the Nordic cities EAT initiative, WHO's Healthy Cities Network, the network of Sustainable Cities in Argentina, and (Mason and Lang 2017) and across Latin America. Sustainable and safe food policies are also one of the ten priority action areas mentioned in the Shanghai Consensus on Healthy Cities (2016).

Food business operators, especially those in the meat and dairy industries, have historically been active in resisting regulations and guidelines on health and sustainability. Today, however, views and action taken by the private, for-profit sector vary widely. More and more companies are making commitments as they identify market opportunities in health and sustainability. Big food companies like Unilever, Nestlé, and Danone set up their own Sustainable Agriculture Initiative in 2002 which has 80 members worldwide. Italian food giant Barilla has funded academics to create guidelines for sustainable and healthy diets, and is actively pushing the sustainability agenda forward. While some of the proliferating corporate actions on food and sustainability can be described as "greenwashing" (Mason and Lang 2017), they do show that the private sector is aware of pressures for change.

In addition many non-governmental organizations and stakeholders such as health professionals have made commitments or statements on sustainability. NGOs focusing on environmental topics are addressing nutrition and health, while those working

in public health are taking up environmental, food, and sustainability perspectives. For example, the Worldwide Fund for Nature (WWF) has produced guidelines for healthy and sustainable diets, while Greenpeace, US Sierra Club, and Friends of the Earth focus on food within their existing lobbying as a vector to redefine policy towards sustainability (Mason and Lang 2017).

A decade ago, the American Public Health Association (2007) made a statement, “Towards a healthy sustainable food system”, covering the improper use of antibiotics, biodiversity, and many other topics. More recently, the European Public Health Association (Birt et al. 2017) has published a paper calling for strategies and action to promote healthy and sustainable diets in European countries including a statutory Sustainable Nutrition Task force, reform of agricultural policies, and development of sustainable dietary guidelines and accountability systems. The US Academy of Nutrition and Dietetics (2016) states in a position paper that appropriately planned vegetarian and vegan diets are healthful, nutritionally adequate, and may provide health benefits in treating certain diseases such as ischemic heart disease, type 2 diabetes, hypertension, certain types of cancer, and obesity. These diets are also more environmentally sustainable than diets rich in animal products because they use fewer natural resources and are associated with much less environmental damage.

4.3 Implementing Commitments and Policies

Implementing commitments made towards healthy and sustainable diets is a complex task that requires many tools. Multiple approaches are potentially useful ranging from improving production efficiencies and creating a more equitable balance of power to changing eating patterns and reducing food waste along the whole supply chain. There are many potential interventions that could influence and change the way we eat, including regulation and legislation, fiscal measures, changing the choice architecture, education, providing information, and raising awareness (Garnett 2014). To get the maximum benefit results, both the production and the consumption of foods need to be influenced.

4.3.1 *Investing in Healthier and More Sustainable Production*

Reshaping food production and food systems is crucial for the health of the planet and for people’s health. Food systems need to become more adaptive and resilient to future changing circumstances, provide nutritious and healthy food for all, act within planetary boundaries, and support livelihoods and the well-being of people working within them. This all requires coherent policy measures.

Food production needs to be progressively shifted towards lower-impact, less-resource-intensive foods that have good nutritional quality. Agricultural practices need to be improved, and investment put into developing new sustainable agricultural

and aquaculture techniques. These changes would benefit from a holistic strategy and good governance that fundamentally acknowledges the critical role that individuals and societies play in the proper functioning of food systems (Gladek et al. 2016).

There are many potential ways that food production can be geared more towards healthy and sustainable food production, including making better use of health impact and environmental impact assessment methods in decision-making processes (*see* Snowdon et al. 2010). A powerful tool to influence food production would be adopting a fiscal policy that promoted sustainability and health. Most developed countries currently provide substantial subsidies to their agricultural sector but sustainability is not taken seriously as part of their allocation.

The European Union's Common Agricultural Policy (CAP) is responsible for around 40% of the EU's budget. More than half of CAP spending goes on meat, dairy, and animal foods; subsidies for fruit and vegetables are far less than those for wine, tobacco, olive oil, and sugar. Moreover, the production within the EU of fruit and vegetables has been slowly decreasing, a worrying trend that requires action (EPHA 2016). The current CAP does not give nutrition much attention. Within the EU, trade, agriculture, and public health experts hold conflicting opinions on nutrition. There is also a lack of clarity on the EU mandate to address nutrition-related health concerns and a lack of understanding about healthy diets (Walls et al. 2016).

It has been suggested that public health and sustainability should become a stronger part of the CAP by means of fiscal tools that would shift support towards more sustainable and healthy options. Concrete proposals include reducing support for the livestock sector and re-allocating subsidies towards rural development programs; using nutrient profiling as criteria for school milk subsidies; and ending preferential treatment for the wine sector including promotional measures. Consumption of fruit and vegetables could be boosted by policy actions while fiscal tools could be deployed to promote both the production and consumption of fruits and vegetables (EPHA 2016).

In the USA agricultural policies have been similarly counterproductive for public health; it is often asserted that the US food system is unhealthy, inequitable, and unsustainable. Antimicrobials are used in raising animals to prevent diseases but in such high doses that they can also serve to promote animal growth. Federal farm bills have favored big companies and supported the growth of cheap oils, grains, meat, and processed foods over the production of fruit and vegetables. Minor amendments to the 2014 Farm Bill did support more diverse and sustainable forms of production, including increased funding for research on fruit, vegetables, and organic crops; federally subsidized crop insurance for farmers growing fruit and vegetables; and insurance payouts for organic producers, but more action is still needed. This could include prohibiting the use of antimicrobials in animal rearing when there are no diseases present, removing distortions in agricultural markets that disincentive fruit and vegetable production, using nutritional standards as criteria for support, discontinuing incentives for the use of corn and soy as biofuels, and providing support for farmers using agro-ecological methods (Shannon et al. 2015).

Globally, investing in agriculture that supports small-holders and acts so as to eradicate hunger and support healthy and sustainable food habits is essential. Most of the 800 million people who go hungry in the world work in agriculture themselves.

Government spending on agriculture is generally low and has been decreasing with a negative impact on many poor farmers. Nevertheless, there are also new funding mechanisms and cooperation initiatives such as community cooperatives that have successfully developed alternative financial investment schemes for small-scale producers in Africa and Latin America (Hilmi and Nærstand 2017).

4.3.2 Education and Information

Education is an essential part of the action that needs to be taken to bring about healthier and more sustainable diets. Ideally it should start as early as possible in children's lives and include not just reliable and attractive information but also practical skills and support to behavior change. Education should include future parents and families with children and continue through educational settings, supported by health care systems and institutions providing consumer information.

To help consumers make informed choices and to orient production and consumption patterns towards more sustainability, it is essential to make available adequate information about sustainable dietary patterns and characteristics of products as well as other relevant information such as guidelines for recycling and waste management. Moreover, education has a more powerful effect if it can be combined with practical skills such as cooking and food handling, and illustrated by models of behavior that can influence lifestyles.

For example, providing healthy and sustainable school meals together with teaching about health, nutrition, cooking skills, and sustainability is a useful tool in promoting healthy and sustainable food habits. School meals are more than food: they can also be part of an educational system that supports learning capacity, healthy lifestyles (Sarlio-Lähteenkorva and Manninen 2010) and a sustainable future. Unfortunately this potential is rarely utilized.

A survey assessing school food in Vancouver's state schools by Black et al. (2015) illustrates some of the challenges. None of the schools in the study were fully supporting the initiative of integrating healthy and environmentally sustainable food in the curriculum. Schools scored highest in the areas of school gardening, compost systems, and integration of food-related teaching and learning activities, but in promoting the availability of healthy and sustainable food were taking only initial steps. Likewise, a study from the UK by Fairchild and Collins (2011) shows that the average school meal among secondary school students fails to meet nutritional standards and guidelines but still has an ecological footprint more than twice that of a typical resident. Most commonly purchased products were soft drinks and more than half the ecological footprint came from meat and dairy. The authors call for attention to be paid to changing pupils' purchasing behavior.

There are also many challenges in providing information and education outside the school setting. At present, various messages are circulated through diverse channels but all with very different objectives. The substantial commercial marketing of unhealthy foods counters and attacks information on healthy diets. It has been estimated that for every dollar the World Health Organization spends on

preventing diseases caused by unhealthy Western diets, the food industry spends more than 500 dollars promoting those same diets. Industry marketing of unhealthy foods high in salt, fat, and sugar content to vulnerable groups such as children has increased in recent years but the promotion of healthier alternatives has not kept pace with it. Yet there has been progress in food labeling in the USA and EU while an increasing number of countries are introducing mandatory nutrition labeling (Mason and Lang 2017).

Communicating sustainability by means of food labels is more complicated. There is a multiplicity of signs and labels for different dimensions of sustainability such as the Fairtrade certificate indicating that farmers and workers obtain good prices and have decent working conditions in developing countries, organic labels for specific production methods, and carbon footprints indicating the environmental impact of a product. Overall, at least 148 different labeling schemes for sustainability have been identified globally (Neto et al. 2016), most of them directly addressing only some dimensions of sustainability. Paradoxically labels that cover broad dimensions of sustainability are more difficult to communicate whereas simple messages such as “dolphin friendly” on tins of fish have proved to be very effective. Moreover, sustainability concerns are intertwined with other food quality attributes in consumers’ attitudes towards foods. The most commonly stated motive for buying organic food, for instance, is concerns about personal health, although health is not a criterion for a product to be certified organic. Unsurprisingly many consumers are very confused about sustainability and have difficulty even in understanding terms such as green, organic, natural, and environmentally friendly (Meybeck and Gitz 2014).

Moreover, changing food-related behavior is not easy – it is often easier to change non-food behavior. Social, cultural, and personal values associated with foods need to be addressed. For example, consumers may not be willing to reduce their intake of foods they value highly like meat, or may not be aware of the association between food consumption and climate change or skeptical of its scientific evidence (Macdiarmid et al. 2016). Motivational factors also vary. Consumers who avoid red and processed meat are motivated mostly by animal welfare and human health concerns, less by those of environmental sustainability (Clonan et al. 2015).

In general, consumer awareness of the environmental impact their diets have is very low. People underestimate the environmental impact of meat consumption itself compared with other behaviors such as using less packaging or eating locally grown produce. Only a minority are ready to reduce their meat consumption for ecological reasons, women being somewhat more likely to do so than men. People also have a low acceptability threshold for unfamiliar foods like insects or for foods they perceive to be unnatural such as cultured meat. Consumer information about the environmental impacts of various food choices certainly helps in encouraging people to adopt new behaviors but other strategies such as nudging, improving taste, and increasing the familiarity of alternatives are equally important (Hartmann and Siegrist 2017).

Even a consumer trying to eat a healthy and sustainable diet can find choices and options difficult. Providing information is important but is not enough. Gjerris et al. (2016) point out that many consumers are confused as to how they should act responsibly given the many approaches and trade-offs entailed in different notions

of sustainability. Moreover, buying products labeled as sustainable do not have a direct and personal impact on a consumer unlike those described as healthy. It can also be argued that consumers should not be pressured to make their decisions based on sustainability criteria given that they are far from being the most powerful stakeholders in the food value chain; sustainability decisions should be made much earlier in a food system. New modes of governance could engage the general public in their capacity as citizens rather than as consumers.

4.3.3 Choice Architecture and Nudging

The immediate environment strongly influences the choices that people make. We buy what is easily available and we usually like what we are used to eating. To promote healthy and sustainable diets, the choice architecture of our food environment can be altered. Choice architecture refers to both the informational and physical structure of an environment that influences the ways in which people make choices. The changes made in this choice architecture such that individuals make more desirable choices almost automatically are called nudges.

A review by Lechner et al. (2016) shows that different types of nudges can be effective. For example, reducing plate diameter or portion size significantly reduces food waste and calorie intake. Having a milk dispenser or water pitcher close to a dining area results in an increased intake of water. Providing simplified information and visual markers such as carbon footprints have proved to influence purchases. Relying on people's adherence to social norms by providing information on ideal types of behavior works particularly well if a behavior is publicly visible and there is general uncertainty as to what appropriate behavior is. The best results have been achieved where nudging is applied without the counteracting effects of commercial marketing. Individuals also need to have positive attitudes and an understanding of the recommended behavior for nudging to be effective. If individuals are nudged to less meat but do not have an internal conviction that doing so is desirable, compliance tends to be low. Nudging should therefore be preceded by information and education aimed at people understanding the underlying policy and rationale.

Incorporating choice architecture into food service guidelines may include using default options (for instance, serving salad instead of chips), payment strategies (such as cookies being purchased only with cash), and placement organization (for example, making recommended food the most accessible or locating only healthy and sustainable options near the checkout lines). Comprehensive approaches using multi-component strategies have proved to be the most successful (Kimmons et al. 2012). Potentially effective options could also include adjusting canteen and store layouts, designing attractive branding, and marketing vegetarian foods or vegetarian meal deals (Garnett 2014).

A holistic approach is needed for a general shift towards healthy and sustainable diets. Food consumption is typically based on habits and unconscious processes rather than on rational informed decisions. Time and effort is needed to break

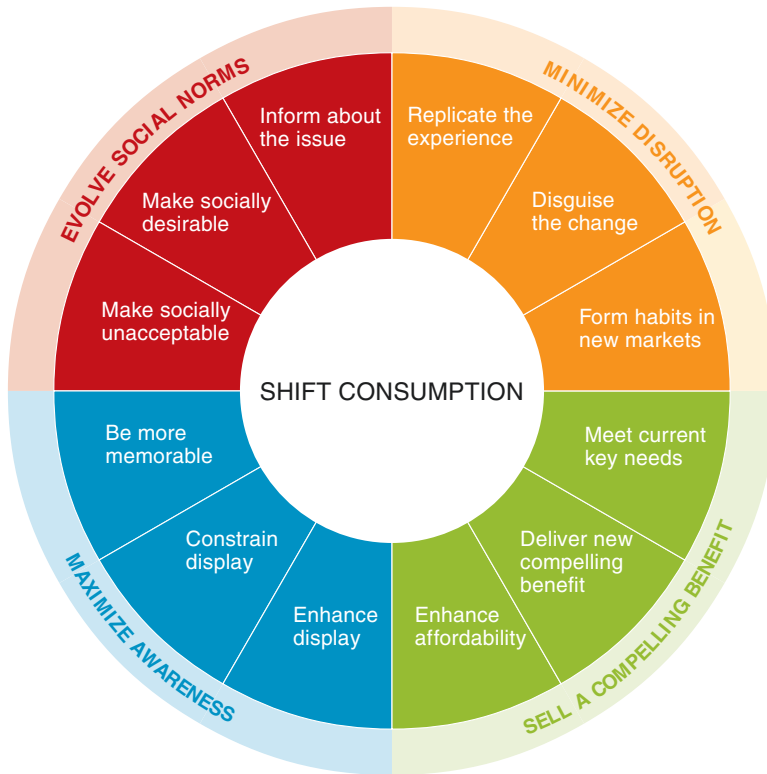


Fig. 4.1 The Shift Wheel with four strategies to shift consumption (Source: Ranganathan et al. (2016) World Resources Institute. Reprinted by permission of the publishers)

current habits and establish new ones. The World Resources Institute suggests a “Shift Wheel” framework (*see* Fig. 4.1) comprising four complementary strategies to shift consumption patterns:

1. minimize disruption;
2. sell compelling benefit;
3. maximize awareness; and
4. evolve social norms.

As any change in taste, look, texture, packaging or even in-store location can be a major barrier to changing consumers’ food behavior, minimizing disruption for consumers refers to strategies such as replicating familiar characteristics – making meat substitutes look and behave like meat, for instance – or disguising the changes, such as gradually replacing some of the meat with vegetables. Selling the compelling benefit involves marketing a product by emphasizing an attribute known to motivate consumption such as animal health, healthiness, or lower price. Maximizing awareness can include improving the visibility or memorability of recommended choices while constraining those for undesired foods. As social norms influence all of us,

making certain foods or behaviors socially desirable or socially unacceptable can change behaviors. When celebrities such as UK chef Jamie Oliver spoke out in favor of free-range eggs, sales of such eggs increased while campaigns against eating shark fins challenged the social acceptability of doing so (Ranganathan et al. 2016).

Despite these positive indicators, evidence also suggests that nudging may not be enough to bring about significant behavioral shifts. Bigger changes in choice architecture are essential, requiring shoves more than nudges (Mason and Lang 2017).

4.3.4 Public Procurement for Healthy and Sustainable Meal Services

Public procurement refers to goods and services purchased with public money by governments and state-owned institutions. Public sector procurement represents about 13–20% of Gross Domestic Product (GDP) in OECD countries while estimates for developing countries are significantly higher (Smith et al. 2015). Food services are an important part of public procurement. Changing institutional food services is a promising strategy to shift dietary patterns towards more healthy and sustainable diets. The overall purchasing power of public institutions can potentially have large-scale impacts at individual, community, and national levels. Indeed, procurement of healthy food could reduce food insecurity and diet-related diseases (Freudenberg 2016). The US federal government has developed guidelines to make sure that healthy and sustainable foods are available at federal workplaces (Kimmons et al. 2012).

Guidelines for institutional food services with health and sustainability criteria have also been developed and implemented at universities, cities, counties, states, and federal agencies. A basic approach to determining dietary standards is to adapt or adopt a set of scientifically based guidelines. Sustainability guidelines include standards on local or regional purchasing and on production methods such as organic or other sustainability certification. Changing food service practice requires comprehensive analysis, engagement, and education of all relevant stakeholders ranging from institutional management through to individual customers (Kimmons et al. 2012). A study by Mikkelsen and Sylvest (2012) shows that implementing changes in food services such as using organic foods involves not only instituting new routines in the purchase and preparation of foods but also organizational changes including in documentation and capacity building while implementing strategies to overcome problems such as insufficiency of supply and price premiums. Interestingly, the introduction of organic foods in Denmark led to the menus being reformulated with less meat and more of a focus on health.

To promote healthier food choices, it is useful to have clear nutrition criteria and standards establishing which foods and beverages are eligible to be purchased and served for use in policies, bids, and contracts for food services. These

criteria could include nutrients to avoid as well as foods and beverages to be encouraged. Gardner et al. (2014) have analyzed food procurement standards for worksites in the USA developed by stakeholders ranging from non-governmental organizations and government agencies to the food industry. Standards focus on nutritional quality but also include topics like product placement, pricing, nutrition education or some elements of sustainability. Most of these standards are based on evidence-based recommendations of nutrients that should be avoided in excess such as salt, saturated fats, trans fats, sugar, and energy. Standards set by different stakeholders are broadly similar but those drawn up by the private sector tend to be less strict. There are also standards promoting vegetarian options and environmental sustainability by increasing organic, local, seasonal, and sustainable food as well as of meat from grass-fed animals. The authors point out that some standards have a more established history and are more evidence-based than others; they recommend relying on evidence-based approaches in future standard-setting.

Niebylski et al. (2014) reviewed 34 studies of various healthy food procurement programs implemented mostly in schools and worksites but also in hospitals, care homes, correctional facilities, government institutions, and other miscellaneous settings. The programs varied greatly from promoting foods like fruit and vegetables to specific food-based standards. Nearly all programs were effective at increasing the availability of healthier food and increasing the intake of healthier foods such as fruit and vegetables while lowering that of food high in fat, sodium, and sugar. Most policies included other components as well such as education, supporting price policies, and health interventions, which may be critical factors for success.

Green Public Procurement (GPP) – the public purchasing of products and services that are less environmentally damaging – is increasingly being used to achieve environmental protection policy objectives. The OECD and European Commission have produced general guidelines and recommendations on GPP. The reviews and market analysis of the public procurement of food and catering services in the EU carried out by Neto et al. (2016) show a multitude of approaches in different member states. These include setting criteria on production methods such as organic production or not using genetically modified organisms (GMOs), quality labels, reduction of ingredients like red meat, management of waste and energy, animal welfare, and packaging. Some states used innovative approaches to buying local food by using criteria such as freshness or avoiding air transport.

Unfortunately these GPP criteria do not mention health or nutritional quality. Indeed, green procurement tends to focus on selected areas of environmental concern only. It has been suggested that sustainable procurement should encompass all pillars of sustainability, integrating social and health priorities as well but this rarely happens. A study using the expertise and case studies from the European Commission-funded Foodlinks project reveals that some communities have nutritional quality as a part of their public procurement policy but environmental criteria, including eating less meat and more organic and seasonal food, seems to be the

dominant approach in sustainable public procurement. There is a scarcity of data about approaches that have both nutrition and health as a part of their procurement criteria (Smith et al. 2015).

Unfortunately procurement policies that include different dimensions of both sustainability and nutrition are rare. Moreover, most guidelines are voluntary and focus on improving access to better options without limiting the availability of other options. There is clearly room for stronger, evidence-based and -informed policies with transparent processes, effective implementation, and proper monitoring so that public bodies can provide healthy sustainable meals in future.

4.3.5 *Fiscal Tools*

Consumer choice of food items is mostly influenced by price, followed by people's habits and taste preferences (Meybeck and Gitz 2014). Therefore, fiscal policies such as taxes and subsidies have a great potential for shifting consumer behavior towards sustainable and healthy diets. Taxing products that are potentially harmful for the environment or consumers' health is a way of internalizing these costs to the companies that make profits from selling them. Otherwise these costs fall on those who suffer the damages such as society and communities or individuals that have to face an increased burden of disease or a despoiled environment. As cheap food does not reflect the true costs of producing or consuming it, fiscal policies can redress the balance to a degree.

But data on fiscal measures is still limited. Different approaches need to be investigated and implemented such as environment-linked production and consumption incentives and disincentives (for instance, taxes and subsidies), personal carbon budgets and a livestock headage tax (Garnett 2014).

Existing studies on health-based fiscal measures on food and drink show promising results. A systematic review by Niebylski et al. (2015) showed consistent evidence that taxing unhealthy foods like soft-drinks and subsidizing healthy foods such as fruit and vegetables influences dietary behavior. To maximize success and effects, the authors suggest that food taxes and subsidies should be set at a minimum of 10–15% and preferably used in tandem.

Some other studies have estimated both the environmental and health impacts of fiscal measures. Spingmann et al. (2016), for instance, estimated the climate change mitigation potential and the health impacts of levying taxes on food commodities based on their greenhouse gas emissions. Data from 150 world regions and 62 agricultural commodities was analyzed. Taxes varied by region and different model scenarios were tested. The results show that levying taxes based on greenhouse gas emissions could be both a health-promoting and climate-friendly policy in all high-income countries, and in most middle- and low-income countries. A regionally optimized tax scenario with maximum health benefits reduced mortality by about 510,000 avoidable deaths and led also to a 8.6% reduction in global food-related greenhouse gas emissions, about two-thirds of which were due

to reduced consumption of beef, and one-quarter to reduced milk consumption. To optimize health benefits, part of the tax revenues could be used to subsidize consumption of recommended foods like fruit and vegetables.

Special attention is needed, however, to make sure that low-income countries and vulnerable groups do not experience negative health consequences. Indeed, people from lower socioeconomic groups obviously have lower incomes, tend to buy cheaper foods, and spend a larger portion of their food budget on meat and dairy products. A greenhouse gas emission-based tax is therefore regressive in that its burden falls disproportionately on households with a lower socioeconomic status. Taxing foods on their emissions only could result in low emission foods such as candy or soft drinks becoming more tempting for consumers. There could also be unintended health consequences if such a tax fails to take into account high-emission foods that are beneficial for health like milk (Kehlbach et al. 2016).

A modeling study by Abadie et al. (2016) calculated the optimum combination of taxes and subsidies for 16 foods in Norway so as to obtain a diet with both reduced emissions and better nutritional quality than the country's current one. Their results show that different emission targets ranging from a 2.5% reduction to 10% reduction lead to a different combination of foods. Reducing emissions by 7.5% seemed to lead to the lowest level of sugar and saturated fat in a diet, which contained less red meat, cheese, soft drinks, and eggs than the present one but more poultry, fish, and milk. The envisaged 7.5% reduction in greenhouse gas emissions was obtained by imposing an 18–40% tax on meat from ruminant animals, coffee, tea, soft drinks, candy and sugar and providing 15–40% subsidies on eggs, milk, poultry, and fish.

Caillavet et al. (2016) studied the potential effect that taxes on specific animal-based foods could have on emissions of three gases: the greenhouse gas carbon dioxide (CO_2), sulphur dioxide (SO_2) which is implicated in air acidification, and nitrogen dioxide (N) which is directly related to the eutrophication of water. They also studied the effect of such taxes on the diet quality of different socioeconomic groups. Their modeling scenario, which included both nutritional quality and environmental benefits, showed that a 20% increase in the price of beef, cooked meats, animal foods high in fat, cheese, and prepared meals resulted in a 7% reduction in CO_2 , 13.2% reduction in SO_2 and 6.6% reduction in N while improving diet quality because of less salt and saturated fat and more vitamins and minerals. The highest environmental impact was seen in low-income families with the youngest children. Modelling indicated an especially improved diet among older groups of people while nutritional inequalities between different groups slightly narrowed.

Clearly any fiscal policy should be carefully designed. A WHO (2016) technical report highlights how important are a proper situation analysis using all relevant information, appropriate objective setting, an implementation plan that includes advocacy for political buy-in, monitoring, and evaluation. Issues that need attention include price elasticity, substitution effects, regressive outcomes, and tools to identify and define products to be included.

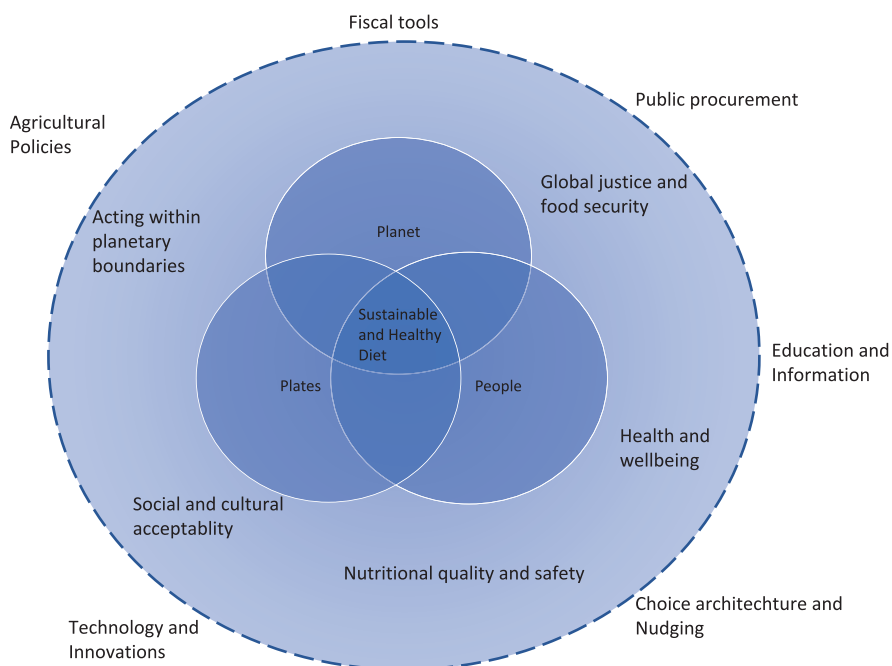


Fig. 4.2 Towards policies to promote healthy and sustainable diets

4.4 Towards Ensuring a Healthy Sustainable Diet Is a Goal of All Public Policies

As emphasized earlier, people need to fill their plates with foods that are not only good for them but also good for the planet. In addition to planetary boundaries, human societies and their governing structures need to pay attention to food security and global justice, cultural and social acceptability, and nutritional quality, health and well-being to ensure that both people and planet are sustained both now and in the future. To this end, we need various approaches as illustrated in Fig. 4.2 including investment in healthier and more sustainable food production, education and information, choice architecture and nudging, fiscal tools and better public procurement policies.

To this end, sustainable and healthy diets need to be on the agendas of decision makers in all sectors of society, both private and public, in areas ranging from environment, health, and agriculture to tax, subsidies, and trade. Policies need to be multisectoral and multidisciplinary operating on multiple levels from local and national to regional and global. As this requires raising awareness, education, media, and communication of research are of paramount importance. Permanent institutional structures ensuring that the healthiness and sustainability of diets is addressed whenever decisions are made on food systems and the food environment are essential.

International commitments have certainly been made, including setting Sustainable Development Goals to be achieved by the year 2030 under the auspices of the United Nations General Assembly (2015), but such commitments are of little value if world leaders and others fail to recognize environmental and health threats and do not implement appropriate measures. Given the many competing approaches, it is crucial that different food-related agendas and values – human health, planetary health, animal welfare, cultural dimensions – are reconciled with each other better than they are at present, especially given that there are many potential synergies in the promotion of healthy food and of sustainability. But a study by Risku-Norja et al. (2014) of national level policy documents in Finland showed that, despite adopting and promoting a Health in all Policies (HiaP) approach, potential synergy advantages between human and environmental well-being were poorly made use of.

Good governance, leadership, and cooperation are indispensable if sustainability is to be achieved. In the field of human health it is well known that people's health is largely produced by factors and influences outside the health sectors per se, and the benefits of multisectoral action are recognized. Multisectoral actions can be carried out in different ways, as reviewed by Bowen and Ebi (2015), but all require systems-based approaches, enabling structures, resources, and leadership. A Health in all Policies approach incorporates health impacts into the policy development processes of other sectors, while a One Health approach uses collaborative networks to address zoonotic infectious diseases that originate at the animal-human-ecosystem interface. There are also important lessons to be learnt from disaster and risk management and from WHO's Commission on the Social Determinants of Health that places equity at the center of all planning, policy, and decision-making. In the future we need approaches that integrate and combine all these elements together.

Given that the issues are complex and that sector-driven strategies have failed, increased inter-linkages between sectors require new integrative approaches. Integration could be achieved by bringing different sectors together to work out joint modeling approaches or joint action plans on topics such as food, water, and energy – the water, energy, and food nexus is currently popular in environmental management (Al-Saidi and Elagib 2017) – or by cross-linking different sectors or assimilating them under one roof.

Many tools can help decision makers identify the potential effects of different policy options. Policymakers can use environmental impact and health impact assessments to inform themselves about the prospective trade-offs involved and to enable politicians make decisions based on the best available information. Snowdon et al. (2010) used combined a health impact assessment with feasibility and effectiveness assessments to improve the food environment in Fiji and Tonga. The entire process involved three basic steps:

1. identifying problem policies and gaps that contribute to an unhealthy food environment;

2. identifying potential policy solutions; and
3. assessing solutions to identify a shortlist of those most recommended for implementation.

Potential health impacts in different population groups were identified followed by a qualitative estimate of their likelihood and size of effect. A feasibility assessment encompassed technical feasibility, cost, political acceptability, cultural acceptability, and trade-related legality. Stakeholders were then invited to give their views on the relative importance of these issues and, guided by the available evidence and data, to assess the potential effectiveness of different options. This participatory process included identifying potential negative and positive side effects, and those potentially affected, followed by estimating the probability, severity, and evidence for the negative effects and suggesting possible actions to counteract them. The successful process provides a systematic way of appraising and understanding those policy interventions that show the most promise (Snowdon et al. 2010). A similar participatory process covering environmental effects and pathways as well could be useful in drawing up policies to promote healthy and sustainable diets. In countries that already have guidelines for sustainable and healthy diets, the starting point could even be identifying potential policy options to implement the guidelines.

Public health nutrition and sustainability are “fiendish” policy problems: they are complex in themselves and their causes and solutions are unclear and contested. Food policies and environmental policies are linked and have flow-on effects on other sectors and systems. Lawrence et al. (2015) present a change schema for food systems to describe the potential of three types or stages of change: adjust, reform, and transform. In the adjustment model, the focus and solutions can be found within the systems themselves, examples being technical innovations to improve resilience within existing structures. The reform model addresses structural and operational shortcomings across sectors, bringing relevant stakeholders together to solve the problems by reforming both structure and operation. In the transform model, the function of a food system is reoriented towards integrating all the relevant departments while promoting empowerment and social inclusion. A combination of all three orders of change may be needed to redesign food systems towards healthy sustainable diets.

Data and research to support policies aiming at healthy and sustainable diets are also essential, as is selecting the best possible tools to collect data and carry out research. In particular, we need to gain more knowledge about sustainable healthy eating patterns and about the health and sustainability implications of current dietary habits in different socioeconomic and demographic groups. Learning more about the social, economic, and policy influences that shape our dietary habits and how to bring about the change needed to shift towards more sustainable and healthy diets is essential. Also fundamental are measuring, monitoring, and accountability mechanisms in place.

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