

Understanding Sustainable Diets: A Descriptive Analysis of the Determinants and Processes That Influence Diets and Their Impact on Health, Food Security, and Environmental Sustainability^{1–3}

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ABSTRACT

The confluence of population, economic development, and environmental pressures resulting from increased globalization and industrialization reveal an increasingly resource-constrained world in which predictions point to the need to do more with less and in a “better” way. The concept of sustainable diets presents an opportunity to successfully advance commitments to sustainable development and the elimination of poverty, food and nutrition insecurity, and poor health outcomes. This study examines the determinants of sustainable diets, offers a descriptive analysis of these areas, and presents a causal model and framework from which to build. The major determinants of sustainable diets fall into 5 categories: 1) agriculture, 2) health, 3) sociocultural, 4) environmental, and 5) socioeconomic. When factors or processes are changed in 1 determinant category, such changes affect other determinant categories and, in turn, the level of “sustainability” of a diet. The complex web of determinants of sustainable diets makes it challenging for policymakers to understand the benefits and considerations for promoting, processing, and consuming such diets. To advance this work, better measurements and indicators must be developed to assess the impact of the various determinants on the sustainability of a diet and the tradeoffs associated with any recommendations aimed at increasing the sustainability of our food system. *Adv. Nutr.* 5: 418–429, 2014.

Introduction

The current global agricultural system is producing enough food to feed the planet, but access to and consumption of sufficient food that is culturally acceptable, affordable, and nutritious is more challenging (1,2). Population growth projections for the next 10–50 y further highlight the need for improving the quality and environmental sustainability of our food system, especially given the challenges imposed by climate change and increasing population growth with a rising appetite for environmentally costly animal source foods (3,4).

Agriculture intensification, poverty, population pressures, urbanization, and lifestyle changes altered food production

and consumption in ways that profoundly affect the health of our diets (4,5). The alarming pace of biodiversity loss and ecosystem degradation concomitant with their negative impact on farming systems, livelihoods, and health make a compelling case for re-examining food systems and diets from a sustainability and public health perspective.

Global dietary patterns changed dramatically in the past 50 y, presenting both a boom and a threat to the health and well-being of populations everywhere (6). Today, people are consuming foods that pose the greatest negative impacts for their health and the environment (7). Increased incomes are accompanied by increased consumption of diets high in meat, dairy, oil, salt, and processed foods. At the same time, the globalization of the food system has contributed to environmental degradation and biodiversity loss, while lowering prices for diets high in energy but low in variety and important nutrients (4). Coupled with urbanization and increasing sedentary lifestyles, there is an unprecedented rise in obesity and, subsequently, noncommunicable diseases, such as cardiovascular disease, diabetes, and hypertension.

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These trends reveal an alarming increase of such health issues across low-, middle-, and high-income countries (8). Although >1 billion people worldwide are overweight and obese, 868 million people are suffering from hunger, and another 2 billion are suffering from micronutrient deficiencies (2). This is the existing global imbalance, a “triple burden” despite the first Millennium Development Goal (MDG1)⁷ to halve hunger by 2015 (8,9).

Historically, there has been little global effort directly addressing the triple burden. As a consequence, there has been low momentum or focus other than broad statements (or initiatives) acknowledging food security, hunger reduction, undernutrition, and less attention on how to tackle the rise in noncommunicable diseases and overweight and obesity from a health, environmental, and development or holistic or systems approach.

Modest Advancements

The 2000 Millennium Declaration committed nations to 8 time-bound health and development goals aimed at eradicating extreme poverty by 2015. One of the targets of MDG1 is to reduce the proportion of people who suffer from hunger between 1990 and 2015 by 50% (10). This target measures hunger as the proportion of the population who are undernourished as measured by energy consumption and the prevalence of children younger than 5 y who are underweight (10). Although progress to meet MDG1 has been mixed, the analysis by UNICEF reveals that the proportion of children younger than 5 y who are underweight declined from 28% to 17% between 1990 and 2011 (11). Additionally, the number of countries on track to achieve MDG1 increased from 46 in 2008 to 63 in 2011 (of 117) (12,13). These modest advancements are still insufficient to meet the MDG target to halve hunger globally with <600 d remaining. Considering increased food price volatility, large-scale land acquisitions in the name of food security, higher amounts of biofuel use, and the negative impacts of unsustainable agricultural practices, the task for reducing global hunger will be more difficult as time goes by (12,14,15).

The common vision statement from the Rio+20 Summit “The Future We Want” argues for sustainable development and “the promotion of economically, socially and environmentally sustainable future for our planet and for present and future generations” (16). At the June 2012 Rio+20 Summit, UN Secretary General Ban Ki-Moon launched the “Zero Hunger Challenge” (Table 1), calling on all nations to work toward a future in which everyone enjoys their right to food and all food systems are resilient. As part of the post-2015 development agenda, a set of sustainable development goals (SDGs) will be created that focus on economic development, social inclusion, and environmental sustainability, with the notions and benefits of sustainable diets central to achieving the proposed SDGs (16,17).

⁷ Abbreviations used: GHGE, global greenhouse gas emission; MDG, Millennium Development Goal; MDG1, the first Millennium Development Goal; SDC, Sustainable Development Commission; SDG, sustainable development goal.

TABLE 1 Zero hunger challenge objectives

100% access to adequate food year round
No more stunted children younger than 2 y, no more malnutrition in pregnancy or early childhood
All food systems are sustainable
100% growth in smallholder productivity and income, particularly for women
Zero loss or waste of food, including responsible consumption

Nutrition has been dominated by the study of specific nutrients, nutrient deficiencies, and sometimes specific foods or food groups and their impact on health and nutrition. In recent years, a number of initiatives and studies focused more directly on the question of diets and their impacts on human health, the environment, and food systems. In 2010, the FAO led an effort to develop the following consensus definition for “sustainable diets”: those diets with low environmental impacts that contribute to food and nutrition 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, are nutritionally adequate, safe, and healthy, and optimize natural and human resources (18). Although elaborate, this definition reflects the recognition that the health of human beings cannot be isolated from the health of ecosystems.

The Chicago Council⁸ found in its study, *Bringing Agriculture to the Table*, that diet-related noncommunicable diseases are on track to rise by 15% by 2020 if current trends in the global commercialization of processed foods continue to be overconsumed by an increasingly less active global population (1). Currently, the global food system is estimated to contribute to 30% of global greenhouse gas emissions (GHGEs). With the global population expected to rise to 9 billion or more people by 2050, the Foresight Project⁹ found that rising demand to transport, store, and consume the most resource-intensive food types (namely dairy and meat) in developing economies will further increase the contributions of food and agriculture to environmental degradation and climate change (4). At the same time, the Livewell Project¹⁰ found that UK diets could in fact be rebalanced in line with the government’s dietary guidelines (the Eatwell Plate) to achieve GHGE targets for 2020 by substantially reducing meat and dairy consumption (19). However, looking to GHGE targets for 2050, researchers noted that changes would be needed in both food production and

⁸ The study by the Chicago Council on Global Affairs “Bringing Agriculture to the Table” examined the rising occurrence of diet-related noncommunicable diseases and the extent to which our modernized food system is contributing to increased health risks around the world, especially for the poor.

⁹ The Foresight Project explored the pressures on the global food system given a rising global population of 9 billion or more between now and 2050 and the decisions that policymakers would need to make in the coming years to ensure a system that can equitably and sustainably feed future generations

¹⁰ The World Wildlife Federation–sponsored Livewell Project mapped the current eating habits in the United Kingdom and compared them with the current eating advice of the UK government (the Eatwell Plate) to ascertain how it might be adapted to include environmental considerations. The intent was to produce a “sustainable diet” that was both nutritionally viable and less harmful to the environment.

consumption to reach these longer-term targets (7). Recent analysis of the new Nordic Diet found that improvements in GHGEs and other environmental wins could be achieved by improving production, reducing transportation, and changing food types (20). Similar recommendations followed an analysis of dietary shifts in France (21).

Moving beyond this Livewell Project effort to construct a sustainable diet, the UK Sustainable Development Commission (SDC)¹¹ examined the synergies and tensions among public health, environmental sustainability, social inequalities, and economic stability in the development of sustainable diets. The SDC found many win-win scenarios associated with advancing sustainable diets, but researchers acknowledged gaps in the analysis, especially concerning the economic impacts and tradeoffs for agricultural producers that may be associated with any proposed dietary changes (22). Most recently, the Overseas Development Institute and the Institute of Medicine of the National Academies in the United States examined in separate reports¹² the considerable strain that current diets are putting on natural resources and the synergies and tradeoffs associated the food system in the United States and other major food systems. Both studies reported wide variance in diets and their influences, as well as substantial opportunities to influence diets through policy but a lack of political will to do so right now (21–23).

All of these initiatives agree on 2 primary recommendations to promote sustainable diets: 1) additional analysis is needed to understand sustainable diets, how they work, and their impacts and 2) closer involvement and coordination of stakeholders across a broad spectrum of sectors are necessary to effectively develop programs and policies that promote sustainable diets and meet common goals for sustainable development now and for the future.

There is an urgent need to develop and promote innovative strategies for understanding, measuring, and promoting sustainable diets and food systems in human health and nutrition: it is crucial to rethink both quantitatively and qualitatively how food is produced, processed, marketed, and consumed. The balance of this review describes what a sustainable diet is, examines the considerations for measuring the sustainability of diets, and presents the tradeoffs associated with them. Finally, this review aims to clarify the roles and contributions of stakeholders to the promotion and governance of this issue. Ultimately, it is hoped that this work will assist future research and help affect policy that will guide culturally sensitive and context-specific practices and programs at the global and local levels.

Why Sustainable Diets and Why Now?

Sustainable diets present an opportunity to successfully advance commitments to sustainable development and the elimination of poverty and food insecurity. The FAO, SDC, Livewell Project, and others are advancing by consensus a definition of sustainable diets. They also are providing guidance concerning the benefits of promoting and consuming such diets. For example, sustainable diets promote environmental and economic stability through low-impact and affordable, accessible foods, while supporting public health through adequate nutrition. Importantly, sustainable diets help promote sovereignty and preserve tradition involving culturally sensitive and acceptable foods (Table 2) (6,7,18). The final report of the Chicago Council makes a strong call for action now to mitigate risks to future food systems and their ability to produce sufficient food in a sustainable manner, as well as offset projections for poor health outcomes due to undernutrition and overweight and obesity (1).

To advance commitments to sustainable diets as a central aspect to sustainable development, there is a need to address the gaps in understanding of what constitutes a sustainable diet for different populations and contexts. Additionally, there is a need to understand how these diets can be assessed within the global food system and how environmental sustainability in consumption patterns and dietary goals can be achieved. Finally, there is a need to examine how (sustainable) diets can help transform the health of populations, while promoting economic development and the slowing of environmental degradation. Although many of these processes are underway, they are not yet receiving due political attention or support. This is partly because of the complex web of interactions between food systems, industry, the environment, public health, and consumer behavior and the challenges policymakers face in making appropriate choices whether they are in government, commerce, or civil society (24).

Defining and Linking the Determinants of a Sustainable Diet

Although the concept of a sustainable diet is not a new one, it is a complex issue with many gaps in our understanding of what such a diet might comprise. The term sustainable diet was first introduced in 1986 by Gussow and Clancy (25) in which they argued that promoting food sustainability and ecologic harmony were essential to promoting a healthy diet for the individual. The concept remained dormant in the following years as the support for industrialization and intensification of agricultural systems and food globalization

TABLE 2 Positive impacts of sustainable diets

Public health: reduced diet-related chronic disease, nutrient deficiencies
Environmental sustainability: mitigation of climate change and natural resource depletion
Economic sustainability: employment, trade opportunities, incomes
Social inequalities: close gaps in health, incomes in developed and developing countries
Other possible benefits: psychologic and physical well-being, animal welfare, cultural and social diversity, and knowledge sharing

¹¹The SDC initiative assessed the synergies and tensions between public health, environmental sustainability, social inequalities, and economic stability in the development of sustainable diets.

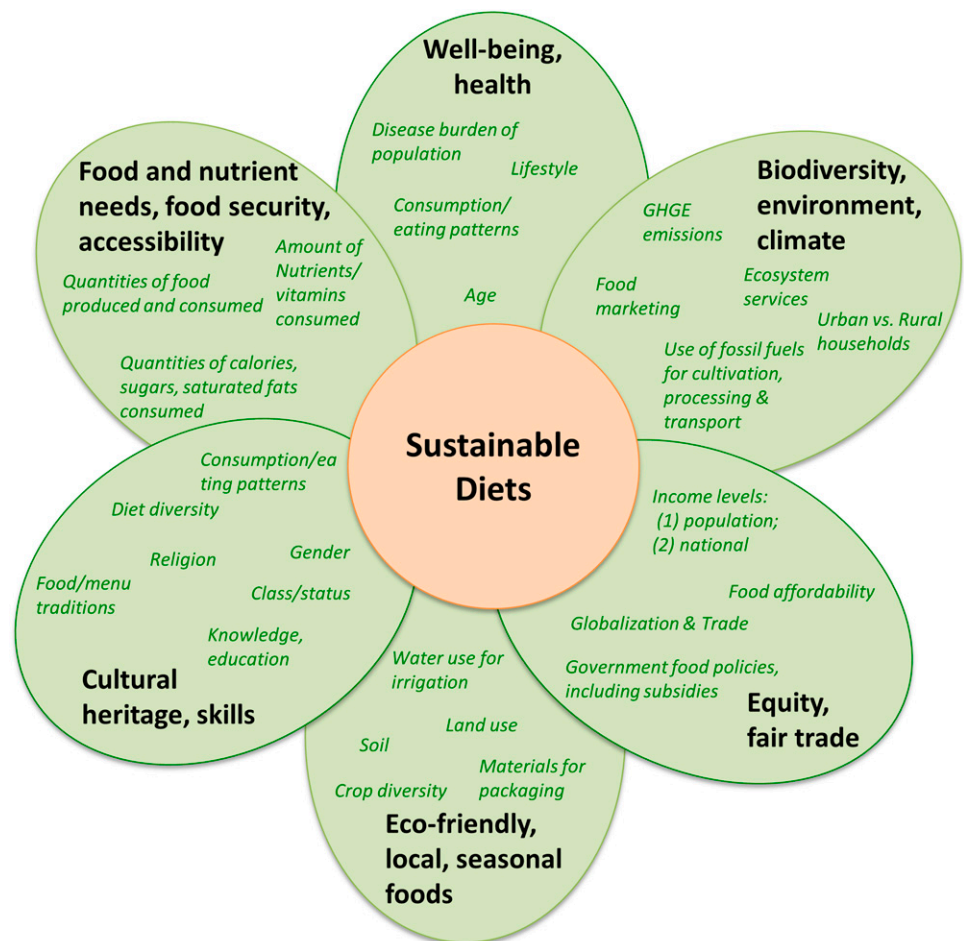
¹²The Overseas Development Institute report examined the implications of modern agriculture and food prices and their implications for diets in the future among populations in developed and developing countries alike. The Institute of Medicine of the National Academies the United States examined the food-environment synergies and tradeoffs associated with the U.S. food system to better understand its impact on diets, human health, the environment, and opportunities for cross-sector collaboration to address these challenges.

increased, with little attention to the sustainability of these agro-food systems (26).

The current consensus FAO definition for a sustainable diet is also complex. The food humans consume is affected by a whole host of inter-related factors, including food availability, food accessibility, and food choice, which in turn are influenced by geography, demography, disposable income, socioeconomic status, urbanization, globalization, religion, culture, marketing, and consumer attitude (27). Sustainable diets consider how the food system influences health and environmental outcomes and vice versa (1,7,19). To understand a sustainable diet, the agricultural, environmental, social-cultural, and economic determinants and effects of the food eaten as well as the nutritional value should be considered. In **Figure 1**, the determinants of a sustainable diet are illustrated within Lairon's original framework to include factors and processes that relate to and affect each other (28).

Agriculture. A starting point for understanding the sustainability of diets begins with considering the agricultural production and processing systems from which our diets are derived and the economic, environmental, health, and cultural factors affected by the system (29). The current system was boosted with the onset of the green revolution in the 1950s and 1960s together with industrialized agricultural and greatly expanded food processing. Production and processing advances in the past 50 y should be credited with making food more convenient, widely available, and affordable to large portions of the world and reducing famines to an almost nonexistent event in the 21st century (1). However, this same successful global agro-food system is the dominant force behind many environmental threats, including climate change, simplification of diets, biodiversity loss, and degradation of land, soil, and freshwater (30). There are widespread problems with soil degradation due

FIGURE 1 The key components, determinants, factors, and processes of a sustainable diet. The large green ovals represent the key components of a sustainable diet, as defined by FAO and Bioversity in 2010 (18). They include the following: 1) well-being, health, 2) biodiversity, environment, climate, 3) equity, fair trade, 4) eco-friendly, local, seasonal foods, 5) cultural heritage, skills, and 6) food and nutrient needs, food security, and accessibility. Each key component is directly connected to the pink circle in the center of the image that represents sustainable diets. Each key component relates to and influences one another and the sustainability of diets, represented by their direct connections to sustainable diets (pink circle), and one another (green ovals). Within each key component (each green oval), we list the different factors and processes that make up the influence of a particular component on what comprises a sustainable diet. This representation helps demonstrate the interdependence and influence that exists across the system that is depicted and how changes to 1 or more factors or processes can influence other factors and processes within the same key component category and others (40). Consistent with the current FAO definition for sustainable diets and for the sake of explanation, the categories, factors, and processes represented do not carry specific weights with respect to their influence on sustainable diets. Currently, it is assumed that all elements are weighted equally in their contributions to what comprise a sustainable diet. In this review, it was discussed that, with tradeoffs across these determinants, they can pull the sustainability of a diet in 1 direction or another. Finally, the key components of sustainable diets and factors and processes contained within each component (each green oval) fall into 5 overarching categories of analysis: 1) agriculture, 2) health, 3) culture, 4) socioeconomic, and 5) environment. Each of these categories is discussed in detail in the review. Adapted with permission from reference 28.



to erosion, loss of soil fertility, salination, and excessive and inappropriate use of chemicals, including fertilizers and pesticides. Rates of water extraction for irrigation are exceeding rates of replenishment in most places, and overfishing has led to a collapse of many aquatic species, as is heavy reliance on fossil fuel–driven energy for transport and synthesis of nitrogen fertilizers and pesticides (29). Additionally, food production and processing systems, including transportation of foods, emit high quantities of GHGs and release other pollutants that build up in the environment, including waste and pollution of water supplies (1). The global food system, from fertilizer manufacture to agricultural production to food transportation, storage, and packaging, currently accounts for 30% of all human-generated GHGs (31–33). If the current global food system continues to produce and process foods at the current amount and speed, it will continue to degrade the environment and compromise the capacity of the world to produce food in the future and will have irreversible effects on ecosystems (1,30,34,35).

Health. Agriculture influences, and is influenced by, health both directly and indirectly. First, agriculture influences health directly through its ability to provide a sufficient quantity of nutritious foods available for consumption in the household or in the marketplace (29). Adequate food consumption provides the necessary nutrients and food components humans require for healthy growth, development, and day-to-day functioning/productivity. Sound health allows people to optimize those nutrients through appetite, digestion, and metabolism and contribute back to agriculture in terms of productivity and a series of important ecosystem services (36). However, an imbalance of nutrients may lead to illness (37,38). Moreover, increases in the agricultural production of low-nutrient and energy-rich foods, such as cereals, tubers, and fats, are contributing to the triple burden of undernutrition, micronutrient deficiency, and overweight and obesity with its associated health issues, such as stunting, anemia, and diabetes (5,8,9,37). The poor are adversely affected by such agriculture and health influences because energy-rich, low-nutrient foods are becoming more affordable to the poor around the world.

Second, good health, economic development, and environmental sustainability are indirectly influenced by agriculture. The effects on employment, individual incomes, and national economic prosperity are positive because they may enable individuals to lead healthier lives, including less strain on budgets for health care or national-level structural improvements to the health system (29). Agriculture also can have negative effects on environment and ecosystem services with the prevalence of certain diseases, access to water, biodiversity loss, and climate change (39,40).

Economic. Agriculture affects economic determinants of sustainable diets, as well. The income amount and the distribution of income of a population or a nation is also a major factor regarding the affordability of a diet. Populations with

higher incomes have the ability to purchase foods of greater variety and nutritional value. Nations with high gross domestic products are able to access foods more readily and often invest in agriculture that not only will provide enough food for their citizens but more nutritious and diverse foods, as well. However, trends reveal that, on average, the diets of these wealthier countries are becoming less healthy and rates of noncommunicable diseases are rising rapidly, and there are considerable changes in lifestyle (1,41). Finally, government food and social protection policies affect diet access and affordability. Subsidies can benefit and distort markets and negatively affect health and nutrition. Current government subsidies to farmers in the United States and parts of Europe enable developed countries to produce large quantities of cheap staple and ultra-processed foods at 40–60% below the cost of local production of similar goods in developing markets (42). In turn, these less healthy foods as imports are considerably less expensive than the locally produced foods, distorting local markets and depressing demand for the more expensive, locally produced, and often times healthier food options (1).

Social–Cultural. Social and cultural norms play important roles in diet. Diets serve not only to provide nourishment but also to provide pleasure heavily influenced by social traditions (37). For example, vegetarian diets in India are influenced by Hindu religious beliefs, whereas traditional diets in Mexico are reflective of its staple maize or corn crop grown in the region for centuries. Such practices, whether a result of religious practice or habit passed through generations, may at times negatively affect diet diversity and nutrition of a population. In India and Mexico, the consumption of certain traditional diets has contributed to nutritional deficiencies, high amounts of stunting, and increased incidence of diet-related noncommunicable diseases (43,44). An individual's knowledge of the food in the diet and its contribution to health and nutrition and effects can drive consumption of a more varied and nutritionally adequate diet. This is clear with the seasonal choices of foods available to rural populations in Congo (45). Additionally, knowing how to prepare a more varied diet can affect consumption of different food products (45). The rich body of knowledge of the nutritional and health benefits of the foods people eat, especially among smallholder producers and consumers, represents an enormous amount of information that is being lost in the shifts in consumption patterns, globalized marketing, and habitat loss (46).

Differing lifestyles reveal the impact of food consumption patterns from the frequency to the amounts consumed. Research showed that overeating is associated with watching television and high amounts of stress (41). In some countries, women suffer more from undernutrition, overweight, and obesity than men, indicating not only different biologic needs and activity patterns but possibly social/cultural norms of discrimination or inequities (47). Finally, increased incomes are resulting in greater consumption of animal-source foods worldwide, whereas other traditional

or local foods, such as millet or cassava in some regions of Sub-Saharan Africa and India, are viewed negatively as an inferior good or “food for the poor” despite the evidence that the food may be a nutritious sustainable option (48). Quinoa went from being a local food in the Andes to being a global, highly valued food.

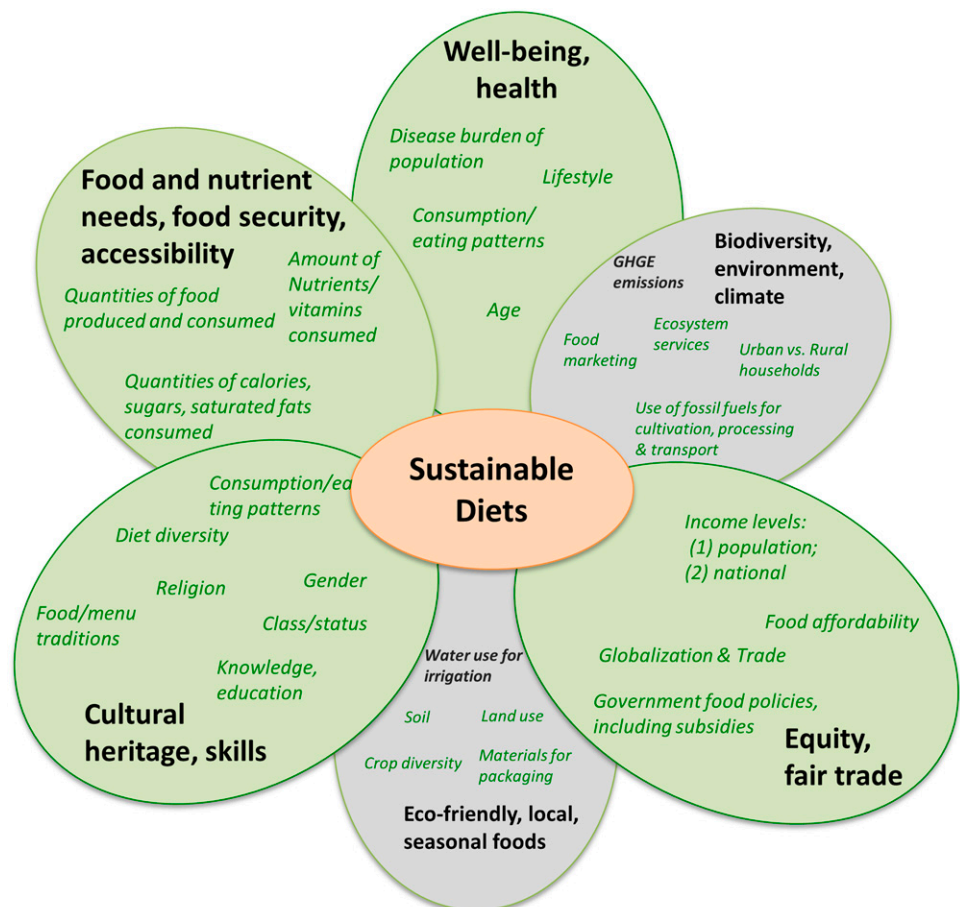
Environment. To understand how environmental determinants influence sustainable diets, human interactions and dietary choices could be considered within a given environment or ecosystem (41). Environment or ecosystems influence the foods people consume. An ecosystem is defined as a complex set of relations among living resources in a defined area (40). An ecosystem includes plants, animals, microorganisms, water, soil, and humans. These elements of an ecosystem form a dynamic community, each affecting the other. If 1 part of the ecosystem is altered or disappears, it has an impact on the system. When an ecosystem is in balance, it is sustainable (40). Urban or rural residence may affect access to foods by a population, which are diverse and nutritious as a result of proximity to markets, local agricultural production of such foods, wild foods, income amounts,

and more. The marketing and packaging of foods also influences consumer dietary choices. Additionally, the dietary choices of a population influence water and land use, biodiversity, and global warming (4). The above-mentioned factors and influences can also reinforce traditional social–cultural norms—or erode them. Food production and consumption practices are placing unprecedented pressures on the natural environment and altering the ecosystems where people live around the world, in turn, profoundly affecting their diets (40,49).

The above discussions reveal that the determinants of a healthy, environmentally suited, affordable, accessible, and culturally appropriate sustainable diet are numerous and complex. Given the connected nature of the determinants of sustainable diets, when factors or processes are changed in 1 category, such changes affect other determinant categories and, in turn, the level of “sustainability” of a diet. Damage, loss, or environmental derangement pulls the whole system out of balance, resulting in unintended consequences and tradeoffs (40).

Figure 2 shows a diet in which food is accessible, affordable, culturally acceptable, and nutritious, yet the food is produced in an environmentally damaging manner due to

FIGURE 2 Schematic representation of an unsustainable diet. Adapted with permission (28). The image provides a visual representation of how the changes or deficiencies associated with the various determinants, factors, or processes of a particular key component of sustainable diets can “shrink” the sustainability of a diet. This is denoted by the smaller pink circle (relative to Fig. 1) at the center that represents sustainable diets. The reduction in the sustainability of the diet is the result of unsustainable agricultural practices and their impact on the environment: water use for irrigation and high GHGEs both denoted in bold dark gray. These determinants are contained within 2 component categories that are depicted in shaded gray ovals and shrunk in size due to the negative/deficient contribution to sustainable diets. Similar to Figure 1, the large green ovals represent the key components of a sustainable diet, as defined by FAO and Bioversity in 2010 (18). This representation helps demonstrate the interdependence and influence that exists across the system that is depicted and how changes to 1 or more factors or processes can influence other factors and processes within the same key component category and others (40). Adapted with permission from reference 28. GHGE, greenhouse gas emission



the higher amounts of GHGEs and water used in the production of the food products consumed in this diet (28). Although this diet could exist in New York City or Istanbul among upper middle-class communities, how is the sustainability of this diet to be interpreted? Clearly, it was derived from the model of the FAO definition (Fig. 1), but the question remains: by how much is sustainability affected or reduced? Additional research and discussion are needed to understand what comprises a sustainable diet and how the above factors and processes eventually influence sustainable diets. Also needed is additional research around the opportunities to measure such factors and processes to ultimately strike a balance that will enable policymakers to promote sustainable diets and people to consume them.

Measuring Sustainable Diets

There is a need to develop metrics and measurement mechanisms for sustainable diets so that policymakers and consumers can understand how a sustainable diet might improve individual and population health and conserve resources and the environment. Also, the ability to measure sustainable diets can help policymakers understand potential tradeoffs for promoting such diets and make investment choices while taking action to address any potential negative consequences (e.g., less demand for meat and dairy products may challenge the mission of producer and manufacturing groups). Most countries adopted dietary recommendations to encourage healthy consumption patterns and, in some cases, reduce negative environmental impacts. These initiatives range from eating 3 portions of vegetables per day to the food miles movement (only eat foods produced within 100 miles of your home). The Food Pagoda of China and the UK Eatwell Plate use visual representations to guide consumption of nutritious foods (50,51). These initiatives were made possible because of the recognition of the need to model and measure the nutritional or environmental impact of the diets. There is a need to do the same for future sustainable diets. The question is: can a process to identify a sustainable diet be developed? And if so, what should be developed, and how? The consensus appears to be that such metrics can be developed and indeed must be developed (52).

However, there are considerable technical and political challenges in the way of developing effective metrics for sustainable diets, especially for low-income countries (12). First, the necessary data for effectively measuring the sustainability of diets are lacking (29,53). There is limited ability to understand whether national agriculture and food systems are providing the correct balance of nutritious foods or whether populations are consuming the recommended dietary patterns (29). This evidence gap means that the impact of changing agricultural practices or policies on dietary intake patterns or on national health profiles cannot be accurately assessed, posing a major obstacle to research and policy (29,53). To assess and monitor the balance of nutritious foods being consumed, sustainable diet advocates are calling for the creation of a global database on food

consumption at the FAO, similar to the Global Database on Child Growth and Malnutrition at the WHO. These advocates also note the need for data on government and private-sector commitment to sustainable diets, because the issue is an inherently “whole of government” responsibility (53,54). The lack of an open-source, reliable database of food composition and consumption of the global food supply continues to be a challenge. There is a clear need for government and the agro-food industry to work together to close the data and methodologic gaps.

The recently launched Access to Nutrition Index uses weighted measures across a range of indicators to assess the ability of some companies to market nutritious, ethical, and legally compliant foods (55). The index uses weighted measures to assess the performance of large food and beverage companies across a range of indicator categories, including governance, products, accessibility, marketing, lifestyles, labeling, and engagement. In its current form, the Access to Nutrition Index does not capture the contributions by companies to sustainable diets or the impact on the environment of the production and marketing of products, but such a dimension could be a future consideration for the evolution of such a tool. Another index compiled for many companies, including food and beverage, does consider their environmental impact. The FTSE4Good index is used by fund managers and investors and does only limited assessment of health and nutrition impacts of products (56).

Another technical challenge concerns the compilation and analysis of complex data. In the Livewell Project, researchers used linear programming methods to understand how UK diets might achieve nutritional adequacy, affordability, and reduced environmental impact (through agriculture and production of foods included in the diets). Should such approaches serve as starting points to generate the options for discussions in government meeting rooms and the marketplace? Given the convergence of population, economic growth, and environmental pressures, should measurement be framed in terms of agricultural growth that “reduces hunger by X for Z levels of input use?” Or should other approaches be examined, such as setting “acceptable constraints” that could be applied to different amounts of emissions or better nutrition (19,53)? Or, given the complexity of determinants of a sustainable diet, should an index be created made up of a suite of indicators similar to the Multi-Dimensional Poverty Index (57)? If so, how and who decides the weights of the various determinants combined into a single index? Given the need for sustainable diets to be local and culturally acceptable, is developing an index going to be applicable at the local level? Is it easy to understand and use for all?

A final technical consideration is: what indicators and cutoffs can and should be considered? The Livewell Project modeled their dietary recommendations based solely on GHGE amounts. The study found that it was possible to design a diet that would meet GHGE target amounts for 2020, without radical alteration of current diets, using established and validated nutritional and environmental indicators (7).

However, what indicators can be identified and used to measure the cultural relevance, ecosystem health, and sustainability of a given diet? Other examples at capturing sustainable diets include the work of the Barilla Center in Italy, which examines the ecologic footprint, energy intake, and cost of consuming the idealized Mediterranean and North-American diets (58). These technical challenges require more research as well as discussion and eventual coordination across diverse stakeholders (20,21,59,60).

Governance for Sustainable Diets

Competing interests of government, civil society, consumers, and private-sector stakeholders also present real challenges for advancing and operationalizing sustainable diets. It is important to consider the preferences and social welfare tradeoffs that both consumers and policymakers are prepared to make (53,61). They reflect values, tradition, history, politics, and culture. For example, proposed changes in agricultural production, food pricing, or consumer behavior would involve tradeoffs, resulting in some win-win scenarios; however, it is more likely that changes will result in many unbalanced outcomes, especially in the short term (22). The SDC report recommends less consumption of meat and dairy but acknowledges that such changes would be resisted by those groups whose livelihoods depend on increased production and sale of those products. Thus, policymakers may be hesitant to propose changes that might have a negative impact on the economic stability and key constituents. The recommendation of the Sarkozy Commission to develop a standardized assessment of sustainable growth did not lead to a permanent commission at the Organisation for the Economic Cooperation and Development precisely because policymakers could not (and still cannot) agree on how to measure it. Furthermore, these disagreements reflect the political challenges inherent in devising how to measure and operationalize sustainable diets.

The interest by consumers and some food companies to access and produce sustainable foods as part of a sustainable diet requires us to understand the entry points and barriers to changing behaviors. The threat to ecosystems of the current agro-food system forces us to identify and map the behaviors that are needed to motivate and sustain a sustainable food system. Experiences from nutritional food labeling point to the importance for food manufacturers responding to what is contained in the label as much as consumers using that information. The positive experiences with the public health efforts to modify salt intake at the population level provided us with valuable lessons on the challenges ahead.

Despite the challenges, it is imperative to develop metrics and measurement mechanisms for sustainable diets to give policymakers the ability to pursue initiatives as discussed above and for producers and consumers to engage in constructive negotiations. With assigned weights on the various determinants of sustainable diets combined with data on the economic and environmental impact of food production and consumption, policymakers would have the tools to evaluate the tradeoffs in pursuing such policies and forestall

possible unintended consequences. The UK government cites the need for more analysis to help guide policymakers to understand how recommendations more in line with sustainable diets, such as to reduce meat consumption, might affect meat producers and people involved in the meat value chain, whereas in Denmark, some industry groups successfully argued that the country did not fully take into account unintended economic consequences when it passed and subsequently cancelled a tax on high-fat foods in 2012 (62). To be sure, adjustments will be made for possible unintended consequences along the way, but the basic measurements and metrics must be developed before adjustments can be considered. Finally, having the ability to measure would facilitate an understanding of the process and track the sustainability of diets, per the guidelines mentioned above (63).

Who Is Involved and Who Should Be Involved? A Closer Look at the Stakeholders

The complexity of sustainable diets will require multiple actors and the inclusion of nonlikely stakeholders to move beyond understanding sustainable diets, to measuring them and ultimately promoting them. The following section examines who the major stakeholders are, what roles they play, and the extent of the roles they play in the design and promotion of sustainable diets. The food consumed mostly comes from agriculture, but aquatic sources, wild foods, insects, and other sources provide a wide array of foods.

Agriculture producers and processors. Agriculture producers and processors grow and market the food that ends up on the plates of everyone around the world. There is little evidence documented on what producers and processors are doing today to contribute to more sustainable food-production practices that benefit diets. The report of the Chicago Council notes that the ever-increasing modernization of the food system has contributed to increased food security around the world (1), yet this achievement has been at the cost of damaging the environment and biodiversity loss and has not necessarily resulted in the production of more nutritious foods for all. However, to garner the ear of the producers and processors, analysis of sustainable diets must go beyond describing environment and nutrition problems. Rather, an economic analysis at many levels of a cost and benefits for producing and marketing foods for sustainable diets must be presented. Can smallholder farmers, small- and medium-sized agriculture enterprises, and the larger industrial agriculture actors profitably engage in production and processing practices that increase the sustainability of our diets? If so, the challenges just described above remain: how much change is needed to achieve sustainability of a diet?

Consumers. Consumers play a central role in advancing sustainable diets. Policymakers and civil-society organizations face substantial challenges in informing consumers or increasing their knowledge of nutritional needs while

affecting behavior change to realize better food choices and sustainable diets. Consumer preferences both drive the demand for what food is produced and are often developed in response to the types of foods industry actors actively market. A clear example is the shift away from breastfeeding to commercial formula and other inferior milk products for infant feeding. This trend is now slightly reversing but only as a result of extensive behavior change, communication and incentives, and regulation on the marketing of breast-milk substitutes. As noted previously in this review, increasing incomes have been accompanied by consumers preferring and purchasing animal-source foods, in turn leading to high production of animal feed and clearing of land for meat production.

Also, research showed that people prefer the taste of sweet, high-fat, and salted foods and have strong aversions to bitterness, affecting the types of food choices consumers make (64,65). It is through changing people's diets that a balance between supply and demand for food can be achieved (1). Some of the identified levers to influence people's diets included campaigns to change individual behavior involving public education, advertising targeted programs in schools and workplaces, incentives to purchase and consume nutritious foods, and the provision of better labeling to enable the public to make more informed decisions. Other strategies included economic interventions, such as taxes on unhealthy foods (although it was noted in the previous section that, without careful consideration of the impacts on other stakeholders or areas of the economy, such interventions can have negative unintended consequences). A final strategy suggested was to enable consumers to "choice edit" their consumption through either regulatory or voluntary actions, including purchasing guidelines by retailers and the food-service sector to restrict choices by consumers or selectively enhance access to better foods (1).

Civil society and policymakers. The role of organizations and individuals in civil society is an important consideration for the future of sustainable diets. Building the knowledge base of researchers, policymakers, educators, consumers, manufacturers, and practitioners in fields such as public health, agriculture, and international development would enable them to fully understand the mechanisms, bottlenecks, and opportunities and address the availability of and access to nutritious and varied foods in a sustainable manner (4,52). Civil-society actors can and do influence policymaker actions on sustainable diets by advancing an understanding of what comprises them and tackling the challenges associated with measurement and governance of the issue. The recent example of the food safety and labeling concerns expressed by consumers in the United Kingdom of horsemeat in the food supply illustrates the increasingly vocal and effective voice of consumers in influencing commercial and food policies (66).

Policymakers are the key to promoting actions that will advance sustainable diets. More is needed to help them be

effective in this area. Policymakers play a central role in creating and disseminating dietary guidelines to consumers, such as the food pyramid or the Eatwell Plate discussed above. Policymakers have the ability to set targets, limitations, and other guidance that affect food production, marketing, accessibility, and affordability. However, currently, policymakers are not well positioned to take meaningful action to promote sustainable diets because they are not equipped with the knowledge or the tools to effectively work on this issue (6). Additionally, agriculture, food, and health agencies often work separately with little interaction and are guided by distinct and sometimes contradictory objectives. Agriculture agencies primarily aim for greater food production, whereas health ministries focus on disease control, with nutrition objectives sometimes playing a role in both sectors but often with lower priority to the main political and technical concerns in the 2 sectors (1).

Also, because of the current inability to measure sustainable diets, policymakers are unable to make decisions or recommendations to advance the concept of sustainable diets. Furthermore, there is a lack of data systems to build understanding and awareness at the policy level to even address sustainable diets; it is clear that whatever is developed must be done with integration of data in mind. Information and knowledge-sharing platforms must have integrated data systems, pulling from databases from UN agencies, such as the WHO and FAO, national data systems, climate-change monitoring systems, etc. In such a way, parties will be able to monitor country and regional data and develop appropriate models to guide decisions accordingly (53,54).

Finally, policymakers need to deepen their understanding of how ecosystem services work to influence diets and vice versa. There is a need for policymakers to better understand the determining factors and processes that comprise a sustainable diet and how the interrelations of human health, environmental sustainability, cultural traditions, and affordability of food affect the sustainability of particular diets (what this review seeks in part to do). One potential pathway for advancing sustainable diets could be informed by successful transformations of local food systems. For example, the Food Dignity project in the United States is currently conducting case studies of community-led food-system transformations that are seeking to confront the interrelated problems of environmental, economic, and social pressures that constrain communities in their ability to consume healthy, affordable, and environmentally friendly diets (6). Such understanding will enable them to participate in and influence the progress of an agenda to promote sustainable diets as part of sustainable development. Also, such an understanding of the challenges associated with determinants will position them to mitigate risks associated with future needs and future diets (6,12).

Overcoming the political challenges and accountability questions to devise a system of governance for sustainable diets will require multisector analysis, cooperation, coordination, and negotiation across all stakeholder groups. It is important to allow each sector to contribute its part as

mechanism for achieving a consensus. The challenge remains as to how this happens, although there are examples from the field of nutrition and population research (67).

Conclusions

Understanding the determinants, factors, and processes that comprise a sustainable diet will become increasingly important in an era of economic growth, rising incomes, climate change, and dietary transitions. The definition of a sustainable diet requires a shift in thinking about diets through a single dimension of nutritional adequacy to an understanding of diets that incorporates aspects of access and affordability of foods, environmental sustainability, and cultural acceptability. Also, sustainable diets highlight how food production and food consumption are interconnected and ecosystem dependent. This, in turn, requires an enhanced understanding of what composes a sustainable diet, how the level of sustainability is measured, and identification of the impacts and tradeoffs involved in promoting sustainable diets at both the individual and population levels.

With strong momentum driving the creation of a set of SDGs for and heighten awareness among the general public concerning the rising costs of public health and consumer marketing efforts, there is scope to influence the evolution of diets to become more sustainable as politicians and consumers, in low-, middle-, and high-income countries alike, confront the health and associated economic and environmental challenges of producing and consuming “unsustainable diets” (6). However, today, it is challenging to define what a sustainable or unsustainable diet translates to in practice. There does not yet exist an agreed on approach or tool to determine the level of sustainability of a diet or the tradeoffs associated with any attempts or recommendations to increase the sustainability of a diet.

If those working to advance sustainable diets are able to devise means to measure diets and build measurement mechanisms that are easy to use (for both policymakers and consumers), many stakeholders will be better positioned to realize the potential benefits of sustainable diets and mitigate the risks associated with growing unsustainable agricultural and consumption practices. Civil-society leaders and policymakers need help to better understand and raise awareness among governments, industry, and consumers that agriculture, food, nutrition, health, culture, the environment, and the achievement of SDGs are strongly interdependent on one another (12). Keats and Wiggins (6) argued recently that, over time, income may become a weaker determinant of diets, and, as a result, this may lead to considerable scope for public policy to have a real influence on diets for the future.

In pursuit of how to measure and promote sustainable diets, it is important consider the question around how sustainable a particular diet is. Could there be the development of an index or measurement tool that would indicate the “pass” or “fail” of a particular diet at national, regional, or global levels? If so, what should be the inputs and who

should be involved in the process? These questions present important opportunities that should not be missed to advance SDGs.

Promoting sustainable diets will require an inclusive approach that reflects the multidisciplinary determinants. Leaders in academia, public policy, civil society, and the private sector from all fields, especially economics, psychology, behavior change, anthropology, nutrition, environment, climate change, and health and agriculture, are being brought to the table to address the emerging opportunities and challenges associated with sustainable diets.

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