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The Future of Plant-Based Diets: Aligning Healthy Marketplace Choices with Equitable, Resilient, and Sustainable Food Systems

Vivica I. Kraak[1] and Jessica Aschemann-Witzel[2]

[1]Department of Human Nutrition, Foods, and Exercise, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA; email: vivica51@vt.edu

[2]MAPP Centre, Department of Management, School of Business and Social Sciences, Aarhus University, Aarhus, Denmark

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plant-based diets, sustainable diets and food systems, planetary health, human health, ecological resilience, social equity, economic prosperity, alternative proteins

Abstract

The future of plant-based diets is a complex public health issue inextricably linked to planetary health. Shifting the world's population to consume nutrient-rich, plant-based diets is among the most impactful strategies to transition to sustainable food systems to feed 10 billion people by 2050. This review summarizes how international expert bodies define sustainable diets and food systems and describes types of sustainable dietary patterns. It also explores how the type and proportion of plant- versus animal-source foods and alternative proteins relate to sustainable diets to reduce diet-related morbidity and mortality. Thereafter, we synthesize evidence for current challenges and actions needed to achieve plant-based sustainable dietary patterns using a conceptual framework with principles to promote human health, ecological health, social equity, and economic prosperity. We recommend strategies for governments, businesses, and civil society to encourage marketplace choices that lead to plant-rich sustainable diets within healthy, equitable, and resilient agroecological food systems.

1. INTRODUCTION

IPCC: International Panel on Climate Change

UN: United Nations

NCD: noncommunicable diseases

GHGE: greenhouse gas emissions

FAO: Food and Agriculture Organization

WEF: World Economic Forum

APs: alternative proteins

FBDGs: food-based dietary guidelines

There is a converging call by international advisory bodies for stakeholders to take collaborative actions across sectors to tackle the interrelated global challenges of food systems. The International Panel on Climate Change (IPCC), United Nations (UN) agencies, and several expert *Lancet* Commission reports have urged governments to implement comprehensive policies to shift populations toward planetary health diets by 2030 and 2050 (68, 69, 129, 137, 148). A food system transformation is needed to address the global syndemic of undernutrition, obesity, and diet-related noncommunicable diseases (NCD) and climate change (68, 69, 129, 135, 148). Moreover, multi-stakeholder collaborations are necessary to create a sustainable food future for people and the planet (116, 150).

The current food system neither equitably serves the basic healthy food needs for all people nor safeguards planetary health as the basis for continued prosperity. The UN's 2022 *State of Food Security and Nutrition in the World* report documented that more than 3.1 billion people worldwide experienced hunger or food insecurity in 2021, and about one-third of the world's population could not afford healthy nutrient-dense diets to reduce malnutrition in all its forms, including stunting, wasting, micronutrient deficiencies, obesity, and diet-related NCD (i.e., cardiovascular disease, type 2 diabetes, and certain cancers) (44). To ensure that ecosystems do not reach a tipping point that will undermine planetary health (126), UN member states have endorsed ambitious UN treaty targets to reduce their contribution to greenhouse gas emissions (GHGE) by 43% by 2030 and to achieve net zero GHGE by 2050 (51, 60, 69).

Achieving these goals will require aligning dietary choices in marketplaces with the principles underlying human and ecological health, social equity, and economic prosperity. Food systems governance actors currently lack a shared definition, vision, narrative, principles, priorities, and governance approaches to promote human and planetary health to create sustainable well-being in society (14, 59, 65, 67, 111, 116, 127, 150, 151, 153). The UN Food and Agriculture Organization (FAO) (42) and World Economic Forum (WEF) (150) have encouraged member states to develop and support new business models that are more inclusive and equitable (129).

Plant-based diets are both central and crucial for the transition and transformation of sustainable food systems. This review article synthesizes recommendations for future plant-based diets to align healthy marketplace choices with equitable, resilient, and sustainable food systems. First, we examine the definitions for sustainable diets and food systems provided by international bodies. We use a guiding framework with principles underlying sustainability to promote human health, ecological health, economic prosperity, and social equity. We discuss how sustainable diets may be achieved through plant-based dietary patterns, suggest that plant-source foods and alternative proteins (APs) are defining factors of future sustainable healthy diets, explore opportunities and challenges for producing and scaling up plant-source and AP products, and apply evidence from food-based dietary guidelines (FBDGs) to guide policies to advance human and planetary health. Thereafter, we synthesize evidence to justify a population-wide shift toward sustainable plant-based dietary patterns and discuss current challenges and opportunities for actions. The article concludes with suggested strategies for governments, businesses, foundations, civil society organizations, and the public to use marketplace solutions to encourage plant-rich sustainable diets and food systems by 2050.

2. DEFINING THE FIELD AND IDENTIFYING CHALLENGES

2.1. Sustainable Diets and Food Systems

Supplemental Material >

Sustainable diets and food systems have evolved over the past decade. **Figure 1** and **Supplemental Table 1** present detailed descriptions of the actions and reports issued by UN agencies

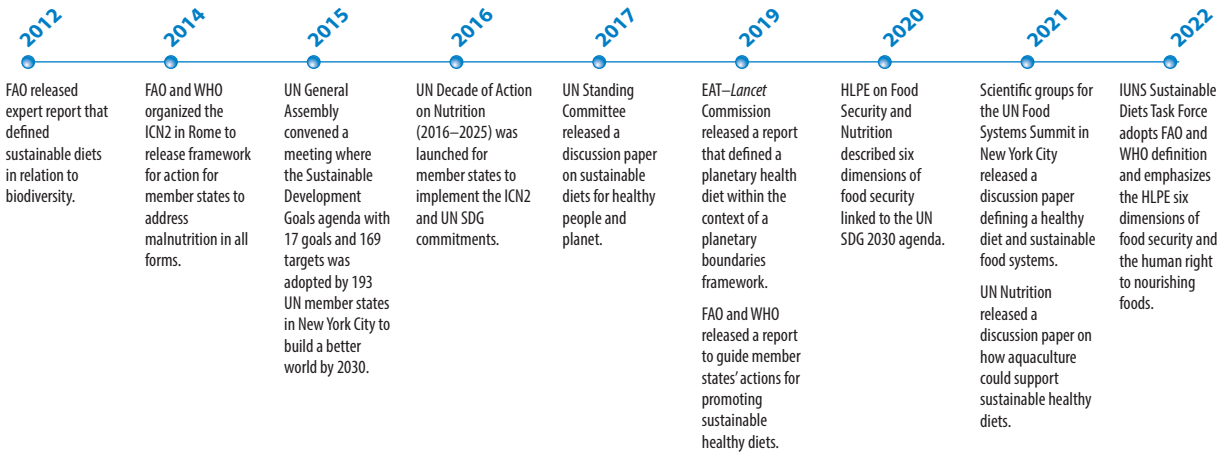

Figure 1

UN and international expert advisory bodies' actions to support sustainable diets and food systems, 2012–2022. Abbreviations: FAO, Food and Agriculture Organization; HLPE, High Level Panel of Experts; ICN2, Second International Congress on Nutrition; IUNS, International Union of Nutritional Sciences; SDGs; Sustainable Development Goals; UN, United Nations; WHO, World Health Organization. Data from References 4, 18, 19, 45, 65, 99, 136, 138, 140, 141, 143, 148. **Supplemental Table 1** provides a detailed description of international advisory bodies' definitions for sustainable diets and food systems, 2012–2022.

and bodies [i.e., FAO, UN Food Systems Summit Scientific Group, UN General Assembly, UN Standing Committee on Nutrition, UN Nutrition, and the World Health Organization (WHO)] and other international expert advisory bodies (i.e., High Level Panel of Experts of the Committee on World Food Security, EAT-*Lancet* Commission, and the International Union of Nutrition Sciences Sustainable Diets Task Force) to advance the concepts of sustainable diets and food systems (from 2010 to 2022) (4, 18, 19, 24, 26, 45, 61, 65, 70, 85, 138, 141, 143). This multistage, decade-long process was intentionally connected to the UN Sustainable Development Goals (SDGs) 2030 agenda (138).

Supplemental Material >

2.2. Guiding Framework: Principles Within Four Domains of Sustainable Diets

We used a conceptual framework with four domains of sustainable diets to structure this article. We examined the evidence for plant-based diets and the food system actors needed to align these domains, balance trade-offs, address conflicts, and engage in collaborative and democratic processes to support sustainable diets and food systems in the future.

Figure 2 provides a framework with principles across four domains (81) adapted from several conceptual frameworks (1, 22, 32, 35, 40, 45, 57, 61, 71, 72, 92). This framework includes different disciplinary views about the weaknesses of current food systems and priorities for action, which include (*a*) the agricultural view, to address the yield gap to promote food security; (*b*) the diet and health view, to address the nutrient gap for diet quality; (*c*) the environmental view, to reduce the food system's footprint; and (*d*) the social justice view, to decentralize power and promote grassroots autonomy (14).

This framework mirrors the Just Rural Transition's principles for the food system transition to benefit people, ecosystems, and the planet (72). The principles aim to ensure that all people's nutritional needs are met (human health and economic prosperity), to operate within planetary boundaries (healthy ecosystems), to ensure climate resilience and avoid environmental degradation (ecological health), to provide viable livelihoods (economic prosperity), to protect the rights

WHO: World Health Organization

SDGs: Sustainable Development Goals

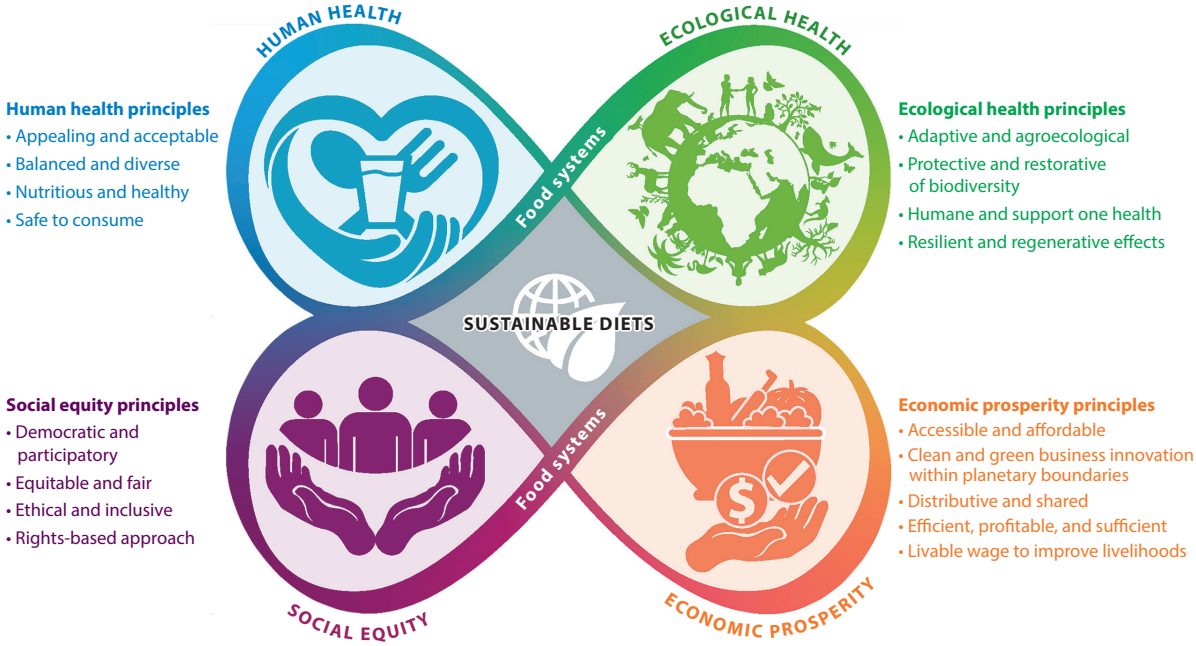

Figure 2

Principles for sustainable diets and food systems across four domains to advance human and planetary health by 2050. Figure adapted with permission from Reference 81.

of people and animal welfare (social equity), and to address power inequities in food value chains (social equity and economic prosperity) (72).

2.3. Dietary Patterns that Reduce Animal-Source Foods to Support Sustainable Diets

A broad range of dietary patterns may support sustainable diets, and all of these recommend reducing animal-sourced proteins (i.e., meat, dairy, and fish) and consuming more plant-rich foods including vegetables, fruits, beans, legumes, pulses, grains, nuts, and seeds. High-protein dietary patterns (i.e., ketogenic and paleo) are typically not included among sustainable dietary patterns because evidence shows that these are less environmentally sustainable compared with the other patterns (8).

Supplemental Material >

The FAO and WHO define dietary patterns as the "amounts, proportions, variety or combination of various foods, drinks and nutrients in diets, and the frequency that these are habitually consumed" (45). **Supplemental Table 2** and the section below define sustainable dietary patterns that include planetary health, flexitarian, Mediterranean, New Nordic, healthy omnivore, plant-based, plant-forward, plant-rich, pescatarian, vegan, and vegetarian.

Figure 3 shows the expert-recommended planetary health or plant-rich diet plate and the daily and/or weekly servings for animal-source proteins. Expert bodies have recommended that individuals limit or avoid processed meats and limit the consumption of lean red meat to about one to three times weekly to support a sustainable healthy diet (39, 82, 148, 149).

The EAT-*Lancet* 2019 Commission suggested that a planetary health diet should consist of high-quality plant-based foods and small amounts of animal-based foods and should limit unhealthy ingredients and highly processed foods (26, 39, 148). A healthy version of the omnivore

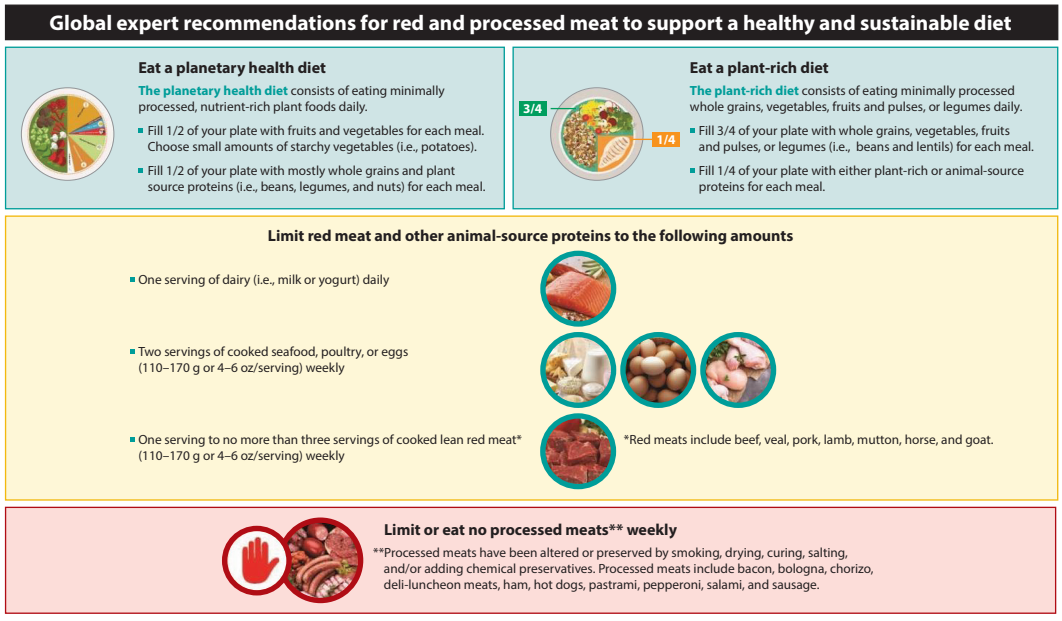

Figure 3

Global expert recommendations for animal-source proteins to support a sustainable healthy diet. Figure adapted with permission from Reference 82.

dietary pattern is also called a plant-forward, omnivorous whole-foods dietary pattern (103). Flexitarian, plant-rich, plant-based dietary patterns have been defined to align with the planetary health or plant-based diet (31, 47, 66, 75, 127, 151) with different degrees of a vegetarian or vegan pattern (47, 75). The Mediterranean and New Nordic dietary patterns address the health, environmental sustainability, and sociocultural domains by encouraging regional foods and eating traditions (32, 55, 84, 90, 104).

Supplemental Material >

Supplemental Table 1 shows several dietary patterns that describe the type or degree of food processing and suggests that people substantially reduce or avoid eating highly processed foods and sugary beverages. Ultra-processed foods (UPFs) are defined as "formulations of ingredients, mostly of exclusive industrial use, that result from industrial processes" (98, p. 937). The NOVA food classification system categorizes foods and food products into four distinct categories based on the extent and purpose of processing, which includes minimally processed foods (NOVA 1) such as plant-based whole foods, culinary ingredients (NOVA 2), nutrient-dense processed products (NOVA 3), and UPF products (NOVA 4) (13, 98). UPFs refer to the processing of industrial ingredients derived from foods and include additives such as preservatives, sweeteners, and flavoring that make foods hyperpalatable but contain little or no whole foods (98). Growing evidence suggests that red and processed meats and sugary beverages are strongly linked to adverse health, environmental, and ecological outcomes (87, 98, 131).

2.4. Regional Differences in the Shift Toward Sustainable Diets

UPFs: ultra-processed foods

NOVA: new (in Portuguese)

Substantial differences exist between the Global South and Global North regions related to the supply and demand for recommended diet and food system changes (116). Policy makers in high- and middle-income countries must incentivize plant-rich and nutrient-dense sustainable diets. Nutrient density refers to the relative amount of nutrients per calorie and is determined by

nutrient profiling methods. Strategies are needed to substantially reduce the dietary intake of red and processed meats by 50% of current intakes, replace other animal-source proteins (i.e., meat, poultry, fish and seafood, eggs, and dairy) with plant-rich proteins, and significantly increase minimally processed whole foods (i.e., nuts, seeds, vegetables, fruits, beans, pulses, and legumes) (148). Vegan diets have special provisions to ensure nutrient adequacy and dietary diversity (47, 75).

Governments in African, Asian, Caribbean, and Latin American countries must expand the availability and access to high-quality, bioavailable, animal-source foods to meet the nutritional needs of infants, young children, and women of childbearing age, who experience micronutrient malnutrition (i.e., iodide, iron, and vitamin A) and stunting (10, 11). No country has halted or reversed overweight and obesity rates linked to diet-related NCD (129). A transition to a flexitarian plant-based diet may not reduce the risk of unhealthy weight gain unless healthy portion sizes are incentivized and the potential consequences of dietary inadequacy or unhealthy weight gain are addressed (83, 88). Governments must also translate planetary health diet recommendations to the specific nutritional needs, sociocultural and economic factors, and environmental contexts for diverse populations (10, 11).

2.5. The Extent to Which FBDGs Address Sustainability Principles

National FBDGs are science-based messages that advise individuals and populations about foods, food groups, and dietary patterns aligned with healthy eating to prevent all forms of malnutrition and keep people well-nourished and healthy. FBDGs establish a basis for developing food and nutrition, health, and agricultural policies and nutrition education programs.

The FAO reports that more than 100 countries have developed FBDGs for populations (82). Yet FBDGs in countries worldwide are not yet incorporating all the dimensions and principles of sustainable diets recommended by international bodies. Studies of FBDGs have found that most countries do not explicitly recommend that individuals reduce beef and dairy consumption, even though it would align with expert-recommended targets (82).

FBDGs do not routinely encourage minimally processed, plant-based foods or dietary patterns recommended by the EAT-*Lancet* Commission report (125). A study of the FBDGs for 83 countries found that these were incompatible with recommended targets to promote human and planetary health (125). A separate study that analyzed 95 FBDGs across 100 countries reported that 40% ($n = 38$) of FBDGs had a position on vegetarian diets, and 45% of FBDGs mentioned plant-based alternatives to animal-source meat or dairy (78).

Assessments of the health and environmental sustainability dimensions addressed by FBDGs vary depending on the study design, indicators, and outcomes used to measure foods and various dietary patterns (including life cycle analyses); carbon, water, and land footprints of foods and patterns; impacts on biodiversity; diet quality, affordability, and equity; and degree of food processing (12, 20, 27, 59, 77, 79, 89, 115, 118, 145). No country has comprehensively addressed how traditional and novel plant-based and hybrid or blended ingredients align with national dietary guidelines to support sustainable diets and food systems.

2.6. Typology of Alternative Protein Sources

APs are any protein-rich ingredients derived from plants, algae, fungi, insects, or animal cells that are used to replace conventional livestock products, such as beef, pork, poultry, fish, seafood, eggs, and dairy (13). Sustainable dietary patterns entail reducing animal-sourced proteins and shifting to a diversity of AP ingredients and products to mitigate the adverse ecological impacts of current food systems, reduce zoonotic diseases, and feed more people with fewer resources (51, 52, 54).

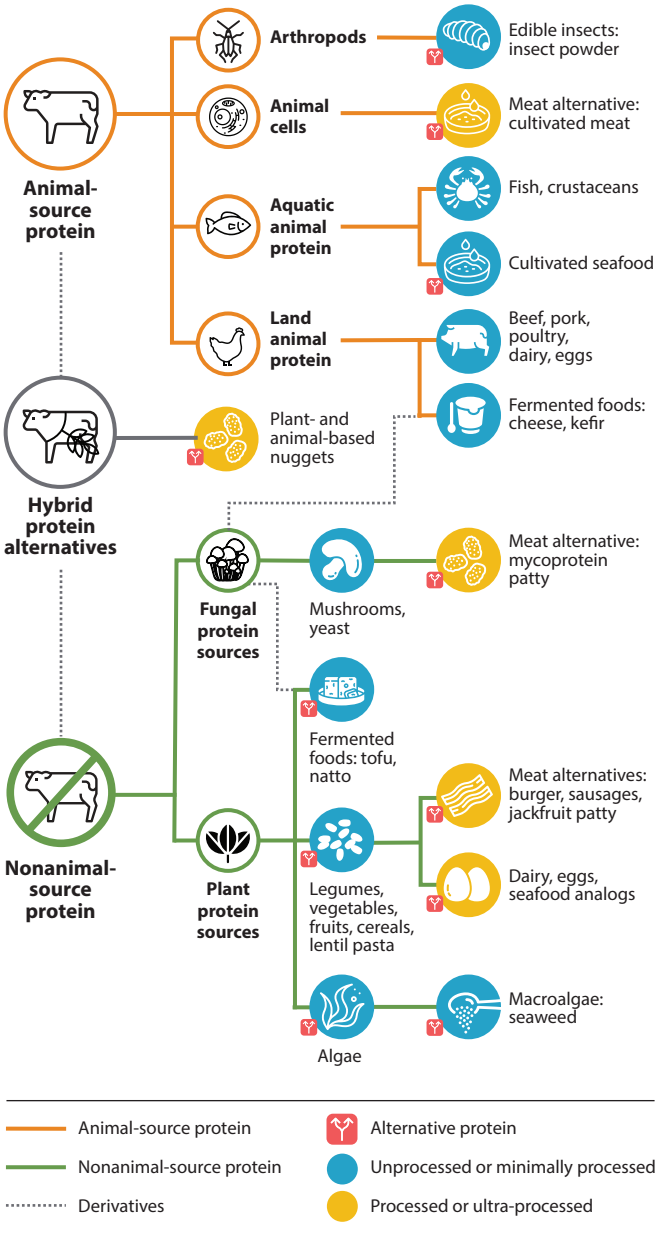

Figure 4

A typology of plant-, animal-, and hybrid-source proteins to encourage plant-based products that support sustainable diets. Figure adapted from Reference 13 (**https://doi.org/10.1016/j.cdnut.2023.102014**) (CC BY 4.0).

Figure 4 shows a typology of plant-, animal-, and hybrid-source proteins used in AP ingredients and products (13). Examples of APs include insect-based foods and cultivated meat, chicken, fish, and seafood (also called lab-produced or cellular agriculture); in addition, hybrid products that combine AP sources may be animal- or plant-based, fermented, and/or cultivated.

Nonanimal-sourced proteins are from plant sources (i.e., beans, grains, and legumes), fungal or mycoprotein sources (i.e., mushrooms and yeast), and microorganisms (i.e., seaweed and marine algae) (13). Blue foods are derived from aquaculture, including aquatic animals, plants, or algae caught or cultivated in the ocean or in fresh water (13).

2.7. Debate about the Healthfulness of AP Processing

A current challenge for AP products is the degree to which they provide nutrient-rich sources of foods and how the processing of AP ingredients impacts human and ecological health outcomes. Studies published between 2021 and 2023 for different countries and regions (28, 56), including Africa (49), the Americas (34, 58), Australia (17, 94), and Europe (108, 114), have shown that the nutritional profiles and types of AP food and beverage products vary substantially both within product categories and across countries.

The NOVA food classification system considers a large proportion of the current plant-based ingredients and products in the marketplace to be UPFs, which would not be recommended for a healthy diet (80). For this reason, some studies suggest that vegetarians and vegans consume more UPFs than do omnivores (76). Assessing the state of evidence of the effect of plant-based diets is complicated because intervention research is often not transparent about participants' dietary patterns (127). Studies tend to categorize all types of AP meat, poultry, and dairy substitutes as UPF products, even though the ingredients and type, and degree of processing may differ substantially (76). There is a vigorous debate among researchers and practitioners about how plant-based AP food and beverage products should be classified (34, 36, 57, 82, 87).

2.8. Current AP Market Demand and Supply Across Regions

The market for AP ingredients and products is characterized by a large investment in research and development with the aim to increase market share and consumer interest. The expansion of AP plant-based, hybrid, and/or cultivated proteins differs within and across national, regional, and global marketplaces. The global 2022 retail sales for plant-based meats, seafood, milk, and dairy were estimated at US$28 billion (53). The global cell-cultured or cultivated meat market could reach US$425 billion by 2030 (16).

Consumer demand for sustainable diets and AP products (6, 74) is growing in the Asian Pacific, Australasian, Western European, and North American regions compared with Latin America, Middle East, Africa, and Eastern Europe. However, AP product consumption represents a small percentage of the trillion-dollar global market of traditional animal-source proteins (53). Businesses are developing new hybrid protein products, such as burger or turkey patties blended with seasoned vegetables, meat made from algae (i.e., spirulina), and nondairy proteins made by precision fermentation that uses genetically modified organisms to produce specific enzymes inserted into microorganisms to produce products that mimic the taste and texture of fluid milk without lactose (9, 53, 121, 130).

3. CHALLENGES ACROSS THE FOUR KEY DOMAINS FOR PLANT-BASED DIETS

3.1. Human Health

The future of plant-based diets is a major, complex public health issue for society that is inextricably linked to planetary health and elevates public health to a new priority level to sustain both human and planetary health. The type and proportion of plant- versus animal-source foods relate

to the burden on the planet and to reducing diet-related morbidity and mortality of populations globally.

A modeling study of 85 countries found that if populations were to adopt the EAT-*Lancet* planetary health diet in national FBDGs, premature population-based mortality could be reduced by 15% (125). Systematic evidence reviews that examined observational and intervention studies of the nutrient adequacy and dietary intake of adults consuming primarily flexitarian, vegetarian, or vegan dietary patterns compared with omnivores who consume meat found that diverse nutrient-rich, plant-based dietary patterns that are lower in total protein, but within the recommended levels of 3 portions of 350–500 g weekly of cooked red meat, will reduce population risk of cancer and cardiovascular disease (30, 39, 149).

Healthy plant-rich dietary patterns contain high amounts of vitamins, minerals, phytochemicals, antioxidants, and dietary fiber associated with better diet quality and healthy weight, and they also reduce the risks of insulin resistance, type 2 diabetes, dyslipidemia, and metabolic syndrome for individuals and populations (73, 91, 100, 133). Observational studies show that healthy plant-based dietary patterns (i.e., vegan, lacto-vegetarian, lacto-ovo-vegetarian) and healthy flexitarian dietary patterns (i.e., Mediterranean, pescatarian, and planetary health) foster a healthy weight and metabolism compared with dietary patterns with excessive calories, red and processed meats, saturated and *trans* fats, added sugars, refined starches, and sodium, which have been associated with diet-related NCD (31, 88, 93, 133).

The nutritional quality of plant-based dietary patterns will vary based on the source, formulation, proportion, nutrient density, quantity, and quality of proteins (91, 100, 115). Many issues must be resolved. Further research is needed to develop a universally accepted method to categorize healthy processed versus UPF products (131). Evidence is lacking for whether the nutrients from cultivated meat and hybrid meat and plant products are bioavailable and will promote a healthy human microbiome (97, 105).

To ensure that plant-based diets support human health, future product portfolios supported by business development efforts must increase beneficial nutrients (i.e., calcium, iron, and fiber) while reducing nutrients of concern (i.e., calories, fat, and sodium) without compromising taste to encourage consumer acceptance (2, 134). Health care and public health professionals should recommend plant-based diets across the life course for a healthy life span that ensures a high quality of and length of life (29).

3.2. Ecological Health

The production of red and processed meat and fluid milk from beef and dairy cattle by modern, large-scale industrialized and consolidated food systems in selected high- and middle-income countries has a large environmental, climate, and carbon footprint (82). The current agri-food sector contributes between 25% and 33% of GHGE (46, 106, 129, 148). The production of animal-based products uses 75–83% (46, 109) of the world's farmlands and 35% of crops as animal feed (46) but provides only 37% of protein and 18% of calories for human consumption (109). The GHGE of livestock production differ by meat source but are about 11.2% (43). Most animal-source foods are resource intensive, associated with more biodiversity loss, and produce higher GHGE compared with plant-based food production (27).

An impactful action to promote ecological health and food systems resilience under a changing climate is to shift the world's population to more sustainable plant-based dietary patterns (69, 109, 110, 123, 148). A study of seven countries found that Australia, France, Germany, and the United States could reduce their agricultural GHGE by two-thirds by reducing red meat consumption (128). Reducing other animal-source foods, increasing the consumption of local and regional

organically grown foods, and adopting plant-based dietary patterns could reduce GHGE by eight billion tons annually by 2050 (66).

Research has often focused on climate change and GHGE indicators. However, food systems must also preserve biodiversity (i.e., plants, animals, and microorganisms used in agroecological food systems) (139) and promote nutrient balance to encourage ecological health principles that prioritize resilience and regenerative agricultural practices (60, 67). Robust evidence shows that the Mediterranean dietary pattern supports human health and also promotes ecological health (55, 90). Apart from the plant-based diet transition, minimizing food loss and food waste must also be addressed to mitigate climate change effects (152).

The impact of sustainable diets on ecological health depends on both the quality and quantity of dietary protein to optimize diet quality and reduce GHGE and other ecosystem indicators worldwide (62). Research has documented that plant-based dietary patterns have lower GHGE, land use, and biodiversity loss compared with omnivorous dietary patterns; however, the impact on water and energy use will depend on the specific animal- and plant-based foods consumed (21). Evidence is lacking for whether new innovations such as cultivated meat can be produced at scale within an agroecological food system (97, 105).

A major challenge for plant-based diets to achieve ecological health is that it is so far only a niche market (144). While there are differences across countries, about 10–30% of European consumers select and eat plant-based diets and use sustainable products based on different values that support concerns about health, the environment, or the planet (119), while close to 25% of consumers globally express an intention to reduce meat consumption (113). Global surveys have shown that consumers in countries worldwide are slow to adopt plant-based diets, especially vegetarian and vegan. Mintel, a global market research firm that tracks consumer trends, conducted a 2023 survey that reported an omnivorous dietary pattern for most respondents (51%), and only a smaller proportion reported adopting flexitarian (13%), vegetarian (3%), pescatarian (2%), or vegan (1%) patterns (96). Although consumers are concerned about the environment, animal welfare, and the climate crisis, many have not yet changed their dietary choices (95, 96, 113).

The observed gap between peoples' environmental concerns compared with their actual behaviors is partly attributed to the choice architecture and marketing trends for food environments. Information and motivation are necessary but insufficient to encourage behavior changes unless other factors are considered, including physical barriers (availability); economic incentives and disincentives (cost); social norms and eating habits; and time, convenience, or appeal and taste (5, 132). Younger generations are more receptive to reducing the amount and frequency of meat intake (95) and to substituting red and processed meats with plant-based AP products or adopting a flexitarian dietary pattern (38, 96).

3.3. Social Equity

Several challenges must be addressed to achieve an equitable food system transition and transformation. Equity, social justice, child and agricultural labor, gender equity, animal welfare, and inclusivity are important issues addressed within the social equity domain (146). A scoping review of the published literature examined the metrics used to assess the four domains of sustainable diets. The review found that the social dimension of the diet-environment-health sustainability relationship is neither well defined nor well researched and is often limited to socioeconomic metrics when reported (146). Existing frameworks that have examined equity have proposed selected variables that combine equity and economic prosperity principles. For example, Gustafson et al. (57) described such variables, including the ethical sourcing of ingredients for

manufacturing products, respecting child labor laws, providing a livable income to workers, and communicating product attributes and benefits clearly through truthful marketing and labeling to consumers.

Addressing the traditions and social norms aligned with red and processed meat intake in many high- and middle-income countries is a complex challenge. The demand for animal-source foods (i.e., beef, poultry, eggs, and seafood) differs by country and region, but the global production and demand for ruminant meat (i.e., beef) are expected to increase by 2050 (116).

The published literature suggests that the population demand for red meat will increase in many low- and middle-income countries and regions (i.e., Latin America, West and North Africa, and Eastern Asia) because meat represents a higher status associated with economic affluence that consumers aspire to achieve (33). Reversing this trend is not aligned with consumers' desires. In all countries where high meat consumption is the cultural and social norm, changing it may be perceived by consumers as abandoning their cultural customs and traditions (102). Even followers of plant-based diets report this viewpoint as a substantial barrier (119). Consumer acceptance of AP products and new food technologies is another barrier given that many consumers favor natural and familiar ingredients and products, and food technophobia differs for various AP products and technologies (i.e., cultivated meat and precision fermentation) (5, 9).

From an equity perspective, the challenge is that each AP ingredient or technology has a segment of consumers who do not accept it, and these groups vary for each ingredient and technology. Any power difference of influence among diverse consumer segments can unequally impact whether and how much the food system changes toward their preference, and only a diversity of product and dietary options can address preferential differences.

Banovic & Grunert (9) show that women are more likely than men to adopt plant-rich diets, reduce consumption of red and processed meats, and select plant-based AP products, whereas Aschemann-Witzel et al. (5) report that men are more likely than women to support new technologies and novel AP ingredients (e.g., cultured meats and insects). In addition, fewer women are food entrepreneurs, and their backgrounds are not as diverse as the consumers for whom they innovate and develop products. Social equity principles are needed to align gender, racial, and/or ethnic diversity for food system decision-makers to enable an equitable and diverse transition to future plant-based diets (5).

An understanding of how food systems impact sustainable diets, including social equity, is needed to inform policies and actions (146). The EAT-*Lancet* 2.0 Commission's 2024 report will focus on how governments may achieve food justice and social equity goals for future food systems and discuss how countries may adapt the planetary health diet to regional and local dietary patterns (39, 148). For example, the Mediterranean pattern has been shown to promote human and ecological health, diverse eating cultures, and local economic vitality (32, 55, 84, 90), which may be adapted for other contexts.

3.4. Economic Prosperity

Economic prosperity is needed for both consumers and businesses to achieve future sustainable diets. The balance is to ensure that plant-based products are affordable for consumers and profitable for businesses to support the transition toward a more sustainable, healthy, equitable, and prosperous food system by 2050. The marketplace issues are strongly influenced by food availability, affordability, and consumers' choices that affect the food supply.

Many studies have emphasized cost as a significant barrier for low-income populations to afford sustainable healthy AP products that support sustainable dietary patterns (35, 41, 64). While a dietary shift away from the excessive consumption of animal-source foods could

substantially reduce hidden costs or externalities of unsustainable diets (43), the planetary health diet has been critiqued as not being affordable for many people worldwide (64). A global study of dietary patterns found that adopting the EAT-*Lancet* planetary health diet would require higher household incomes, lower food commodity prices, and government safety-net program assistance (64).

A modeling study of the global and regional costs of sustainable healthy dietary patterns found that these were one-fifth to one-third lower in cost (22–34%) for people in upper-middle-income to high-income countries and 18–29% more expensive for people in low-income countries (124). Vegetarian and vegan dietary patterns were more affordable, but pescatarian diets, which include fish and seafood, were more expensive (124). Many governments and businesses are investing in cultivated meat research and production as one of many strategies to address concurrent sustainability challenges (118). Yet evidence is lacking for whether the bioreactors needed to produce cultivated meats can be scaled up to ensure healthy affordable AP products for consumers (97, 105).

A current barrier to transitioning to a profitable plant-based market is the slow rate of systems change and problems related to the early innovation stages that manifest as legal barriers, inability to reach economies of scale, and the slow uptake of AP products in traditional retail settings. The sociotechnical "regime," as it is called in transitions literature, is slow and inert to change because of institutionalized preferences for the current technology, policies, and practices (37, 135). Novel AP products are hampered by different safety and health policies of government regulatory agencies in countries and regions prior to entering the marketplaces worldwide (52, 86).

Another challenge is the higher profit margins for products that require processing and allow differentiation and branding, which is a disadvantage for healthier and more environmentally sustainable products such as marketing for legumes and pulses (142). Economies of scale and externalization of the cost of environmental damage have favored centralization and globalization over diversity and resource efficiency over more ecologically resilient, agroecological practices (33).

A commonly perceived trade-off is that sustainability conflicts with economic development or prosperity (14). Business management research and economic literature as well as private-sector organizations are exploring strategies to resolve the trade-off, such as using doughnut economics and a steady-state economy on the macro level, as well as pursuing a business case for sustainability and circular and sustainable business models at the micro level (112, 147). There is a shift in the economist Milton Friedman's view of "business as the business of business" to the position that companies have a social responsibility to all stakeholders including to protect the planet (147). Momentum is growing among diverse private-sector constituencies to move beyond business as usual to use environmental, social, and governance metrics to transition to sustainable healthy diets and agroecological food systems.

For the future development of a profitable plant-based diet market, there must be active public- and private-sector investment into the research and development of new technologies (63); removal of legal barriers (86); a shift in professional mindsets, practices, and business models (37); and the application of policies that will change macroenvironmental factors (61). For example, retailers, restaurants, and food service providers can combine choice-architecture and marketing-mix strategies synergistically to nudge people to select plant-rich, sustainable diets or planetary health diets as the default and desirable choice (15, 107). Choice-architecture and nudge strategies may change food environments to be healthy and environmentally and socially sustainable, but also must align with business strategies and economic incentives to be economically sustainable.

3.5. Transitioning and Transforming Diets and Food Systems by 2030 and 2050

Food systems transition involves "incrementalism and reform that suggests moving from one place or state to another," whereas transformation refers to a reinvention or reshaping that leads to a "deep, rapid and radical global systems change" (23, p. 787). Plant-based foods and beverages are important components for a population's transition to sustainable diets and food systems. Policy makers must work with businesses, civil society, and other actors to ensure an equitable transition to sustainable diets that promote dietary diversity and societal well-being, especially for socially marginalized populations (120). **Table 1** presents opportunities, challenges, and actions that food systems governance actors may take to promote plant-based sustainable diets by 2030 and anticipated impacts by 2050.

With regard to plant-based diets and human health, we suggest that it is essential for governments and expert bodies to clarify the role of AP products in national dietary guidelines to incentivize a shift to more nutritious and healthier versions of these products both among the public and among businesses. With regard to plant-based diets and the ecological health of the planet, we suggest that improving the affordability and availability of plant-based products and meals to populations worldwide is a crucial collaborative-sector task to achieve a broad uptake of more environmentally friendly and climate-smart diets to protect ecosystems and promote planetary health.

For plant-based diets to address social equity, more efforts are needed to invest in adapting and diversifying products, services, and diet types to different cultures and consumer segments to enhance the appeal and social normalization of plant-based diets. To accelerate business investment and innovative actions toward plant-based diets, economic prosperity principles and goals must be better aligned through supportive policies and a greater investment in diverse innovations undertaken by both public and private actors and taken to scale.

As overarching issues, systems and resilience thinking applied to ensure policy coherence across sectors and disciplines will help to align disconnected goals. This approach will ensure that diverse and interdisciplinary solutions are promoted, ranging from technological to societal approaches. Applying systems thinking across domains will contribute to strategic policies and coordinated actions, which are needed to address several barriers, including convenience, social norms, and preferences that reinforce the overconsumption of meat, especially red and processed meats and UPF products (50). Such holistic thinking that entails greater awareness of trade-offs and feedback mechanisms can help to reach societal tipping points that accelerate the transformation to plant-based diets (7) and improve availability and affordability.

Moreover, print, broadcast, and digital media should consider better coverage of reports about dietary changes by framing the reduction of red and processed meat and food loss and waste as important climate-mitigation strategies to transition populations toward sustainable diets and equitable, resilient, and healthy food systems rather than framing the issues as a polarized debate or as personal choices (25, 48, 117). Such communication increases awareness on a broad scale and supports a change in social norms toward sustainable healthy eating (102), which can trigger societal tipping points (7).

There are many examples of innovations and collaborative actions in countries worldwide that promote plant-based diets to support the transition to sustainable diets and food systems. **Supplemental Figure 1** and **Supplemental Table 3** provide examples of policy innovations for plant-based diets throughout the food system in different countries and regions. National and municipal governments have made ambitious plant-based diet commitments aligned with the UN SDG 2030 timeline to support ecological health goals and also influence the actions taken by governments and businesses in other countries. In 2023, the Dutch government presented a plan to

Supplemental Material >

Table 1 Opportunities, challenges, and actions to promote plant-based sustainable diets by 2030 and anticipated impact by 2050

Sustainable diet domain	Current situation	Opportunities and challenges	Actions by 2030	Anticipated impact by 2050
Human health	Diets and food systems lack essential nutrients and have excessive amounts of calories, fats, added sugars, and sodium that contribute to malnutrition in all forms from undernutrition to obesity and noncommunicable diseases.	Many current plant-based AP products have nutritional shortcomings to meet recommended dietary patterns.	Nutritional guidelines must clarify the role of highly processed plant-based and hybrid AP ingredients and products to ensure optimal nutritional health.	Policies and incentives will be implemented to develop and market healthy plant-based AP products at all processing levels and to improve the healthiness of AP products in the marketplace.
Ecological health	Diets and food systems that are high in animal-based products and food waste are a major cause of climate change and biodiversity loss.	Current plant-based AP trends remain a niche market and do not have a substantial impact to shift dietary patterns to reduce the food systems' environmental and ecological footprints.	Large-scale consumer behavior changes will involve collaborative actions among diverse actors to improve environmental and ecological outcomes.	Plant-based diets will be adopted by the broader society, and the average meat and dairy consumption will align with the recommended targets in food-based dietary guidelines.
Social equity	Decision-making power for food systems is unequally distributed and citizens are not adequately engaged and involved.	Sociocultural differences and social norms represent a barrier for dietary changes that expand plant-based AP products.	Healthy and sustainable plant-based AP ingredients and products must be tailored to diverse cultural preferences and appeal to different consumer segments.	Businesses will improve the taste and appeal of plant-based products and diets to different consumer segments and cultures, increase the diversity of products, and socially normalize plant-rich diets.
Economic prosperity	Value creation is disproportionately in the processing, technology, and products and less in achieving sustainable healthy diet outcomes.	Current agri-food system policies favor the industrialized animal-based sector that is resistant to change.	Change and diversify economic system to ensure that profit is made in food categories that are healthy and sustainable and to favor diverse resilient solutions.	Reduce the trade-offs for business decision-makers and accelerate investments and development efforts to achieve products and services that support healthy and sustainable diets and lifestyles.
Cross-cutting issues	There is a disconnect and lack of shared governance among human health, environmental/ ecological, economic, and social equity policy goals for current agri-food systems at local, national, regional, and global levels.	Responsibilities between different policy areas are divided and actions remain siloed within disciplines.	Systems and resilience thinking needs to underpin alignment of policies: A sustainable food system needs policies that support a combination of social and technological innovations, and a diversity of AP solutions.	Policies support a diverse solution space ranging from societal to technological approaches and that considers all sustainability dimensions, and the market consists of diverse products, services, and dietary patterns.

Abbreviation: AP, alternative protein.

double legume consumption in their population by 2030 (122). **Supplemental Figure 2** shows the 16 cities in Asia, Europe, and the Americas where the elected mayors have signed the C40 Good Food Cities Declaration for climate actions by 2030 by shifting citizens' food consumption habits (3, 101).

Supplemental Material >

4. CONCLUSION

Shifting the world's population to consume nutrient-dense, plant-based diets with less red meat will enable the transition to sustainable food systems under a changing climate and feed 10 billion people by 2050. Plant-based diets are both central and crucial in discussing the transition and transformation of future sustainable food systems. Sustainable dietary patterns entail reducing animal-sourced proteins and shifting to a diversity of AP sources to mitigate the adverse ecological impacts of current food systems, reduce zoonotic diseases, and feed more people efficiently with fewer resources.

Achieving sustainable diets and food systems will require balancing principles across four domains for human health, ecological health, economic prosperity, and social equity. Food-based dietary guidelines in countries worldwide are not yet incorporating all the dimensions and principles of sustainable diets as recommended by international bodies. The degree to which AP products provide nutrient density and how AP ingredient processing impacts human and ecological health outcomes are current challenges. No country has comprehensively addressed how traditional and novel plant-based ingredients may support sustainable diets and food systems.

Evidence shows that plant-based diets can support human health. However, the nutritional quality of plant-based dietary patterns will vary based on the sources, formulation, proportion, nutrient density, quantity, and quality of proteins. Future product portfolios supported by businesses must increase beneficial nutrients (i.e., calcium, iron, and fiber) while reducing nutrients of concern (i.e., calories, fat, and sodium) without compromising taste to encourage consumer acceptance and enable widespread affordability.

A collaborative effort among food systems governance actors must ensure that plant-based diets move from a niche market to mainstream marketplaces to reduce pressures on ecosystems and the planet. This mainstreaming is characterized by diversity to ensure appeal to consumer segments, regional adaptation, and food system resilience. Many innovative and collaborative actions are growing globally to promote plant-based diets. Policy makers must work with businesses, civil society, and other actors to ensure an equitable transition of marketplace choices that encourage plant-rich sustainable diets within healthy, equitable, and resilient agroecological food systems by 2050.

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