DQPN ei-SPIE Introductory Call
Date: Wednesday, January 9, 2019
Time: 2pm-4pmET/1pm-3pmCT/11am-1pmPT

Pre-Call Materials

- Agenda
- Bios
- Research Literature (sampling)

Agenda

- Intros
- Project Overview
- Specific Aims of Project
- Call Objectives
    - Preferred Operations: Discussion
    - Project Chair: Discussion
    - Relevant Metrics/Sources: Discussion
    - Immediate Next Steps

SCIENTIFIC PANEL OF INDEPENDENT EXPERTS (for Environmental Impact)

SPIE-Environmental Impact Members: Goretty Dias, Gidon Eshel, Kate Geagan, Helen Harwatt, Danielle Nierenberg, Steve Osofsky, Christian Peters, Bill Ripple
Ex Officio Members: Christopher Gardner, David Jenkins, Walter Willett

BIOS: SPIE-Environmental Impact

GORETTY DIAS, PhD

Dr. Dias is a professor in the School of Environment, Enterprise & Development at the University of Waterloo, Canada. She holds a PhD in Atmospheric Science from the University of Guelph and has 30 years of combined experience in greenhouse gas measurement and analysis, environmental modeling, and product life cycle modeling.

Dr. Dias uses an interdisciplinary lens, which combines environmental sciences, industrial ecology, and sustainability science, to study food systems. Her current research interests include developing and applying life cycle sustainability assessment approaches to the study of food systems and dietary patterns in order to provide evidence-based solutions for sustainability issues occurring from farm-to-fork. Her research addresses resource use and potential environmental impacts due to food production, food waste assessment, as well as the potential of sustainable food consumption through appropriate dietary patterns.

GIDON ESHEL, PhD

Dr. Eshel is a research professor of environmental physics at Bard College and runs the website environmentalCalculations.com. He is best known for his work quantifying the geophysical consequences of agriculture and diet. Most recently, he has compared various livestock in terms of land and water use, fertilizer-based water pollution, and greenhouse gas emissions per unit product and compared the global-warming consequences of different beef-production strategies (including grass- versus trough-fed beef). His widely varied scientific interests also include the development of algebraic tools for simultaneous optimization of health and environmental outcomes through dietary choices, climate physics, and measures of time scale–specific ecosystem stability.

At Radcliffe, Eshel is collaborating with scientists from the Harvard University Center for the Environment and the Harvard T.H. Chan School of Public Health on developing multi-objective metrics of diet. The metrics combine disparate environmental impacts (e.g., greenhouse gas emissions or water and land use) with health outcomes (e.g., cardio- and cerebrovascular diseases or diabetes) in a manner most suitable for using in optimizations designed to improve public health while easing environmental burdens.

Eshel studied physics and earth sciences at the Technion and the University of Haifa, in Israel, before getting an MA, an MPhil, and a PhD at Columbia University in mathematical geophysics. Before his post at Bard, he was a NOAA Climate & Global Change Postdoctoral Fellow hosted by Harvard, a staff scientist at the Woods Hole Oceanographic Institute, and a faculty member of the Department of the Geophysical Sciences at the University of Chicago.

KATE GEAGAN, MS, RDN

Ms. Geagan is a nationally known registered dietitian who is on the vanguard of integrating nutrition guidance with agricultural health and sustainable food systems. Called "a global thought leader in her field" by Discovery Health of South Africa, Ms. Geagan is the author of *Go Green, Get Lean: Trim Your Waistline with the Ultimate Low Carbon Footprint Diet* (Rodale 2009). An international speaker and lecturer, she has helped to illuminate the connections between a healthy diet and a healthy planet for consumer, healthcare and business audiences worldwide, and is a sought-after speaker on nutrition and performance for executives at some of America's leading companies and associations. She currently serves as an advisor and consultant to food, nutrition and advocacy organizations that are seeking to create a healthier, more sustainable food economy. In 2013, Ms. Geagan was named "One of the Top 10 RDs Making a Difference in the US" by Today's Dietitian Magazine.

Kate has extensive television, print and digital media experience as a nutrition writer and an expert resource. She is an Advisory Board Member for Kiwi Magazine, and formerly served as a Medical Advisory Board Member and blogger for The Dr. Oz Show. From 2008-20011 she was the Nutrition Contributor for Pregnancy Magazine.

Previously, her company was an exclusive nutrition vendor to both Tufts and Harvard Pilgrim Healthcare, providing innovative nutrition, culinary and nutrition lifestyle programs to thousands of individuals throughout New England. Kate received her B.A. from Middlebury College (Cum Laude) and her M.S. in Nutrition and Health Promotion from Simmons College in Boston.

HELEN HARWATT, PhD

Dr. Harwatt is an environmental social scientist, with a focus on food systems shifts and their contribution to climate change mitigation goals. Dr. Harwatt's current projects focus on assessing the impacts of food systems shifts on a range of issues around environmental sustainability, public health and ethics, to identify pathways toward creating food systems that minimize adverse environmental impacts, maximize public health benefits, and address ethical issues.

Prior to joining HLS, Dr. Harwatt spent 3 years developing the environmental nutrition research program at the Loma Linda University in California, and 7 years at the University of Leeds' Sustainability Research Institute in the UK, conducting research on climate change mitigation, focused on consumers, businesses and governments, as an affiliate of the Tyndall Centre for Climate Change Research and the Centre for Low Carbon Futures. Helen won an international award from the International Transport Forum for her PhD research, which focused on the potential to meet climate change mitigation targets through a personal carbon trading scheme in the UK. Dr. Harwatt also runs the consultancy group Planet Friendly Food.

DANIELLE NIERENBERG, MS

Ms. Nierenberg is President of Food Tank and an expert on sustainable agriculture and food issues. She has written extensively on gender and population, the spread of factory farming in the developing world and innovations in sustainable agriculture. Danielle co-founded Food Tank, a 501(c)(3) non-profit organization, in 2013 as an organization focused on building a global community for safe, healthy, nourished eaters. Ms. Nierenberg has also recruited more than 40 of the world's top leaders in food and agriculture policies and advocacy work as part of Food Tank's Advisory Board.

Her knowledge of global agriculture issues has been cited widely in more than 8,000 major print and broadcast outlets worldwide. Ms. Nierenberg has authored or contributed to several major reports and books. She has spoken at hundreds of major conferences and events all over the world.

Ms. Nierenberg has an M.S. in Agriculture, Food, and Environment from the Tufts University Friedman School of Nutrition Science and Policy and spent two years volunteering for the Peace Corps in the Dominican Republic.

STEVE OSOFSKY, DVM

Dr. Osofsky is the Jay Hyman Professor of Wildlife Health & Health Policy at Cornell University's College of Veterinary Medicine. Prior to that, he was the Executive Director for Wildlife Health at the Wildlife Conservation Society, a US-based international nonprofit focused on conservation and sustainable development around the world. Dr. Osofsky is one of the pioneers of the One Health movement, having led the drafting of the core Manhattan Principles on One World, One Health in 2004. He has developed, launched and managed some of the first major applied One Health programs, including the AHEAD (Animal & Human Health for the Environment And Development) Program (launched at the 2003 IUCN World Parks Congress in Durban, South Africa) and the HEAL (Health & Ecosystems: Analysis of Linkages) Program (launched in 2009). As the only veterinarian serving on The Rockefeller Foundation-Lancet Commission on Planetary Health, he was able to bring his range of practical experiences (from both health and environmental conservation perspectives) to the task of shaping the highly interdisciplinary conceptual approach underpinning the field of Planetary Health (http://planetaryhealthalliance.org).

Prior to his leadership role at WCS, Dr. Osofsky served as the World Wildlife Fund (WWF-US) Director of Field Support for species programs in Asia and Africa. In the early 1990s, he was the first Wildlife Veterinary Officer for the Botswana Department of Wildlife and National Parks. As an American Association for the Advancement of Science (AAAS) Science and Diplomacy Fellow, he served as a Biodiversity Program Specialist at the U.S. Agency for International Development (USAID), where he focused on ground-truthing integrated conservation and development projects, with an emphasis on harvesting the synergies of strategic interdisciplinary programming.

Dr. Osofsky's diverse publications list includes the edited volume Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock and Human Health. He received his undergraduate degree from Harvard University and a Doctorate of Veterinary Medicine from Cornell University, and completed a small animal medical/surgical internship at Virginia Tech.

CHRISTIAN PETERS, PhD

Dr. Peters' research interests lie in the developing field of sustainability science, within the thematic area of food systems. Within this broad, trans-disciplinary field, Dr. Peters focuses on the modeling of food systems. To date, he has used quantitative modeling approaches to explore four major topics: (1) Land requirements of the human diet, (2) the human carrying capacity of agricultural land resources, (3) the potential of local and regional production systems to supply food needs, and (4) Feed needs of livestock systems. Dr. Peters is perhaps most well-known for his spatial analysis of potential local foodsheds, providing a concrete example of a term that has resonated with the local and regional food movements. As a result of this experience, Dr. Peters was invited to lead a research team within the USDA-funded project entitled "Enhancing Food Security of Underserved Populations in the Northeast through Sustainable Regional Food Systems" (or EFSNE). The "Scenarios and Modeling Team" includes all modelers on the EFSNE project and is charged with the development of scenarios and the identification of opportunities for linking models. Dr. Peters accepted this role in hopes of integrating biophysical and economic models of regional food systems. Finally, Dr. Peters seeks to understand the contribution that

modeling has made to the knowledge base related to the sustainability of food systems. To this end, he has developed a new course entitled "Food Systems Modeling and Analysis" designed to teach students some of the approaches used in this emerging field.

WILLIAM RIPPLE, PhD

Dr. Ripple is Distinguished Professor of Ecology at Oregon State University, specializing in carnivores, mammal ecology, and biodiversity conservation. Additionally, he is an adjunct professor in Environmental Nutrition at Loma Linda University's School of Public Health. He is a widely published researcher, lecturer, and a prominent international figure in the field of ecology. He has published over 110 peer-reviewed journal articles, 3 edited books, and 9 children's books. He has served as consultant to National Academy of Sciences, Office of Science and Technology-The White House, President Clinton's Forest Summit, Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. General Accounting Office. Dr. Ripple also studies and publishes research about the environmental and climate effects of livestock and human carnivory (meat eating by humans). His writings have shown that lowering human-driven methane emissions by reducing global ruminant livestock production could have a significant role to play in efforts to mitigate climate change.

BIOS: Ex Officio Members

CHRISTOPHER GARDNER, PhD

Dr. Gardner has a PhD in Nutrition Science and is a Professor of Medicine at Stanford's School of Medicine. He has been researching the health effects of a plant based-diet and its components for 20 years, primarily with federal (NIH) funding. Recently his nutrition interests have expanded to two new areas. The first is to explore motivators other than health for making positive dietary changes, linking to ongoing social movements around animal welfare, climate change, social justice, and their relationships to food – stealth health. The second is to focus on a food systems approach to dietary improvements that addresses the quality of food provided by schools, hospitals, worksites, food banks and other institutional food settings.

DAVID JENKINS, MD, PhD, DSc

Dr. Jenkins is currently a professor in both the Departments of Medicine and Nutritional Sciences, Faculty of Medicine, University of Toronto, a staff physician in the Division of Endocrinology and Metabolism and the Director of the Clinical Nutrition and Risk Factor Modification Center, St. Michael's Hospital. He was educated at Oxford University, where he obtained his DM, DPhil and DSc. After further research at the British Medical Research Council's Clinical Gastroenterology Unit, he returned to Oxford to a joint appointment in the Department of the Regius Professor of Medicine (Richard Doll) at the Radcliffe Infirmary and as a faculty member of the University Laboratory of Physiology. He is a fellow of the Royal College of Physicians (London) and of the Royal College of Physicians of Canada.

He has served on committees in Canada and the United States that have formulated nutritional guidelines for the treatment of diabetes and recommendations for fibre and macronutrient intake for the general population under the new joint United States-Canada DRI system (RDAs) of the National Academy of Sciences (Washington, DC).

His research area is the use of diet in the prevention and treatment of hyperlipidemia and diabetes. He has over 300 original publications on these and related topics. His team was the first to define and explore

the concept of the glycemic index of foods and demonstrate the breadth of metabolic effects of viscous soluble fiber, including blood glucose and cholesterol lowering. His studies on combining cholesterol lowering food components (dietary portfolio) have been recognized as creating an effective dietary alternative to drug therapy (statins) for many people and was the only dietary approach referenced in the last Guidelines of the US National Cholesterol Education Program (ATP III) and the Canadian Cardiovascular Society Guidelines.

To make therapeutic diets more accessible, he has devoted much time to working with the food industry to develop products for the supermarket with specific health attributes and, for example, helped to initiate Loblaw's 'too good to be true' and 'Blue Menu' line of products.

He was awarded the W.O. Atwater Award of the USDA and the American Society of Nutrition for his studies on functional foods for the treatment of disease (2013) and the Order of Canada (OC) in 2013.

He believes in the value of plant-based diets, and that a major effort is required to mount large studies to determine the extent of their health benefits. He also believes that diets have to be environmentally sustainable.

WALTER WILLETT, MD, DrPH

Dr. Willett is Professor of Epidemiology and Nutrition at Harvard T.H. Chan School of Public Health and Professor of Medicine at Harvard Medical School. Dr. Willett studied food science at Michigan State University, and graduated from the University of Michigan Medical School before obtaining a Masters and Doctorate in Public Health from Harvard T.H. Chan School of Public Health. Dr. Willett has focused much of his work over the last 40 years on the development and evaluation of methods, using both questionnaire and biochemical approaches, to study the effects of diet on the occurrence of major diseases. He has applied these methods starting in 1980 in the Nurses' Health Studies I and II and the Health Professionals Follow-up Study. Together, these cohorts that include nearly 300,000 men and women with repeated dietary assessments, are providing the most detailed information on the long-term health consequences of food choices.

Dr. Willett has published over 1,700 original research papers and reviews, primarily on lifestyle risk factors for heart disease, cancer, and other conditions and has written the textbook, Nutritional Epidemiology, published by Oxford University Press, now in its third edition. He also has written four books for the general public. Dr. Willett is the most cited nutritionist internationally. He is a member of the National Academy of Medicine of the National Academy of Sciences and the recipient of many national and international awards for his research.

RESEARCH LITERATURE

Poore J, T. Nemecek. Reducing food's environmental impacts through producers and consumers. Science. 2018;360:6392:987-992.

http://science.sciencemag.org/content/360/6392/987

Abstract: Food's environmental impacts are created by millions of diverse producers. To identify solutions that are effective under this heterogeneity, we consolidated data covering five environmental indicators; 38,700 farms; and 1600 processors, packaging types, and retailers. Impact can vary 50-fold among producers of the same product, creating substantial mitigation opportunities. However, mitigation is complicated by trade-offs, multiple ways for producers to achieve low impacts, and interactions throughout the supply chain. Producers have limits on how far they can reduce impacts. Most strikingly, impacts of the lowest-impact animal products typically exceed those of vegetable substitutes, providing new evidence for the importance of dietary change. Cumulatively, our findings support an approach where producers monitor their own impacts, flexibly meet environmental targets by choosing from multiple practices, and communicate their impacts to consumers.

Esteve-Llorens, X. Darriba C. Moreira MT. Feijoo G. González-García S. Towards an environmentally sustainable and healthy Atlantic dietary pattern: Life cycle carbon footprint and nutritional quality. Science of The Total Environment. 2019;646:704-715.

https://www.sciencedirect.com/science/article/pii/S0048969718327578?via%3Dihub

Abstract: Production and consumption of food has a significant effect on climate change. The effect of different consumption habits on the environment should not be under estimated, as there are different studies that mention the environmental impact associated with different foods, especially those of animal origin. The analysis of the Atlantic diet (AD), as the most common dietary pattern in Northwestern Spain, serves as an example of a diet with a high consumption of local, fresh and seasonal products, home cooking and low-processed foods. The evaluation was carried out by quantifying the carbon footprint following the Life Cycle Analysis methodology and identifying its nutritional quality according to the value of the Nutrient-rich Dietary index (NRD9.3.). According to the main results, the consumption of livestock products and shellfish is responsible for most GHG emissions (70% of the total). The basic ingredients of the AD, such as vegetables and legumes, make a relatively minor contribution (with an impact of 30% of the total) to the total carbon footprint of 3.01 kg CO2eq·person−1·day−1. As regards nutritional quality, AD has a high nutritional score (474), mainly due to the low intake of sodium, added sugars and saturated fats (nutrients to be limited in healthy diets). In general, both the carbon footprint and the nutritional index score are consistent with those of other studies on the Mediterranean diet, which has been recognized as beneficial. Therefore, it can be concluded that the AD may be recommended from a nutritional and environmental point of view, mainly due to the high intake of fish and vegetables. The communication of this valuable environmental and nutritional information to consumers should be taken into account when considering strategic actions for the adoption of healthy and sustainable dietary patterns.

Boehm R, Wilde PE, Ver Ploeg M, Costello C, Cash SB. A Comprehensive Life Cycle Assessment of Greenhouse Gas Emissions from U.S. Household Food Choices. Food Policy.2018;79(C):67-76.

https://www.sciencedirect.com/science/article/abs/pii/S0306919217310552?via%3Dihub

Abstract: Changes in diet have been proposed as one way to reduce carbon emissions from the food system. But evidence on the implications of changing to low carbon food choices for both diet quality and food affordability are limited in the U.S. The objective of this study was to (a) estimate greenhouse gas emissions (GHGEs) from U.S. household food purchases; (b) examine the source of GHGEs across U.S. food production industries and stages of the supply chain; and (c) show the association between GHGEs and spending by food categories and

household sociodemographics. GHGEs from food expenditures made by households participating in the National Household Food Acquisition and Purchase Survey were calculated using Economic Input-Output Life Cycle Assessment. Results indicate that food purchases accounted for 16% of U.S. GHGEs in 2013 and average weekly household GHGEs were 71.8 kg carbon dioxide equivalents per standard adult. 68% of average weekly household GHGEs from food spending came from agriculture and food manufacturing stages of the food supply chain. Industries that produce animal proteins accounted for 30% of average weekly household GHGEs, the largest share of any food industry. Households generating the highest levels of GHGEs spent a significantly larger share of their food budget on protein foods compared to households generating lower levels of GHGEs. White households and those with higher education levels generated more GHGEs from food spending compared to non-white and less educated households. Overall these findings inform the ongoing debate about which diets or food spending patterns in the U.S. are best for mitigating GHGEs in the food system and if they are feasible for consumers to purchase.

Gazan R, Brouzes CMC, Vieux F, Maillot M, Lluch A, Darmon N. Mathematical Optimization to Explore Tomorrow's Sustainable Diets: A Narrative Review. Adv in Nutr. 2018;9(5):602–616.
https://academic.oup.com/advances/article/9/5/602/5098393
Abstract: A sustainable diet is, by definition, nutritionally adequate, economically affordable, culturally acceptable, and environmentally respectful. Designing such a diet has to integrate different dimensions of diet sustainability that may not be compatible with each other. Among multicriteria assessment methods, diet optimization is a whole-diet approach that simultaneously combines several metrics for dimensions of diet sustainability. This narrative review based on 67 published studies shows how mathematical diet optimization can help with understanding the relations between the different dimensions of diet sustainability and how it can be properly used to identify sustainable diets. Diet optimization aims to find the optimal combination of foods for a population, a subpopulation, or an individual that fulfills a set of constraints while minimizing or maximizing an objective function. In the studies reviewed, diet optimization was used to examine the links between dimensions of diet sustainability, identify the minimum cost or environmental impact of a nutritionally adequate diet, or identify food combinations able to combine ≥2 sustainability dimensions. If some constraints prove difficult to fulfill, this signals an incompatibility between nutrient recommendations, over-monotonous food-consumption patterns, an inadequate supply of nutrient-rich foods, or an incompatibility with other dimensions. If diet optimization proves successful, it can serve to design nutritionally adequate, culturally acceptable, economically affordable, and environmentally friendly diets. Diet optimization results can help define dietary recommendations, tackle food security issues, and promote sustainable dietary patterns. This review emphasizes the importance of carefully choosing the model parameters (variables, objective function, constraints) and input data and the need for appropriate expertise to correctly interpret and communicate the results. Future research should make improvements in the choice of metrics used to assess each aspect of a sustainable diet, especially the cultural dimension, to improve the practicability of the results.

González-García S, Esteve-Llorens X, Moreira MT, Feijoo G. Carbon footprint and nutritional quality of different human dietary choices. Sci Total Environ. 2018;644:77-94.
https://www.sciencedirect.com/science/article/pii/S004896971832415X?via%3Dihub
Abstract: Apart from industrial activities, our eating habits also have a significant environmental cost associated with crop cultivation, manufacturing processes, packaging, refrigeration, transport cooking and waste management. In a context of growing social awareness of the role of different dietary choices in the environment, the review of different alternatives on the road to a healthy and sustainable diet should integrate relevant information on the nutritional quality of different eating habits. Since dietary choices have an effect on environmental sustainability and human health, a literature review on different dietary choices has been

conducted to determine the differences in carbon footprint and nutritional quality identifying the main hotspots trying to give advice towards the identification of sustainable diets. After applying a set of criteria for reference selection, 21 peer-reviewed studies have been analysed in detail, allowing the comparison of 66 dietary scenarios. We identified that the so-called Mediterranean and Atlantic diets present high nutritional scores and low carbon footprints. On the contrary, the dietary choices identified in northern and Western Europe, as well as in the United States, have the highest carbon footprints, highlighting the contribution of dairy products as a basic source of high-quality nutrients and protein. Broadly speaking, dietary choices rich in vegetables (e.g., vegan, vegetarian as well as Indian and Peruvian) have a better environmental profile than those rich in meat (mainly ruminant meat). In line with these findings, the shift in meat consumption habits from beef and veal to chicken, pork and poultry, the introduction of alternative foods to animal protein (e.g. quinoa) and the consumption of olive oil as a major source of vegetable oil may be compatible with a healthier and more environmentally friendly diet. However, the complete elimination of meat and dairy products from the daily diet may not be feasible in case the supply of some micronutrients (e.g., calcium and vitamin D) is not guaranteed. Limitations were identified in the consulted studies related to the consideration of the different system boundaries, as well as underlying uncertainties related to data sources. Therefore, efforts should be made to develop consistent and agreed-upon methods for estimating both the carbon footprint and nutritional quality scores.

Hallström E, Davis J, Woodhouse A, Sonesson U. Review: Using dietary quality scores to assess sustainability of food products and human diets: A systematic review. Ecological Indicators. 2018;93:219-230.
https://www.sciencedirect.com/science/article/pii/S1470160X1830325X?via%3Dihub
Abstract: The increased recognition of inter-relationships between the environmental and health effects of food has resulted in a new fast-growing research area. Development of methods for integrated analysis of environmental and nutritional impacts is essential to facilitate policy decisions and actions for sustainable food systems. Dietary quality scores is one of the methods suggested to combine environmental and nutritional assessments of foods, meals and diets. This systematic review provides an overview of how dietary quality scores are used in environmental sustainability studies of food products and diets. The review includes 24 articles applying 20 different types of dietary quality scores. We describe current approaches used to combine environmental and nutritional assessments, discuss methodological choices of importance and their impact on results, and identify research gaps that require further efforts to push the current frontier of knowledge. Based on our analysis we identify two different categories of dietary quality scores and four approaches used to integrate environmental and nutritional assessments. There is a large number of methods available to quantify a dietary quality score: which one is chosen as well as how they are combined with environmental assessments can affect the results, and hence also the conclusions of which foods that are more sustainable to eat. This is critical to understand for the set-up of studies and for the interpretation of results and drawing conclusions. Our categorization of existing methods used, how they differ, what applications they are suited for, and which methodological challenges they involve increases the understanding of what analyzes are possible today and point out areas where methods are lacking and where more research is required. Continued efforts are needed to bring about a transition to sustainable food systems that do not exceed the planets ecological limits and promote healthy populations. This systematic review provides guidance for future use and development of methods within the field of sustainable nutrition.

Kramer GFH, Martinez EV, Espinoza-Orias ND, Cooper KA, Tyszler M, Blonk H. Comparing the Performance of Bread and Breakfast Cereals, Dairy, and Meat in Nutritionally Balanced and Sustainable Diets. Front Nutr. 2018;(7)5:51.
https://www.frontiersin.org/articles/10.3389/fnut.2018.00051/full
ABSTRACT: Objective: To quantify the performance of food products in a sustainable diet based on the balance of their contribution to nutrient intake and environmental impact, within the context of the Dutch diet. Design: While fixing the quantity of a specific food group at different levels, optimized diets that met nutrient requirements and stayed as close as possible to the current Dutch diet were calculated, in order to understand its potential environmental impact and its nutritional quality. Bread & breakfast cereals, dairy and meat were compared between 0-250% of current intake. Their performance is expressed in the relationship between the quantity of these food products and (1) the environmental impact of diets and (2) the nutrient balance of the diets. Setting: The Netherlands. Subjects: Women aged 31 to 50
Results: The amount of bread & breakfast cereals in the optimized diets were inversely correlated with their environmental impact. The nutrient balance of the optimized diets was maintained despite varying cereal content, with the expected improvement over the current diet. Increasing amounts of dairy in the optimized diet were associated with an increase in environmental impact and meat with a steep increase. The nutrient balance of optimized diets with varying dairy and meat contents was also maintained at high levels, even at 0% content.
Conclusions: Bread & breakfast cereals are sources of nutrients with a better environmental performance compared to dairy or meat within the context of the Dutch diet. It is possible to optimize diets for environmental impact whilst maintaining a high nutrient balance.

Walker C, Gibney ER, Hellweg S. Comparison of Environmental Impact and Nutritional Quality among a European Sample Population – findings from the Food4Me study. Scientific Reports 2018;8(1).
https://www.nature.com/articles/s41598-018-20391-4
Abstract: This study evaluates the relationship between environmental impacts and diet quality through several environmental and nutritional indicators, using data from over 1400 participants across seven European countries in the Food4Me study. Comparisons of environmental impacts and dietary quality were evaluated across country, gender groups, and dietary patterns. While there was clear variability within the different subsets, there were large differences observed in both dietary quality and environmental impacts between cultures, genders, and dietary patterns. Individuals abstaining from red meat consistently had lower impacts in combination with lower consumption of harmful nutrients (saturated fats, sodium, and sugars) while maintaining average intake of beneficial nutrients. A 'best practice' diet with low impacts, adequate nutrient intake, and low saturated fats, sodium, and sugars, was constructed from the sample and used as a benchmark. Recorded eating patterns were compared to this recommended diet. On average, intakes of sweets, meats, and drinks should be decreased and intakes of vegetables and cereals increased, at varying rates depending on country and gender. However, the study shows a large spread of eating patterns and recommendations for lowering environmental impacts and increasing nutritional quality vary greatly among individuals.

Clune S, Crossin E, Verghesec K. Systematic review of greenhouse gas emissions for different fresh food categories. J Cleaner Prod. 2017;140(2):766-783.
https://www.sciencedirect.com/science/article/pii/S0959652616303584
Abstract: This paper presents the results of a systematic literature review of greenhouse gas emissions for different food categories from life cycle assessment (LCA) studies, to enable streamline calculations that could inform dietary choice. The motivation for completing the paper was the inadequate synthesis of food greenhouse gas emissions available in the public domain. The paper reviewed 369 published studies that

provided 1718 global warming potential (GWP) values for 168 varieties of fresh produce. A meta-analysis of the LCA studies was completed for the following categories: fresh vegetables (root vegetables, brassica, leaves and stems); fresh fruits (pepo, hesperidium, true berries, pomes, aggregates fruits and drupes); staples (grains, legumes, nuts, seeds and rice); dairy (almond/coconut milk, soy milk, dairy milk, butter and cheese); non-ruminant livestock (chicken, fish, pork); and ruminant livestock (lamb and beef). The meta-analysis indicates a clear greenhouse gas hierarchy emerging across the food categories, with grains, fruit and vegetables having the lowest impact and meat from ruminants having the highest impact. The meta-analysis presents the median, mean, standard deviation, upper and lower quartile, minimum and maximum results for each food category. The resultant data enables streamline calculations of the global warming potential of human diets, and is illustrated by a short case study of an Australian family's weekly shop. The database is provided in the Appendix as a resource for practitioners. The paper concludes with recommendations for future LCA studies to focus upon with respect to content and approach.

Notarnicolaa B, Salab S, Antonc A, McLarend SJ, Saouterb E, Sonessone U. The role of life cycle assessment in supporting sustainable agri-food systems: A review of the challenges. J Cleaner Prod. 2017;140(2):399-409.
https://linkinghub.elsevier.com/retrieve/pii/S095965261630748X
Abstract: Life cycle thinking is increasingly seen as a key concept for ensuring a transition towards more sustainable production and consumption patterns. As food production systems and consumption patterns are among the leading drivers of impacts on the environment, it is important to assess and improve food-related supply chains as much as possible. Over the years, life cycle assessment has been used extensively to assess agricultural systems and food processing and manufacturing activities, and compare alternatives “from field to fork” and through to food waste management. Notwithstanding the efforts, several methodological aspects of life cycle assessment still need further improvement in order to ensure adequate and robust support for decision making in both business and policy development contexts. This paper discusses the challenges for life cycle assessment arising from the complexity of food systems, and recommends research priorities for both scientific development and improvements in practical implementation. In summary, the intrinsic variability of food production systems requires dedicated modelling approaches, including addressing issues related to: the distinction between technosphere and ecosphere; the most appropriate functional unit; the multi-functionality of biological systems; and the modelling of the emissions and how this links with life cycle impact assessment. Also, data availability and interpretation of the results are two issues requiring further attention, including how to account for consumer behaviour.

Rosi A, Mena P, Pellegrini N, Turroni S, Neviani E, Ferrocino I, Di Cagno R, Ruini L, Ciati R, Angelino D, Maddock J, Gobbetti M, Brighenti F, Del Rio D, Scazzina F. Environmental impact of omnivorous, ovo-lacto-vegetarian, and vegan diet. Sci Rep. 2017.7(1):6105.
https://www.nature.com/articles/s41598-017-06466-8
Abstract: Food and beverage consumption has a great impact on the environment, although there is a lack of information concerning the whole diet. The environmental impact of 153 Italian adults (51 omnivores, 51 ovo-lacto-vegetarians, 51 vegans) and the inter-individual variability within dietary groups were assessed in a real-life context. Food intake was monitored with a 7-d dietary record to calculate nutritional values and environmental impacts (carbon, water, and ecological footprints). The Italian Mediterranean Index was used to evaluate the nutritional quality of each diet. The omnivorous choice generated worse carbon, water and ecological footprints than other diets. No differences were found for the environmental impacts of ovo-lacto-vegetarians and vegans, which also had diets more adherent to the Mediterranean pattern. A high inter-individual variability was observed through principal component analysis, showing that some vegetarians and vegans have higher environmental impacts than those of some omnivores. Thus, regardless of the environmental

benefits of plant-based diets, there is a need for thinking in terms of individual dietary habits. To our knowledge, this is the first-time environmental impacts of three dietary regimens are evaluated using individual recorded dietary intakes rather than hypothetical diet or diets averaged over a population.
3 indexes: the carbon footprint (CF)-greenhouse gas emissions, the water footprint (WF)-consumption of water resources and the ecological footprint (EF)-amount of biologically productive land/sea needed to produce a unit of food product).

Ulaszewska MM, Luzzani G, Pignatelli S, Capri E. Assessment of diet-related GHG emissions using the environmental hourglass approach for the Mediterranean and new Nordic diets. Sci Total Environ. 2017;(574):829-836.
https://doi.org/10.1016/j.scitotenv.2016.09.039
Abstract: Food production and preparation affect the environment in many ways, with effects on greenhouse gases, use of land, biodiversity, etc. The impact is influenced by consumer demand and eating habits. Two different recommended dietary models were considered, the Mediterranean Diet and the New Nordic Diet, with quantitative analysis of GHG emissions through LCA. An environmental hourglass (EH) approach based on LCA was introduced to help translate health-promoting dietary recommendations that consider regional circumstances and cultural diversity into practical eating habits, to promote sustainable and environmentally friendly consumption. Using the environmental hourglass approach, we examined whether dietary choices based on nutritional recommendations can minimise certain negative effects on the food production environment. Using two examples of health-enhancing, regionally-oriented and culturally appropriate dietary patterns - the Mediterranean Diet and the New Nordic Diet - we showed that consumption of high protein foods has a similar and comparable environmental impact to fruit and vegetable consumption. The results of this work may provide a starting point for integrated policy addressing issues related to the healthy diet of the population, aware food choices and sustainable agriculture.
Highlights
• Environmental Hourglass supports evaluation of GHG impacts of dietary recommendations.
• Recommended consumption of protein food had similar GHG impact to fruit and vegetable.
• Mediterranean Diet and New Nordic Diet had similar total values of GHG emissions.

Aleksandrowicz L, Green R, Joy EJ, Smith P, Haines A. The Impacts of Dietary Change on Greenhouse Gas Emissions, Land Use, Water Use, and Health: A Systematic Review. PLoS One. 2016;3;11(11):e0165797. doi: 10.1371/journal.pone.0165797.
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Abstract: Food production is a major driver of greenhouse gas (GHG) emissions, water and land use, and dietary risk factors are contributors to non-communicable diseases. Shifts in dietary patterns can therefore potentially provide benefits for both the environment and health. However, there is uncertainty about the magnitude of these impacts, and the dietary changes necessary to achieve them. We systematically review the evidence on changes in GHG emissions, land use, and water use, from shifting current dietary intakes to environmentally sustainable dietary patterns. We find 14 common sustainable dietary patterns across reviewed studies, with reductions as high as 70-80% of GHG emissions and land use, and 50% of water use (with medians of about 20-30% for these indicators across all studies) possible by adopting sustainable dietary patterns. Reductions in environmental footprints were generally proportional to the magnitude of animal-based food restriction. Dietary shifts also yielded modest benefits in all-cause mortality risk. Our review reveals that environmental and health benefits are possible by shifting current Western diets to a variety of more sustainable dietary patterns.

Donini LM, Dernini S, Lairon D, Serra-Majem L, Amiot MJ, Del Balzo V, Giusti AM, Burlingame B, Belahsen R, Maiani G, Polito A, Turrini A, Intorre F, Trichopoulou A, Berry EM. A Consensus Proposal for Nutritional Indicators to Assess the Sustainability of a Healthy Diet: The Mediterranean Diet as a Case Study. Front Nutr. 2016;29(3)37.

https://www.frontiersin.org/articles/10.3389/fnut.2016.00037/full

BACKGROUND: There is increasing evidence of the multiple effects of diets on public health nutrition, society, and environment. Sustainability and food security are closely interrelated. The traditional Mediterranean Diet (MD) is recognized as a healthier dietary pattern with a lower environmental impact. As a case study, the MD may guide innovative inter-sectorial efforts to counteract the degradation of ecosystems, loss of biodiversity, and homogeneity of diets due to globalization through the improvement of sustainable healthy dietary patterns. This consensus position paper defines a suite of the most appropriate nutrition and health indicators for assessing the sustainability of diets based on the MD. METHODS: In 2011, an informal International Working Group from different national and international institutions was convened. Through online and face-to-face brainstorming meetings over 4 years, a set of nutrition and health indicators for sustainability was identified and refined. RESULTS: Thirteen nutrition indicators of sustainability relating were identified in five areas. Biochemical characteristics of food (A1. Vegetable/animal protein consumption ratios; A2. Average dietary energy adequacy; A3. Dietary Energy Density Score; A4. Nutrient density of diet), Food Quality (A5. Fruit and vegetable consumption/intakes; A6. Dietary Diversity Score), Environment (A7.Food biodiversity composition and consumption; A8. Rate of Local/regional foods and seasonality; A9. Rate of eco-friendly food production and/or consumption), Lifestyle (A10. Physical activity/physical inactivity prevalence; A11. Adherence to the Mediterranean dietary pattern), Clinical Aspects (A12. Diet-related morbidity/mortality statistics; A13. Nutritional Anthropometry). A standardized set of information was provided for each indicator: definition, methodology, background, data sources, limitations of the indicator, and references.

CONCLUSION: The selection and analysis of these indicators has been performed (where possible) with specific reference to the MD. Sustainability of food systems is an urgent priority for governments and international organizations to address the serious socioeconomic and environmental implications of short-sighted and short-term practices for agricultural land and rural communities. These proposed nutrition indicators will be a useful methodological framework for designing health, education, and agricultural policies in order, not only to conserve the traditional diets of the Mediterranean area as a common cultural heritage and lifestyle but also to enhance the sustainability of diets in general.

Eshel G. Shepon A, NoorE, Milo, R. Environmentally Optimal, Nutritionally Aware Beef Replacement Plant-Based Diets. Environ. Sci. Technol. 2016;50(15):8164-8168.

https://pubs.acs.org/doi/abs/10.1021/acs.est.6b01006

Livestock farming incurs large and varied environmental burdens, dominated by beef. Replacing beef with resource efficient alternatives is thus potentially beneficial, but may conflict with nutritional considerations. Here we show that protein-equivalent plant based alternatives to the beef portion of the mean American diet are readily devisible, and offer mostly improved nutritional profile considering the full lipid profile, key vitamins, minerals, and micronutrients. We then show that replacement diets require on average only 10% of land, 4% of greenhouse gas (GHG) emissions, and 6% of reactive nitrogen (Nr) compared to what the replaced beef diet requires. Applied to 320 million Americans, the beef-to-plant shift can save 91 million cropland acres (and 770 million rangeland acres), 278 million metric ton CO2e, and 3.7 million metric ton Nr annually. These nationwide savings are 27%, 4%, and 32% of the respective national environmental burdens.

Nelson ME, Hamm MW, Hu FB, Abrams SA, Griffin TS. Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review. Adv Nutr. 2016;7(6):1005-1025.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5105037/pdf/an012567.pdf

Abstract: To support food security for current and future generations, there is a need to understand the relation between sustainable diets and the health of a population. In recent years, a number of studies have investigated and compared different dietary patterns to better understand which foods and eating patterns have less of an environmental impact while meeting nutritional needs and promoting health. This systematic review (SR) of population-level dietary patterns and food sustainability extends and updates the SR that was conducted by the 2015 US Dietary Guidelines Advisory Committee, an expert committee commissioned by the federal government to inform dietary guidance as it relates to the committee's original conclusions. In the original SR, 15 studies met the criteria for inclusion; since then, an additional 8 studies have been identified and included. The relations between dietary intake patterns and both health and environmental outcomes were compared across studies, with methodologies that included modeling, life cycle assessment, and land use analysis. Across studies, consistent evidence indicated that a dietary pattern higher in plant-based foods (e.g., vegetables, fruits, legumes, seeds, nuts, whole grains) and lower in animal-based foods (especially red meat), as well as lower in total energy, is both healthier and associated with a lesser impact on the environment. This dietary pattern differs from current average consumption patterns in the United States. Our updated SR confirms and strengthens the conclusions of the original US Dietary Guidelines Advisory Committee SR, which found that adherence to several well-characterized dietary patterns, including vegetarian (with variations) diets, dietary guidelines–related diets, Mediterranean-style diets, the Dietary Approaches to Stop Hypertension (DASH) diet, and other sustainable diet scenarios, promotes greater health and has a less negative impact on the environment than current average dietary intakes.

Heller MC, Keoleian GA, Willett WC. Toward a Life Cycle-Based, Diet-level Framework for Food Environmental Impact and Nutritional Quality Assessment: A Critical Review. Environ. Sci. Technol. 2013;47(22):12632–12647.

https://pubs.acs.org/doi/10.1021/es4025113

Abstract: Supplying adequate human nutrition within ecosystem carrying capacities is a key element in the global environmental sustainability challenge. Life cycle assessment (LCA) has been used effectively to evaluate the environmental impacts of food production value chains and to identify opportunities for targeted improvement strategies. Dietary choices and resulting consumption patterns are the drivers of production, however, and a consumption-oriented life cycle perspective is useful in understanding the environmental implications of diet choices. This review identifies 32 studies that use an LCA framework to evaluate the environmental impact of diets or meals. It highlights the state of the art, emerging methodological trends and current challenges and limitations to such diet-level LCA studies. A wide range of bases for analysis and comparison (i.e., functional units) have been employed in LCAs of foods and diet; we conceptually map appropriate functional unit choices to research aims and scope and argue for a need to move in the direction of a more sophisticated and comprehensive nutritional basis in order to link nutritional health and environmental objectives. Nutritional quality indices are reviewed as potential approaches, but refinement through ongoing collaborative research between environmental and nutritional sciences is necessary. Additional research needs include development of regionally specific life cycle inventory databases for food and agriculture and expansion of the scope of assessments beyond the current focus on greenhouse gas emissions.