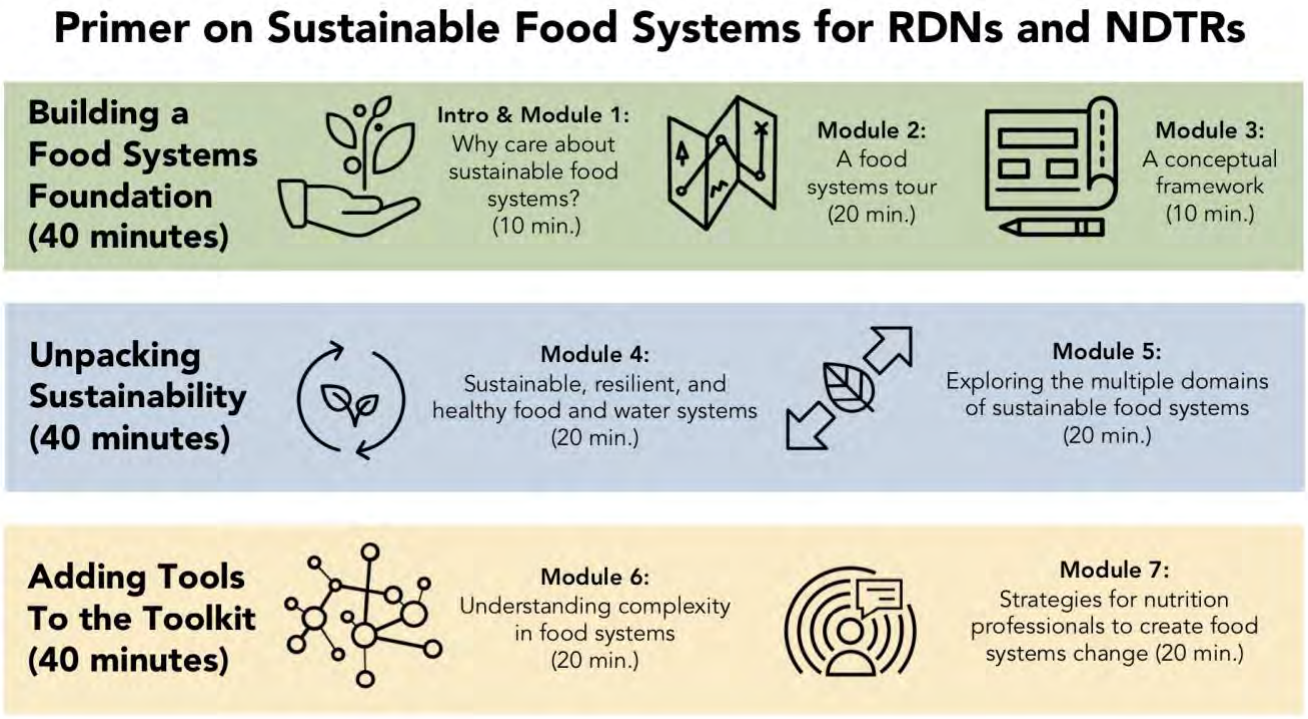
Academy of Nutrition and Dietetics Foundation



Primer on Sustainable Food Systems for RDNs and NDTRs

Table of contents (click to skip to specific modules)

How to use this handout

This handout includes learning outcomes, a list of abbreviations, information organized by slide for all seven modules of the primer (including audio transcripts from the recording, references and image attributions, and an annotated bibliography with resources for further learning), and an overall reference list.

To navigate this PDF more easily, we recommend enabling the Table of Contents in your View settings.

About the Primer on Sustainable Food Systems for RDNs and NDTRs

This primer was created to answer the question, "What should a practitioner of nutrition and dietetics know about sustainable food systems?" The need for an introductory resource in a modular format for practitioners and students was identified by the Sustainable Food Systems Curriculum Working Group, which was convened by the Academy of Nutrition and Dietetics Foundation's Healthy and Sustainable Food Systems Fellow.

This resource was not designed to provide a definitive answer to questions at the intersection of nutrition and sustainability; it was designed to provide foundational knowledge, vocabulary, and critical thinking skills so that learners are equipped to bring their nutrition expertise to the evolving dialogue on sustainable, resilient, and healthy food and water systems.

This resource is suitable for both credentialed nutrition and dietetics practitioners (RDNs and NDTRs) and for students and interns. Outside of dietetics, it may also be of interest to students and practitioners in food systems, nutrition, and public health more broadly.

There are many ways to engage with this resource, depending on your interest and time available. If you are new to the topic, viewing the pre-recorded videos and slides (7 modules totaling 2 hours of content) will provide a high-level overview. Each module can stand alone–they range from 10 to 20 minutes—though we encourage you to view them in order as they build towards a more complete understanding of sustainable food systems.

If you are looking for more depth, the handout provides a transcript, references, and additional resources. Supplement 1, an educators' guide, provides a listing of relevant ACEND competencies and sample discussion questions for each module. Supplement 2 provides further examples for the Individual plus Policy, Systems, and Environment (I+PSE) Conceptual Framework for Action that is presented in the primer. The modular format of the primer lends itself to integration in a variety of educational settings.

If you have questions about continuing and professional education for this resource, please contact foundation@eatright.org. If you have questions about the content of the primer, please contact Marie Spiker, PhD, MSPH, RDN at mspiker@uw.edu.

Learning Outcomes for the Primer

By the end of this primer, you will be able to:

- Use a conceptual framework of the food system to describe how the food system influences diets, nutrition and health.
- Discuss sustainability, resilience, and health in food systems through the lens of environmental, economic, and social factors.
- Use tools from systems thinking to describe complexities, co-benefits, and trade-offs within food systems.
- Identify five entry points through which nutrition and dietetics professionals can leverage their unique skills to cultivate sustainable food systems.
- Locate reliable resources related to sustainable food systems for nutrition and dietetics professionals.

Learning Outcomes for Specific Modules

Building a Food Systems Foundation

Module 1: Why care about sustainable food systems?

- Describe the growing interest in sustainable food systems from individuals, institutions, and policymakers.
- Identify core skills of the nutrition and dietetics profession that are especially helpful in navigating issues in the food system.
- Identify ways that familiarity with sustainable food systems can help RDNs and NDTRs meet their goals in a variety of practice settings.

Module 2: A food systems tour
- Define the concept of food systems.
- Provide examples of how food supply chains, food environments, and consumer behavior can vary in different geographic settings.

Module 3: A food systems conceptual framework
- Identify the three major components of food systems.
- Identify at least three underlying drivers that influence food systems.
- Describe at least three ways nutrition is important for achieving the Sustainable Development Goals.

Unpacking Sustainability

Module 4: Sustainable, resilient, and healthy food and water systems
- Define the concepts of sustainability, resilience, and health on their own and within the context of food systems.
- Define the concept of equity and discuss how equity is related to sustainability, resilience, and health in the food system
- Describe the importance of water for food systems and human health.

Module 5: Exploring the multiple domains of sustainable food systems
- Identify the four domains of sustainable, resilient, and healthy food and water systems.
- Describe principles within each domain.
- Discuss how human diets affect and are affected by environmental, economic, and social factors.

Adding Tools to the Toolkit

Module 6: Understanding complexity in the food system
- Define a complex system.
- Describe at least three characteristics of complex systems.
- Discuss how systems thinking can be used to approach issues in nutrition.
- Provide at least one example of a co-benefit and one example of a tradeoff within the food system.

Module 7: Strategies for RDNs & NDTRs to create food systems change
- Identify five entry points through which RDNs and NDTRs can leverage their knowledge and skills to cultivate sustainable food systems.
- Identify cross-cutting skills that are common to nutrition and dietetics practice that can help RDNs and NDTRs to promote sustainable food systems.
- Locate reliable resources related to sustainable food and water systems for RDNs and NDTRs.

Abbreviations

CDC	United States Centers for Disease Control
CO_2	Carbon dioxide
DPG	Dietetics Practice Group
EPA	United States Environmental Protection Agency
FAO	Food and Agriculture Organizations of the United Nations
FDA	United States Food and Drug Administration
FOF	Future of Food (an initiative of the Academy of Nutrition and Dietetics)
GHG	Greenhouse gas
HLPE	High Level Panel of Experts (convened by the United Nations Committee of World Food Security)
I+PSE	Individual plus Policy, Systems, and Environmental Change
LMIC	Low- and Middle-Income Countries
NAM	National Academy of Medicine (formerly the Institute of Medicine)

MDG	Millennium Development Goals (set by the United Nations for 2015)
MIG	Member Interest Group
NDTR	Nutrition and Dietetics Technician, Registered
RDN	Registered Dietitian Nutritionist
SDG	Sustainable Development Goals (set by the United Nations for 2030)
SOPP	Standards of Professional Performance
US	United States
USDA	United States Department of Agriculture
WHO	World Health Organization

Acknowledgements

The development of the *Primer on Sustainable Food Systems for RDNs and NDTRs* was a project of the Academy of Nutrition and Dietetics Foundation's Future of Food Initiative, supported by an educational grant from the National Dairy Council.

This resource was developed by Marie Spiker, PhD, MSPH, RDN, Healthy and Sustainable Food Systems Fellow at the Academy of Nutrition and Dietetics Foundation; Amanda Hege, MPH, RDN, Project Manager with the Academy of Nutrition and Dietetics Foundation; and Janice Giddens, MS, RDN, Director of Health and Wellness Partnerships at the National Dairy Council.

We thank those who provided expert review at different points during the development process, including Erin Bergquist, MPH, RD, LD; Mildred Cody, PhD, RD; Anita Courtney, MS, RD; and Angie Tagtow, MS, RD, LD. We also thank students and interns who assisted with reviewing, proofreading, and image sourcing: Andrea Dudenhoefer, Amy Ervin, Blair Hayes, and Ivory Loh.

We also thank the Sustainable Food Systems Curriculum Working Group, a group of educators and students whose collaboration during the 2018-2019 academic year informed the need for and scope of this resource. The working group included program directors, educators, preceptors, and dietetic interns and students including Erin Bergquist at Iowa State University, Nancy Prange at Northern Illinois University, Diane Stadler at Oregon Health & Science University, and Aaron Schwartz and Liz Combs at the University of Kentucky.

Recommended citation:

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Introduction

Slide 1: Title

Welcome to the *Primer on Sustainable Food Systems for Nutrition and Dietetics Professionals*. You'll also see the title of this primer using the abbreviations RDN (for registered dietitian nutritionist) and NDTR (for nutrition and dietetic technician, registered). I want to note that this primer is intended broadly for those who work in nutrition and dietetics, regardless of your career stage or track or the country of your credentialing.

Slide 2: Acknowledgements

My name is Marie Spiker. At the time this was recorded I was the Healthy and Sustainable Food Systems Fellow at the Academy of Nutrition and Dietetics Foundation (Foundation), and I want to acknowledge all who were involved in creating this resource including the co-developers, expert reviewers, and assistants who are shown here.

Slide 3: About the Future of Food Initiative

This resource was developed as part of the Foundation's Future of Food Initiative, which is funded by an educational grant from National Dairy Council.

The Future of Food Initiative was launched in 2012 to position the Academy and its members to address the issues of global food security, hunger, and malnutrition. The initiative was launched with support from National Dairy Council and Feeding America. Resources produced within the Future of Food initiative include curricula, publications, webinars, toolkits, infographics, and other resources.

One of the publications describes a framework for action for how registered dietitian nutritionists (RDNs) and nutrition and dietetics technicians registered (NDTRs) can cultivate sustainable food systems, and we'll explore this framework in Module 7.

I encourage you to visit the Future of Food website to see the most recent resources.

Links:

- Link to Future of Food website
- *Food Banking / Food Insecurity curriculum:*
  - Link to curriculum
  - Link to publication describing curriculum development: Handu D, Medrow L, Brown K. Preparing future registered dietitian nutritionists for working with populations with food insecurity: A new food insecurity/food banking supervised practice concentration piloted with dietetic interns. Journal of the Academy of Nutrition and Dietetics. 2016 Jul 1;116(7):1193-8.
- *Sustainable, Resilient, and Healthy Food and Water Systems (SFS) curriculum:*
  - Link to curriculum
  - Link to publication describing curriculum development: Knoblock-Hahn A, Medrow L. Development and implementation of a sustainable, resilient, and healthy food and water systems curriculum for dietetic interns. Journal of the Academy of Nutrition and Dietetics. 2020 Jan 1;120(1):130-3.
- *Publications:*
  - Vogliano C, Steiber A, Brown K. Linking agriculture, nutrition, and health: the role of the registered dietitian nutritionist. Journal of the Academy of Nutrition and Dietetics. 2015;115(10):1710-4.
  - Spiker ML, Knoblock-Hahn A, Brown K, Giddens J, Hege AS, Sauer K, Enos DM, Steiber A. Cultivating sustainable, resilient, and healthy food and water systems: a nutrition-focused framework for action. Journal of the Academy of Nutrition and Dietetics. 2020 Jun 1;120(6):1057-67.

Slide 4: Learning Outcomes for this Primer

By the end of this primer, you will be able to:

1. Use a conceptual framework of the food system to describe how food systems influence diets, nutrition, and health.
2. Discuss sustainability, resilience, and health in food systems through the lens of environmental, economic, and social factors.
3. Use tools from systems thinking to describe complexities, co-benefits, and trade-offs within food systems.
4. Identify five entry points through which nutrition and dietetics professionals can leverage their unique skills to cultivate sustainable food systems.
5. Locate reliable resources related to sustainable food systems for nutrition and dietetics professionals.

Slide 5: A Primer on Sustainable Food Systems for RDNs and NDTRs

You can complete this primer in two hours, but it is designed to be broken down into smaller, 15 to 20-minute modules.

The first three modules help us to build a food systems foundation: we'll talk about why food systems are important for nutrition and dietetics professionals, we'll go on a tour through the food system, and we'll use a conceptual framework to tie things together.

Modules 4 and 5 focus on sustainability. We'll talk about what sustainability and resilience mean in the context of food systems, and we'll explore the multiple dimensions of sustainable food systems.

Modules 6 and 7 add tools to your toolkit. We'll share some basic systems thinking terminology, describe ways that RDNs and NDTRs can leverage their skills in support of sustainable food systems, and describe where you can find reliable resources to continue learning in this area.

Image sources: *All icons are from the Noun Project. Top Row: care by Kokota, trail map by Nicole Steffen, Protoyping by ProSymbols. Middle Row: Sustainability by Emily Rinehart, environmental impact by Made. Bottom Row: Network by Meaghan Hendricks, Influencer by Alequinho.*

Module 1: Why Care About the Food System?

Slide 6: Module 1 Introduction

Module 1 provides a quick intro to why we should care about sustainable food systems as nutrition and dietetics professionals.

Image sources: *Care icon by Kokota from the Noun Project*

Slide 7: Module 1 Learning Outcomes

By the end of this module, you will be able to:

1. Describe the growing interest in sustainable food systems from individuals, institutions, and policymakers.
2. Identify core skills of the nutrition and dietetics profession that are especially helpful in navigating issues in the food system.
3. Identify ways that familiarity with sustainable food systems can help RDNs and NDTRs meet their goals in a variety of practice settings.

Slide 8: Nutrition and food are inseparable from sustainability

To get right to the heart of the question that frames this module, we should care about sustainable food systems because nutrition and food are inseparable from sustainability.

We recommend varied and balanced diets, but people can't follow our recommendations if these foods are not accessible, affordable, or available in the food supply.

For example, in the United States, when researchers applied the 2010 Healthy Eating Index (HEI) to our overall food supply, they found that all of the food we produce and import had an HEI score of 55 out of 100, indicating poor alignment with the 2010 Dietary Guidelines for Americans (1).

Our average per capita availability of vegetables, fruits, and fish all fall short of recommended amounts, when we take into account the sum of what is produced and imported in the US (2,3)

And globally, 45% of the world lives in countries where the World Health Organization's fruit and vegetable target of 400 grams per person per day is not available in the food supply, and this gap is predicted to widen in the future due to increased demand and climate change (4).

Sources cited:

1. Miller PE, Reedy J, Kirkpatrick SI, Krebs-Smith SM. The United States food supply is not consistent with dietary guidance: evidence from an evaluation using the Healthy Eating Index-2010. Journal of the Academy of Nutrition and Dietetics. 2015 Jan 1;115(1):95-100.
    - *In this paper, researchers use the Healthy Eating Index-2010 to evaluate the overall quality of the US food supply in 2010 using the Food Availability Data System. The Healthy Eating Index is typically applied to the diets of individuals or groups (rather than a food supply), and it measures compliance with the Dietary Guidelines for Americans.*

2. Bentley J. *US trends in food availability and a dietary assessment of loss-adjusted food availability, 1970-2014.* USDA ERS Economic Information Bulletin No. (EIB-166). 2017.
    - *This report calculates per capita availability of different foods using the USDA's Loss-Adjusted Food Availability dataset. The estimates in this dataset include production and imports and exclude exports and food loss/waste and the retail and consumer levels.*

3. Institute of Medicine, National Research Council. A framework for assessing effects of the food system. National Academies Press; 2015 Jun 17. P. 289.
    - *This source does not directly state the per capita availability of fish in the United States, but it provides data we can use to make an estimate. According to 2013 data from the National Fisheries Institute, as of 2012 the per capita availability of fish was 14.4 pounds per capita per year, which is equivalent to 4.43 ounces per capita per week. Pages 287-300 of this report contain a useful systems thinking case study of the US fish system as a complex adaptive system.*

4. Mason-D'Croz D, Bogard JR, Sulser TB, Cenacchi N, Dunston S, Herrero M, Wiebe K. Gaps between fruit and vegetable production, demand, and recommended consumption at global and national levels: an integrated modelling study. The Lancet Planetary Health. 2019 Jul 1;3(7):e318-29.

Additional resources:

- Buzby JC, Wells HF, Vocke G. Possible Implications for US Agriculture from Adoption of Select Dietary Guidelines. USDA ERS Economic Research Report No. (ERR-31). 2006.
    - *This report analyzed 2006 data and found that in order to supply the amount of fruits and vegetables recommended in the Dietary Guidelines for Americans, the United States would need to produce an additional 13 million acres of fruits and vegetables.*

Slide 9: Nutrition and food are inseparable from sustainability

Another thing that unites nutrition and sustainability is that feeding people always involves an ecological footprint.

Agricultural practices account for 34% of global land use (1), 70% of water used for human purposes (2), and 11% of global greenhouse gas emissions (3).

Knowing that it's not feasible to feed the world without using any resources, that leaves us with a key question: how can we responsibly use our shared resources to ensure the long-term viability of natural, economic, social and other resources so that future generations have a food supply that supports nutrition and health?

Sources cited:

1. Ramankutty N, Evan AT, Monfreda C, Foley JA. Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000. Global Biogeochemical Cycles. 2008 Mar;22(1).

2. Molden, D., et al., 2007. Pathways for increasing agricultural water productivity. In: Molden, D. (Ed.), Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. International Water Management Institute, London: Earthscan.

3. Global Emissions. Center for Climate and Energy Solutions website. https://www.c2es.org/content/international-emissions/. Accessed March 25, 2020.

4. World Resources Institute. Working Paper: Reducing Food Loss and Waste. 2013.

Slide 10: Patients and clients have questions about sustainability

One reason for nutrition and dietetics professionals to care about sustainable food systems is that we are seeing a growing interest in sustainability from the general public. Patients and clients increasingly have questions about food labels, organic versus conventionally grown foods, local and seasonal food, food packaging and waste, and genetically modified foods. They want to know about plant-based versus animal-source foods, and they're confused about what kind of fish they should buy. The questions shown here were reported in a 2019 Member Pulse Survey to Academy members (1), and so they reflect questions that practitioners are currently fielding. Of over 2,600 survey respondents, half reported that they have received questions related to sustainability from patients and clients.

These questions illustrate something important: members of the public are concerned about some of the broader impacts of the food system – they're concerned about climate change, water use, biodiversity, animal welfare, and whether we'll have enough food for the future – but at the they're also concerned about how agricultural different practices affect the safety and nutritional value of the foods they consume. If we're not prepared to answer these questions, we miss out on a big opportunity to guide consumers towards nutritious choices, and consumers may seek nutrition advice from people who are not credentialed practitioners.

Sources cited:

1. Academy of Nutrition and Dietetics House of Delegates. Member Pulse Survey: Shaping and Delivery Dietary Guidance related to Food Systems and Sustainability. Results shared at May 2019 House of Delegates meeting.

Slide 11: Institutions have questions about sustainability

We're also seeing growing interest in sustainability from institutions where RDNs and NDTRs are employed, whether those are commercial and noncommercial food service organizations, supermarkets, healthcare institutions, or other workplaces.

Institutions are seeking guidance on how to incorporate sustainability into their food procurement choices, menu planning, and waste reduction efforts. They're looking to create environments where the easiest choice is also the healthy and sustainable choice. And they want to ensure that any new programs are sustained over the long term, which requires engaging and training frontline workers. Because RDNs and NDTRs work in so many diverse foodservice roles, the profession is well positioned to catalyze positive changes in this area, as well as oversee training and implementation to ensure that sustainability initiatives are successful over the long term.

Additional resources:

- Food Service Guidelines Federal Workgroup. *Food Service Guidelines for Federal Facilities.* Washington DC: US Department of Health and Human Services; 2017.
    - *This guide includes goals for conducting environmentally responsible practices that promote nutrition and health and support communities economically through local food sourcing.*

- Healthcare Without Harm. *Fresh, Healthy and Sustainable Food: Best Practices in European Healthcare* 2016.
    - *This is a resource for sustainable food procurement within hospital settings.*

- Nordic Food Policy Lab. *Solutions Menu: A Nordic guide to sustainable food policy.* Denmark: Nordic Council of Ministers; 2018.
    - *Includes content on the use of public meals as a potential solution to improve nutritional quality and address sustainability concerns, among other public health goals.*

Slide 12: Policymakers have questions about sustainability

There is also growing interest in sustainability from policymakers. The 2015 Dietary Guidelines Advisory Committee was the first of its kind to consider sustainability, with the rationale that whether people can actually follow our dietary recommendations requires that nutritious foods are available within the food supply. Though sustainability was ultimately not included in the final guidelines in 2015, the fact that it was included in the scientific report and was debated in the public sphere shows the elevation of sustainability within the larger conversation around public health. Around 100 countries have food-based dietary guidelines (1), and a growing number of countries are making the connection between human diets and sustainability in their guidelines including Brazil, Canada, China, Germany, Sweden, and the United Kingdom.

Sources cited:

1. Springmann M, Spajic L, Clark MA, Poore J, Herforth A, Webb P, Rayner M, Scarborough P. The healthiness and sustainability of national and global food based dietary guidelines: modelling study. BMJ. 2020 Jul 15;370.
    - *At the time this study was published in 2020, 99 countries had food-based dietary guidelines. This study also asks a larger research question about whether the adoption of food-based dietary guidelines is associated with different health and environmental outcomes.*

Additional resources:

- Dietary Guidelines Advisory Committee. 2015. *Scientific Report of the 2015 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and the Secretary of Agriculture.* US Department of Agriculture, Agricultural Research Service, Washington, DC.
    - *Chapter 5 includes the results of the Committee's systematic reviews related to sustainability.*

- Food and Agriculture Organization of the United Nations. *Plates, pyramids, planet* FAO and the University of Oxford. 2016.
    - *This report documented 4 countries that had incorporated sustainability into their food-based dietary guidelines as of 2016: Brazil, Germany, Qatar, and Sweden.*

- Jones R, Vogliano C, Burlingame B. Chapter 16: Sustainable Diets and Food-based Dietary Guidelines. Sustainable Diets: Linking Nutrition and Food Systems. 2018 Dec 10:158.
    - *These authors documented 11 countries that incorporated sustainability into their food-based dietary guidelines as of 2019: Australia, Brazil, China, Estonia, France, Germany, the Netherlands, Qatar, Sierra Leone, Sweden, and the United Kingdom.*

- Health Canada. 2019. Canada's Dietary Guidelines for Health Professionals and Policy Makers.
    - *In addition to the 11 countries mentioned above, as of 2019 the Canadian Dietary Guidelines also connect healthy eating to environmental impact.*

Slide 13: Are we prepared…

In light of all these important and challenging questions from individuals, institutions, and policymakers, we should be asking ourselves whether we are prepared to respond – as individual practitioners, and as a profession.

Slide 14: The core skills of the nutrition and dietetics profession

Though the questions we're receiving about sustainability may feel new, many of our profession's core skills are well suited to helping us respond to these challenges.

For example, topics related to sustainability often involve complexity and uncertainty, but nutrition and dietetics professionals are already well versed in helping people navigate dietary choices amidst complexity and uncertainty. For example, diet-disease relationships are not straightforward, and one strength of our profession is helping people find the signal within the noise.

We are also well versed in fulfilling multiple goals through food. We know that food can't just be nutritious: it also needs to be safe, culturally appropriate, delicious, accessible, and affordable. Adding sustainability as one of our goals aligns with our current multi-dimensional view of food.

RDNs and NDTRs are also skilled at critically evaluating and translating research from a variety of scientific disciplines to accessible messaging for the public. This is important as many challenges in the food system require us to engage with research from fields such as environmental science, economics, or racial equity.

Challenges in the space of sustainability also require that we collaborate as part of interprofessional teams and engage with other sectors such as government, academia, civil society, and the private sector. Regardless of our practice setting, this type of interprofessional collaboration is not new, though we may need to broaden our view of collaborators to include farmers, food manufacturers, retailers, and other food systems stakeholders.

Slide 15: When RDNs and NDTRs are familiar…

Developing familiarity with food systems and sustainability allows RDNs and NDTRs to elevate our practice, regardless of whether we currently work in a role that has "sustainability" in the title or not.

For example, if we have a working knowledge of issues in the food system, when we receive questions about things like food waste, packaging, or eco-labels, we can fulfill our role as food and nutrition experts and use these opportunities to help guide people towards nutritious choices.

Understanding the broader food system also helps us to amplify our effectiveness. For example, even if I work on interventions at the individual level, such as education and behavior change, having an awareness of barriers and opportunities at the policy, systems, and environmental levels can help me to be more effective in my work.

In addition to understanding how the food system may affect the daily lived experiences of our patients and clients, as dietitians we also have the ability to generate positive change within the larger food system. For example, we can identify and initiate actions that strengthen local food economies or improve equitable access to culturally appropriate foods through policy advocacy, changing institutional protocols, or changing purchasing decisions.

Additional resources:

- Cohen L, Swift S. The spectrum of prevention: developing a comprehensive approach to injury prevention. Injury prevention. 1999 Sep 1;5(3):203-7.
    - *The concept of policy, systems, and environmental change (PSE) comes from the idea that we can affect human health along a spectrum of prevention. This was one of the first papers to describe this concept, and it did so within the realm of injury prevention.*

Slide 16: Transition

[Transition to the next module]

Module 2: A Food Systems Tour

Slide 17-18: Transition

[Transition to the module]

Slide 19: Module 2 Introduction

In Module 2, we'll go on a tour through global food systems.

Image sources: trail map icon by Nicole Steffen from the Noun Project

Slide 20: Module 2 Learning Outcomes

By the end of this module, you will be able to:

1. Define the concept of food systems.
2. Provide examples of how food supply chains, food environments, and consumer behavior can vary in different geographic settings.

Slide 21: What is the food system?

There are many definitions for the concept of the food system, and one that we'll use here is by Roni Neff and Bob Lawrence, who define the food system as "a system encompassing all the activities and resources that go into producing, distributing, and consuming food; the drivers and outcomes of those processes; and the extensive and complex relationships between system participants and components" (1). This is a big definition with many parts to unpack, and we'll spend the next few minutes doing just that.

Sources cited:

1. Neff R and Lawrence R. Chapter 1: Food Systems. In Neff R, editor. Introduction to the US food system: public health, environment, and equity. John Wiley & Sons; 2014 Oct 20.

Additional resources:

- Note that in this resource, we refer interchangeably to the singular "the food system" or the plural "food systems." We acknowledge that there is no single food system, and that any given system contains multiple sub-systems.

Slide 22: Preview of the food systems conceptual framework

In Module 3 we'll introduce a food systems conceptual framework from the United Nations High Level Panel of Experts (1). For now, I'm showing a simplified version of the framework to give you a preview of what we'll see on the food systems tour.

Sources cited:

- Framework adapted from: HLPE. 2017. Nutrition and food systems. A report by the High-Level Panel of Experts on Food Security and Nutrition.

Slide 23: Preview of the food systems conceptual framework

Our food systems definition from Neff and Lawrence describes three distinct stages – producing, distributing, and consuming food. These map onto the three major components of the food system that shown in bold here – food supply chains, food environments, and consumer behavior.

Slide 24: Preview of the food systems conceptual framework

Taken together, we know that food supply chains, food environments, and consumer behavior influence dietary intake. In turn, dietary intake leads to many outcomes – outcomes for human nutrition and health, as well as broader environmental, economic, and social outcomes. There are also underlying drivers that influence all components of the food system. So when Neff and Lawrence talk about drivers and outcomes, this is what they're referring to.

Slide 25: Preview of the food systems conceptual framework

Neff and Lawrence also mention the "extensive and complex relationships between system participants and components," and throughout this primer we'll provide examples of some of these relationships. But for now, let's start our food systems tour.

Slide 26: We produce many kinds of food – crops, livestock, marine plants & animals

We produce many different kinds of food. We grow plants on land, and we harvest plants from the sea. We consume animals and animal products, from both land and marine animals. Food production, regardless of the type, requires resources – land, soil, water, biodiversity, energy, and human and mechanical labor.

Additional resources:

- Max Roser and Hannah Ritchie (2020) - "Food Supply". Published online at OurWorldInData.org.
  - *Visit this site for interactive visuals of the composition of our global food supply. Note that many of the visuals have a slider to show change over time.*
- Hannah Ritchie and Max Roser (2019) - "Land Use". Published online at OurWorldInData.org.
  - *Visit this site for interactive visuals about agricultural land use. Note that many of the visuals have a slider to show change over time.*

Image sources: Left: 6okean via Getty Images. Middle: Astrid860 via Getty Images. Top Right: EoNaYa via Getty Images. Bottom Right: Irenadragan via Getty Images.

Slide 27: We produce food for many purposes – subsistence, income, community

We also produce food for many purposes. The Food and Agriculture Organization (FAO) estimates that 2.5 billion people worldwide depend on agricultural livelihoods for their survival (1) – whether that's for subsistence, or whether they're growing enough to sell. Food producers are an important population in their own right, and they're also feeding the rest of us – so global public health is closely tied to the health and welfare of our farmers, ranchers, and fishers and the many farmworkers and other laborers that support them.

It's also worth noting that we can grow food for reasons other than subsistence or income. While home gardens and community gardens can be a source of food, they also provide other benefits including community, knowledge of food traditions and practices, self-reliance, and connection to the natural world.

Sources cited:

1. United Nations Food and Agricultural Organization (FAO). Increasing the Resilience of Agricultural Livelihoods. Rome, Italy: FAO; 2016.

Additional resources:

2. Santo R, Palmer A, Kim B. Vacant Lots to Vibrant Plots: A Review of the Benefits and Limitations of Urban Agriculture. 2014.
   - *This report from the Center for a Livable Future describes the benefits and limitations of urban agriculture, and notes that even when urban agriculture doesn't wholly provide for food or income needs, it can still provide benefits related to education, community cohesion, and cultural integration:*

Image sources: Left: Nikhil Patil via Getty Images**.** Middle: Alffoto via Getty Images**.** Right: Monkeybusinessimages via Getty Images.

Slide 28: We produce food at many different scales

We also produce food at many different scales. For reference, one hectare is about 2.5 acres, or the approximate size of a professional sports field. The average farm size in India is around 1.3 hectares, it's around 1.2 hectares in Japan, and 1 hectare in Ethiopia. This is a much different scale than farms in the United States, which average 179 hectares, or 582 hectares in Argentina. The size of a farm is not inherently good or bad, but the size influences factors like whether outside labor is required, how much capital is needed for equipment and inputs, and whether a farm can leverage economies of scale.

You might hear people talk about small farms or family farms. About 12% of the world's agricultural land is cultivated by small farms, which are defined as less than 2 hectares. And about 75% of the world's agricultural land is cultivated by family-run farms. (1). There are both positives and negatives to growing food at different scales – it really depends on what goals and perspectives we are considering.

Sources cited:

- Lowder SK, Skoet J, Raney T. The number, size, and distribution of farms, smallholder farms, and family farms worldwide. World Development. 2016 Nov 1;87:16-29.
    - *This peer reviewed article provides comprehensive country-level estimates of the number and size of farms worldwide, using agricultural census data through the year 2000.*
- Born B, Purcell M. Avoiding the local trap: Scale and food systems in planning research. Journal of planning education and research. 2006 Dec;26(2):195-207.
    - *This landmark paper from a geographer deconstructs the idea of scale within agriculture: can any scale of food production be inherently good or bad?*

Additional resources:

- Paul C, Nehring R, Banker D, Somwaru A. Scale economies and efficiency in US agriculture: are traditional farms history?. Journal of Productivity Analysis. 2004 Nov 1;22(3):185-205.
    - *For further reading about the trade-offs of large- and small-scale agricultural production in the US.*

Image sources: Left: Branex via Getty Images. Right: Tfoxfoto via Getty Images.

Slide 29: We produce food using different ways of providing & recycling nutrients

An important part of the food system is nutrients. The nutritional status of humans depends on the nutritional status of the plants and animals we consume. Some of the nutrients that aid in plant growth are nitrogen, phosphorus, and potassium. In some cases, food producers compost organic matter to supply nutrients to crops – the top left photo shows composting rows. And in other cases, food producers use synthetic inputs; shown on the bottom left is a fertilizer plant that is converting atmospheric nitrogen to ammonia through the Haber Bosch process, which is an innovation that has allowed us to dramatically increase the quantity of crops we can grow globally. Inputs such as fertilizer can be applied at large or small scales, in more or less judicious ways. So it's not just what is being applied to fields, but how much and how it is applied.

We manage not only the nutrients that go into food production, but also the nutrients that come out. Sometimes we manage these processes in a closed loop in a single location. The top right shows an aquaponics facility where the waste products of fish and plants are recycled in a closed system where they use each other's outputs as inputs. Sometimes this closed loop and recycling of nutrients takes place across different sites. On the bottom right is an anaerobic treatment lagoon for livestock manure, and some of this can be applied to farmers' fields to close the loop. Again, with all of these, there are positives and negatives that relate to human health, the environment, the economy, and society. Nutrient run-off from sites of agricultural production into soil and waterways has important implications for the global nitrogen cycle, soil and water quality, and the health of flora, fauna, fish, and humans.

Additional resources:

- Bouwman L, Goldewijk KK, Van Der Hoek KW, Beusen AH, Van Vuuren DP, Willems J, Rufino MC, Stehfest E. Exploring global changes in nitrogen and phosphorus cycles in agriculture induced by livestock production over the 1900–2050 period. Proceedings of the National Academy of Sciences. 2013 Dec 24;110(52):20882-7.
    - *This peer-reviewed article provides an overview of how agriculture has altered global nitrogen and phosphorous cycles between 1950 and 2000, and the positive and negative effects associated with these changes.*

- Cordell D, Drangert JO, White S. The story of phosphorus: Global food security and food for thought. Global Environmental Change. 2009;19(2):292-305.
    - *For more reading about finite supplies of phosphate rock, which is used to create synthetic fertilizer inputs.*

- Hornick SB. Factors affecting the nutritional quality of crops. American Journal of Alternative Agriculture. 1992 Jan 1:63-8.
    - *For an overview of factors affecting the nutritional quality of crops.*

- Temkin A, Evans S, Manidis T, Campbell C, Naidenko OV. Exposure-based assessment and economic valuation of adverse birth outcomes and cancer risk due to nitrate in United States drinking water. Environmental research. 2019 Sep 1;176:108442.
    - *For more reading about health impacts of agricultural runoff. Nitrates in groundwater have human impacts in agricultural community including methemoglobinemia (blue-baby syndrome).*

- United States Department of Agriculture, Economic Research Service. Nutrient Management. 2020.
    - *Provides a good overview on issues of nutrient management in US agriculture.*

Image sources: Top Left: Crystalclear - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=2544361. Bottom Left: Sharon Loxton, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=9311811. Middle: Photo by Marie Spiker, used with Permission. Top Right: Ryan Somma - Aquaponics, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=7928078. Bottom Right: kjkolb - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=260166

Slide 30: We produce food using water from different sources – irrigated, rainfed

Another important part of the food system is water. Some agriculture is purely rainfed, and some relies partially or completely on irrigation. One consideration related to irrigation is whether water is withdrawn at a rate that can be sustained over the long term given the rate at which groundwater sources such as aquifers are recharged. You may have heard of the Ogallala Aquifer, which supplies groundwater to many states within the Great Plains, and is in danger of having water withdrawn much faster than it can be recharged.

Here we see a few different ways of supplying water to crops: a center pivot irrigation system on the top left, and a drip irrigation system on the top right. On the bottom left is an irrigation canal along a wheat field in India, and on the bottom right we see wetland rice production.

Additional resources:

- Hannah Ritchie and Max Roser (2018) - "Water Use and Stress". *Published online at OurWorldInData.org.*
    - *Visit this site for visuals about global water use, including agricultural water use, see these figures from Our World in Data (note that many of the figures have a slider to show change over time).*

- Hanjra MA, Qureshi ME. Global water crisis and future food security in an era of climate change. Food policy. 2010 Oct 1;35(5):365-77.
    - *This peer reviewed publication describes global water supplies and food security.*

- Scott M. National climate assessment: Great plains' Ogallala Aquifer drying out. 2019.
    - *An accessible overview of how the Ogallala Aquifer, which underlies the great plains, has water withdrawn for agriculture and other purposes at rates that exceed the aquifer's recharge rates.*

Image sources: Top Left: Simazoran via Getty Images. Top Right: DiyanaDimatrova via Getty Images. Bottom Left: Hitesh Singh via Getty Images. Bottom Right: North-Tail via Getty Images.

Slide 31: We have different methods of on-farm storage

After food is harvested, there are many ways of storing crops on farm. Shown here are metal containers to store grain – in India on the left, and in Indiana on the right. The middle photo shows an extension agent training farmers to use PICS bags – Purdue improved crop storage bags. If these bags are sealed properly, letting them sit for long enough ensures that any pests inside die due to lack of oxygen, allowing farmers to retain more of their harvest for home consumption and sale.

On-farm storage has important implications for postharvest loss – we want to ensure that farmers can retain and sell as much of their crops as possible, rather than losing them to pests or spoilage. According to FAO, "food loss" refers to losses during production, post-harvest, and processing whereas "food waste" occurs at later stages of the food supply chain, such as the retail and consumer levels (1). In low- and middle-income countries, where there is limited infrastructure for on-farm storage and distribution, we tend to see more losses, with 40% of loss at the production, post-harvest, and processing levels. On the other hand, in industrialized nations, more than 40% of food losses occur as waste at the retail and consumer levels (2).

On-farm storage also has important implications for human health. When crops are not able to fully dry, like in humid environments with limited infrastructure, toxic substances are more likely to form. Aflatoxin, for example, is a class of mycotoxin fungi that grows on crops such as corn, peanuts, and tree nuts, and it's one of many fungal toxins that may be associated with childhood stunting and many other issues; for more, see the FDA's Bad Bug Book (3).

Sources cited:

1. Gustavsson J, Cederberg C, Sonesson U, Van Otterdijk R, Meybeck A. *Global food losses and food waste - Extent, causes and prevention.* Rome, Italy: Food and Agriculture Organization of the United Nations; 2011.

2. World Resources Institute. Working Paper: Reducing Food Loss and Waste. 2013.
    - *This resource takes information from Gustavsson 2011 and presents clear visuals.*

3. US Food and Drug Administration. Bad Bug Book: Handbook of foodborne pathogenic microorganisms and natural toxins. 2012.

Additional resources:

- Purdue Improved Crop Storage. PICS Network.
    - *For more information about PICS bags.*

- *Peer-reviewed articles on the links between aflatoxins and childhood stunting, and the links between climate change and the presence of mycotoxins:*
    - Khlangwiset P, Shephard GS, Wu F. Aflatoxins and growth impairment: a review. Critical reviews in toxicology. 2011 Oct 1;41(9):740-55.
    - Medina Á, González-Jartín JM, Sainz MJ. Impact of global warming on mycotoxins. Current Opinion in Food Science. 2017 Dec 1;18:76-81.

- United States Department of Agriculture, Economic Research Service. Food Loss. 2019.
    - *A high-level overview of how food loss is measured at the retail and consumer levels by the USDA.*

Image sources: Left: Photo by Marie Spiker, used with permission. Middle: A demonstration of the PICS bag is presented to a women's group in Kenya in March 2014; photo credit: Dieudonné Baributsa, Department of Entomology, Purdue University; used with permission. Right: Photo by Marie Spiker, used with permission.

Slide 32: … and many ways of transporting food…

Once food leaves the farm, it can face a long and circuitous journey. The vegetables in this truck on the left, in India, may not fare as well as the vegetables transported in the refrigerated truck shown in the middle. On the right you can see the refrigeration units on big shipping containers on a cargo ship.

A few notes about transporting food:

- In general, the environmental footprint associated with transporting food is smaller than the environmental footprint of producing food. However, there are many factors to consider.
- More perishable foods – fresh fruits and vegetables, meat, and dairy – are more expensive to transport. These foods are often heavier, with fruits and vegetables having a larger volume of water, and they're much more likely to undergo loss from mishandling and spoilage along the way.
- Providing nutrient-rich foods far from where they are grown is challenging – whether that entails reaching rural areas in a country where something is grown, or transporting to another country on truck, train, ship, or by air. The last "food miles" can be the most expensive.
- Transportation involves energy use, which adds to the expense of the product. However, economies of scale can be helpful – in some cases, the cost per kilogram of transporting tomatoes across the United States may be less than the cost per kilogram of transporting them across a city to a farmers' market.

Additional resources:

- Hawken P, editor. Drawdown: The most comprehensive plan ever proposed to reverse global warming. Penguin; 2017.
    - *According to Project Drawdown, which ranked the top solutions to climate change based on expert consensus, the top ranked strategy with potential for reducing total atmospheric carbon dioxide is refrigerant management.*

- Hannah Ritchie and Max Roser (2020) - "Environmental impacts of food production". *Published online at OurWorldInData.org.*
    - *Visit this site for interactive visuals of how the environmental footprint of transportation compares to food production.*

Image sources: Left: Photo by Marie Spiker, used with permission**.** Middle: Vitpho via Getty Images**.** Right: Eugenesergeev via Getty Images

Slide 33: … and distributing large quantities of food

The way we distribute foods looks different from one place to the next – shown here are wholesale markets and produce distribution centers around the world. The infrastructure of wholesale markets influences factors like food safety, perishability, food prices, and food loss and waste. You can see some of those factors in these photos, as you look at whether food is stored indoors or outdoors, what kind of containers it is stored in, and what kind of equipment is available for cooling or moving food.

Image sources: Left: Photo by Marie Spiker, used with permission. Middle: Deniscostille via Getty Images. Right: Balonici via Getty Images

Slide 34: We sort and process food, ranging from minimally- to ultra-processed

Our methods of sorting and processing food are another important point of intervention for nutrition and food safety. We can influence ingredients and processing methods in ways that may affect taste, nutrient content, and shelf life.

Food processing is a continuum ranging from minimally processed foods that might simply be cut and bagged to more heavily processed foods such as frozen meals.

Food processing involves many tradeoffs. Whereas some processing and preservation techniques can extend shelf life of highly perishable foods, they may also involve an environmental footprint through energy use for machinery and cooling.

Another tradeoff is that some machines for sorting and chopping foods are phenomenally efficient and can minimize the loss of non-edible portions, but some machines are unable to handle oddly shaped products, which means that farmers with products that don't fit the uniform standards of machines may need to seek out specific buyers if they want to minimize losses.

Image sources: Left: Wabeno via Getty Images**.** Middle: Herraez via Getty Images**.** Right: G Annison via Getty Images

Slide 35: We package food for food safety, preservation, quality, and convenience

Our methods of packaging food also have a bearing on both nutrition and sustainability.

Like sorting and processing, packaging also involves tradeoffs: packaging can help to preserve shelf life, but it can also be wasteful. You might have experience with patients and clients who are more likely to choose something in a form of packaging that makes that choice convenient, but that packaging may also involve a larger footprint.

Image sources: Left: JackF via Getty Images. Middle: DuxX via Getty Images. Right: AlexWang_AU via Getty Images

Slide 36: The supply chains that bring food to us depend on many different workers

Our food system involves many different workers, who face a variety of occupational exposures and income inequality. For example, agricultural laborers may be in contact with machinery or highly concentrated chemical inputs. They might be performing physically intensive work while exposed to extreme conditions including heat, dust, or wildfire smoke (1). Laborers who work in close contact with animals may be at higher risk of developing zoonotic diseases (2). Workers in meat and poultry processing plants often work at high-speed processing lines where they are susceptible to injury from knives and machinery or injuries from repetitive movements, and they are exposed to loud environments that may have extreme temperatures (3). Workers in supermarkets, restaurants, and other foodservice settings may be susceptible to cuts, burns, and falls, or exposed to hazardous cleaning materials (4).

In terms of income inequality, agricultural workers are systematically disenfranchised from many of the labor protections that benefit other kinds of workers. For example, it is challenging for farmworkers to advocate for a minimum wage: about half of farmworkers in the US are undocumented (5), workers on small farms and employees who are family members are exempt from the minimum wage provisions of the Fair Labor Standards Act (6), and farmworkers lack protection for joining unions and engaging in collective bargaining. Restaurant workers also face a number of systemic inequities – at the federal level, the Fair Labor Standards Act only requires that tipped employees are paid a minimum of $2.13 per hour (7), and restaurant employees may be exempt from state-level laws requiring paid sick leave.

Sources cited:

1. Demers P, Rosenstock L. Occupational injuries and illnesses among Washington State agricultural workers. American journal of public health. 1991 Dec;81(12):1656-8.

2. Myers KP, Olsen CW, Setterquist SF, Capuano AW, Donham KJ, Thacker EL, Merchant JA, Gray GC. Are swine workers in the United States at increased risk of infection with zoonotic influenza virus?. Clinical infectious diseases. 2006 Jan 1;42(1):14-20.

3. Lander L, Sorock GS, Stentz TL, Eisen EA, Mittleman M, Hauser R, Perry MJ. A case-crossover study of occupational laceration injuries in pork processing: methods and preliminary findings. Occupational and environmental medicine. 2010 Oct 1;67(10):686-92.

4. Alamgir H, Swinkels H, Yu S, Yassi A. Occupational injury among cooks and food service workers in the healthcare sector. American journal of industrial medicine. 2007 Jul;50(7):528-35.

5. JBS International. Findings from the National Agricultural Workers Survey (NAWS) 2015-2016: A demographic and employment profile of United States farmworkers. 2018.

6. US Department of Labor. Fair Labor Standards Act in Agriculture. 2020.

7. US Department of Labor. Restaurant Employment Toolkit. 2020.

Additional resources:

- Max Roser (2020) - "Employment in Agriculture". *Published online at OurWorldInData.org.*
    - *For visuals about the agricultural workforce.*

- *The following publications provide additional information about challenges faced by workers throughout the food system, including agricultural workers and foodservice workers:*

    - Clayton ML, Clegg Smith K, Neff RA, Pollack KM, Ensminger M. Listening to food workers: Factors that impact proper health and hygiene practice in food service. International Journal of Occupational and Environmental Health. 2015;21(4):314-327.

    - Rodman SO, Barry CL, Clayton ML, Frattaroli S, Neff RA, Rutkow L. Agricultural exceptionalism at the state level: Characterization of wage and hour laws for U.S. farmworkers. Journal of Agriculture, Food Systems, and Community Development. 2016;6(2):89-110.

Image sources: Left: Rightdx by Getty Images**.** Middle: 21597185 via Getty Images**.** Right: Pixfly via Getty Images

Slide 37: Our food environments have many characteristics

And now we get to the part of the supply chain that we as consumers are more familiar with, which is our many food environments. The places where we purchase and consume food have so many characteristics – is the food available, affordable, safe? What information do we have access to, including both information we access voluntarily (such as nutrition facts panels) and information we are exposed to involuntarily (such as advertising)?

Additional resources:

- Lytle LA. Measuring the food environment: state of the science. American journal of preventive medicine. 2009 Apr 1;36(4):S134-44.
    - *This paper provides a summary of methods used to measure food environments, primarily in high income countries.*

- Turner C, Kalamatianou S, Drewnowski A, Kulkarni B, Kinra S, Kadiyala S. Food Environment Research in Low-and Middle-Income Countries: A Systematic Scoping Review. Advances in Nutrition (Bethesda, Md.). 2019 May 11.
    - *This scoping review provides information about food environment research in LMICs.*

- US Food and Drug Administration. Bad Bug Book: Foodborne pathogenic microorganisms and natural toxins. 2012.
    - *This is a good general reference for food safety.*

- *For information on how targeted food advertising affects health outcomes:*
    - Williams JD, Crockett D, Harrison RL, Thomas KD. The role of food culture and marketing activity in health disparities. Preventive Medicine. 2012 Nov 1;55(5):382-6.
    - Grier SA, Kumanyika SK. The context for choice: health implications of targeted food and beverage marketing to African Americans. American journal of public health. 2008 Sep;98(9):1616-29.
- *The "commercial determinants of health" refers to the idea that corporate activities, including food advertising, can influence factors that affect human health. For more reading in this area:*
    - Ireland R, Bunn C, Reith G, Philpott M, Capewell S, Boyland E, Chambers S. Commercial determinants of health: advertising of alcohol and unhealthy foods during sporting events. Bulletin of the World Health Organization. 2019 Apr 1;97(4):290.
    - Maani N, Collin J, Friel S, Gilmore AB, McCambridge J, Robertson L, Petticrew MP. Bringing the commercial determinants of health out of the shadows: a review of how the commercial determinants are represented in conceptual frameworks. European Journal of Public Health. 2020 Jan 18.

Image sources: Top Left: Zephyr18 via Getty Images**.** Top Middle: Industryview via Getty Images**.** Top Right: Public Domain, https://commons.wikimedia.org/w/index.php?curid=48273553**.** Bottom Left: The World Traveller via Getty Images**.** Bottom Right: Maradaisy via Getty Images

Slide 38: We sell food in markets, for preparing at home

In some cases we buy food at markets to prepare at home. We might purchase food from an open air market, from a full service grocery store, or from a smaller corner store, convenience store, or bodega. We might purchase foods that originate from local food producers, and we might purchase foods that came to us through global food supply chains. The places where we gather to buy food can create important linkages between economic vitality and the social and cultural needs within communities.

Additional resources:

- Downs SM, Ahmed S, Fanzo J, Herforth A. Food Environment Typology: Advancing an Expanded Definition, Framework, and Methodological Approach for Improved Characterization of Wild, Cultivated, and Built Food Environments toward Sustainable Diets. Foods. 2020 Apr;9(4):532.
    - *This peer-reviewed article provides a visual typology of different types of food environments, including built food environments (which include informal and formal market systems) and natural food environments (which include wild and cultivated systems). It provides a framework for how different settings might transition through various food environments, analogous to the concept of the nutrition transition. Whereas the nutrition transition focuses on the outcome of diet-related disease, the "transition" in this paper focuses on food environments.*
- Ahmed S, Downs SM, Yang C, Chunlin L, Ten Broek N, Ghosh-Jerath S. Rapid tool based on a food environment typology framework for evaluating effects of the COVID-19 pandemic on food system resilience. Food Security. 2020 Aug;12(4):773-8.
    - *This article, from the same authors as the previous reference, provides a tool for applying the concept of "food environment typologies" in the context of evaluating the effects of COVID-19 on the resilience of food systems.*

Image sources: Left: Balaji Srinivasan via Getty Images**.** Middle: Vera_Petrunina via Getty Images**.** Right: Danielvfung via Getty Images**.**

Slide 39: … and we sell prepared foods away from home

We also eat foods that are prepared away from home. We might gather with others in a crowded food court, or stop for a quick bite from a roadside vendor on the way home. Sometimes we share a meal in a sit-down restaurant, and sometimes we eat in our vehicles. And there is an emerging market of ways to distribute prepared foods, from curbside pickup to doorstep delivery.

In 2010, for the first time since the USDA has been recording this data, Americans spent more money on food away from home than they did on food prepared at home (1), which has both financial and nutritional implications. Notably, the coronavirus pandemic has caused a decrease in spending on food away from home, and it remains to be seen how this trend will stabilize in the long-term (2).

Sources cited:

1. Saksena M, Okrent A, Anekwe T et al. America's eating habits: Food away from home. USDA Economic Information Bulletin No. (EIB-196). 2018.
    - *This report from the USDA contains national-level data about trends in eating food away from home in the United States.*

2. USDA Economic Research Service (ERS). Eating-out expenditures in May 2020 were 37% lower *than in May 2019*.

Additional resources:

- Smith, Lindsey P et al. Trends in US home food preparation and consumption: analysis of national nutrition surveys and time use studies from 1965-1966 to 2007-2008."Nutrition journal vol. 12 45. 11 Apr. 2013.
    - *Good background information on how often US consumers consume food at home and away from home. Note that as of 2020, these trends are changing due to the coronavirus pandemic.*

Image sources: Left: Ciara Sherry via Getty Images (Hawker). Middle: Photo by Corbin Cunningham, used with permission. Right: Oleksandr Hyrtsiv via Getty Images.

Slide 40: As consumers, our behaviors are complex…

As consumers, our behaviors are complex. The motivations behind our food choices are numerous – they might include taste, convenience, habit, familiarity, social and cultural norms, health, or other aspirational goals. And some of our food-related behaviors may be driven less by choice and more by circumstance, including circumstances rooted in structural inequities such as a lack of access to affordable, nutritious foods.

Additional resources:

There is a growing body of literature on the various "drivers of food choice," much of it conducted in specific geographic contexts. Some of this work draws from quantitative methods, and some draws from qualitative methods including anthropological study of different "foodways" (cultural, social, and economic practices related to the production and consumption of food). Below is a small selection of this research.

- *In the United States:* Alkon AH, Block D, Moore K, Gillis C, DiNuccio N, Chavez N. Foodways of the urban poor. Geoforum. 2013 Aug 1;48:126-35.

- *In Europe:* Pieniak Z, Verbeke W, Vanhonacker F, Guerrero L, Hersleth M. Association between traditional food consumption and motives for food choice in six European countries. Appetite. 2009 Aug 1;53(1):101-8.

- In "Western nations" more broadly: Looy H, Dunkel FV, Wood JR. How then shall we eat? Insect-eating attitudes and sustainable foodways. Agriculture and human values. 2014 Mar 1;31(1):131-41.

- *In India:* Bailey C, Garg V, Kapoor D, Wasser H, Prabhakaran D, Jaacks LM. Food choice drivers in the context of the nutrition transition in Delhi, India. Journal of nutrition education and behavior. 2018 Jul 1;50(7):675-86.

- *In the Philippines:* Cuevas RP, de Guia A, Demont M. Developing a framework of gastronomic systems research to unravel drivers of food choice. International journal of gastronomy and food science. 2017 Oct 1;9:88-99.

Image sources: Left: Caymia via Getty Images. Middle: Monkeybusinessimages via Getty Images. Right: Aleksandr_Vorobev via Getty Images

Slide 41: We don't just eat food, we also waste it

There's food that we eat, but there's also the food that we waste. If food waste were a country, it would be a third largest emitter of Greenhouse Gases, behind China and the US (1). Wasted food also contains wasted nutrients; in the US, our daily waste is equivalent to the recommended intake of iron for 2/3 of the US population (2). Loss and waste can occur at all levels of the supply chain from farm to fork, but in the US the majority occurs at the retail and consumer levels. One of the driving forces behind consumer-level waste is confusion about food date labels (3). Whereas date labels on food *can* indicate food safety considerations, they frequently indicate the freshness and optimal quality of a product, and people frequently discard products past the date on the label even when there are no food safety reasons for doing so.

Sources cited:

1. World Resources Institute. Working paper: reducing food loss and waste. 2013.

2. Spiker ML, Hiza HAB, Siddiqi SM, Neff RA. Wasted Food, Wasted Nutrients: Nutrient Loss from Wasted Food in the United States and Comparison to Gaps in Dietary Intake. Journal of the Academy of Nutrition and Dietetics. 2017;117(7):1031-1040.e1022.

3. Neff RA, Spiker M, Rice C, Schklair A, Greenberg S, Leib EB. Misunderstood food date labels and reported food discards: A survey of US consumer attitudes and behaviors. Waste management. 2019;86:123-132.

Additional resources:

- *The EPA's waste management hierarchy – reduce, reuse, recycle – has an analogous version for food recovery. According to this hierarchy of food waste management, the first priority should be source reduction (reducing the volume of surplus food generated), followed by using surplus food to feed hungry people and animals, followed by methods to recycle or dispose of food (e.g., biofuels and compost are prioritized, whereas landfilling or incineration is a last resort). It's worth noting that this hierarchy is not always straightforward to implement; for example, reducing all food surplus may not always be favorable because surplus food is often made available to people at a lower cost through food banks and food aid to other countries.*

Image sources: Left: ChiccoDodiFC via Getty Images**.** Middle: Highwaystarz-Photography via Getty Images**.** Right: Martin Poole via Getty Images

Slide 42: We know that diets affect human nutrition and health

As nutrition professionals, we know that diets affect human nutrition and health. Poor diet quality is the leading cause of mortality worldwide, with an estimated 1 in 5 deaths due to suboptimal dietary intake (1). We also know that every country in the world is affected by at least one burden of malnutrition, and 41 countries face a triple burden of malnutrition including childhood stunting, micronutrient deficiencies, and overweight (2). Globally, around 821 million people experience hunger (3), 2 billion experience micronutrient deficiency (also known as hidden hunger) (4), and 2.1 billion experience overweight or obesity (1). Although dietary intake is not the only factor that influences nutritional status and health status, we know that it has an important role in disease treatment and prevention.

Sources cited:

1. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, Mullany EC, Abate KH, Abbafati C, Abebe Z, Afarideh M. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2019 May 11;393(10184):1958-72.

2. Development Initiatives. 2018 Global Nutrition Report: Shining a light to spur action on nutrition. Bristol, UK: Development Initiatives; 2018.

3. FAO, IFAD, WFP. The state of food insecurity in the world: Building climate resilience for food security and nutrition. Rome, Italy: FAO; 2018.

4. Gödecke T, Stein AJ, Qaim M. The global burden of chronic and hidden hunger: Trends and determinants. Global food security. 2018 Jun 1;17:21-9.

Additional resources:

- *In addition to the report, the Global Nutrition Report website contains additional resources including Country Nutrition Profiles, stakeholder commitment tracking, and malnutrition case studies and briefings.*

- *The Global Burden of Disease Study also created this interactive tool, GBD Compare, to visualize the top causes of death by region and explore patterns by country, age, and sex.*

- *For more information about measurement of hidden hunger:* Muthayya S, Rah JH, Sugimoto JD, Roos FF, Kraemer K, Black RE. The global hidden hunger indices and maps: an advocacy tool for action. PLoS One. 2013;8(6).

- *For more information about how dietary intake fits in alongside other risk factors for malnutrition:*

    - Black RE, Allen LH, Bhutta ZA, Caulfield LE, De Onis M, Ezzati M, Mathers C, Rivera J, Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: global and regional exposures and health consequences. The Lancet. 2008 Jan 19;371(9608):243-60.
        - *The UNICEF conceptual model describes the determinants of undernutrition (see Figure 1).*

    - Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, De Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, Uauy R. Maternal and child undernutrition and overweight in low-income and middle-income countries. The Lancet. 2013 Aug 3;382(9890):427-51.
        - *The conceptual model from 2013 Lancet Series on Maternal and Childhood Nutrition (Figure 1) describes a framework for achieving optimum fetal and child growth and development.*

Image sources: Left: Vinhdav via Getty Images. Right: Foxys_forest_manufacture via Getty Images.

Slide 43: But our diets also have environmental, economic, and societal impacts

What may be less clear is that our diets also have broader environmental, economic, and societal impacts. I'm going to use a few examples related to seafood. The *Dietary Guidelines for Americans* recommends the consumption of 8 ounces of seafood per week (1).

Thinking about environmental impacts, it would be really challenging for all Americans, much less the entire global population, to consume 8 ounces of seafood per week without degrading marine environments (2). Our global demand for seafood, especially for a diversity of larger finfish at higher levels of the food chain, has contributed to the overfishing of marine environments, in some cases to the point of collapse, meaning that fish stocks may not recover in the short or medium term. According to the FAO, 1/3 of all global fish stocks are fished at biologically unsustainable levels (3,4)

Thinking about economic impacts, approximately 60 million people have livelihoods in capture fisheries or aquaculture (3). Demand for fish in one part of the world can trigger economic incentives in other parts of the world. In a case study of Senegal, growing international demand for a type of cod caused small-scale fisheries to target this particular species almost to the point of extinction (5). In some cases, trade deals can drive down commodity prices so that locally harvested fish are more expensive than imported fish, which has further ramifications for the economic security and food security of local producers.

Thinking about societal impacts, one important consideration is equity. Fish is one of the most traded global food commodities, with 35% of all fish production entering international markets (6). Products from industrial-scale aquaculture in low- and middle-income countries are typically either sold to high-income consumers in that country or exported to high-income countries, where the demand for large, high-quality fish is high. Although there is enough nutrient-rich fish globally to meet a substantial portion of nutrient needs for residents of low- and middle-income coastal nations, international trade deals that support demand in high-income countries contribute to persistent food insecurity and malnutrition for those living in communities that produce fish (6, 7).

Sources cited:

1. U.S. Department of Health and Human Services and U.S. Department of Agriculture. *2015 – 2020 Dietary Guidelines for Americans.* 8th Edition. December 2015.
2. National Research Council. A framework for assessing effects of the food system. National Academies Press; 2015 Jun 17. P. 289.
    - *Pages 287-300 of this report includes an in-depth case study of fish production and consumption in the United States.*
3. United Nations Food and Agriculture Organization (FAO). The state of World fisheries and aquaculture: Meeting the sustainable development goals. Rome, Italy: FAO; 2018.
    - *This is a good resource for general background information, including statistics on global fish stocks and livelihoods.*
4. Lotze HK, Coll M, Dunne JA. Historical changes in marine resources, food-web structure and ecosystem functioning in the Adriatic Sea, Mediterranean. Ecosystems. 2011 Mar 1;14(2):198-222.
    - *This paper provides more information about the impact of human activity on marine food webs.*
5. Thiao D, Chaboud C, Samba A, Laloë F, Cury PM. Economic dimension of the collapse of the 'false cod' Epinephelus aeneus in a context of ineffective management of the small-scale fisheries in Senegal. African Journal of Marine Science. 2012 Oct 1;34)
6. Hicks CC, Cohen PJ, Graham NA, Nash KL, Allison EH, D'Lima C, Mills DJ, Roscher M, Thilsted SH, Thorne-Lyman AL, MacNeil MA. Harnessing global fisheries to tackle micronutrient deficiencies. Nature. 2019 Oct;574(7776):95-8.
    - *Comments on the impact of international fish trade on equity.*
7. Gormaz JG, Fry JP, Erazo M, Love DC. Public health perspectives on aquaculture. Current environmental health reports. 2014 Sep 1;1(3):227-38
    - *Comments on the impact of international fish trade on equity.*

Additional resources:

- Fröcklin S, de la Torre-Castro M, Lindström L, Jiddawi NS. Fish traders as key actors in fisheries: Gender and adaptive management. Ambio. 2013 Dec 1;42(8):951-62.
    - *Fish production and value chains have implications for equity, and they also have implications related to gender. See this case study of Tanzania as one example. This paper notes that women are often able to generate less income from selling fish because they typically have less access to high-value fish and profitable markets. For example, women may not have access to as many transportation options to access markets that have lower vendor fees, or they may not be part of social interactions that open up economic opportunities for men.*

Image sources: Left: Gnomeandi via Getty Images. Right: Wmaser890 via Getty Images.

Slide 44: Additionally, there are underlying drivers influencing the whole system

We can also take a step back and look at some of the underlying drivers that shape the whole food system.

Thinking about environmental drivers, food systems rely on finite natural resources and are affected by global environmental changes such as climate change. The handout provides some additional resources for understanding the many mechanisms by which climate change may impact food production, food security, the nutritional value of crops, and human health.

Thinking about innovation, technology, and infrastructure drivers, our tour through global food systems highlights many issues where a lack of infrastructure is a root cause – for example, the higher rates of perishable food losses.

Political and economic drivers can affect food systems in direct and indirect ways – for example, there are policies that impact the food system directly, such as the Farm Bill in the United States. But issues such as land tenure rights, food prices, living wages, and labor laws also affect the way people participate in food systems.

Additional resources:

- **Environmental drivers:** Myers SS, Smith MR, Guth S, et al. Climate Change and Global Food Systems: Potential Impacts on Food Security and Undernutrition. Annual Review of Public Health. 2017;38:259-277.
    - *Read for an overview of the mechanisms by which climate change may impact food security, nutrition, and human health. Figure 2 is an especially helpful visual.*

- **Infrastructure drivers:** Downs SM, Ahmed S, Fanzo J, Herforth A. Food Environment Typology: Advancing an Expanded Definition, Framework, and Methodological Approach for Improved Characterization of Wild, Cultivated, and Built Food Environments toward Sustainable Diets. Foods. 2020 Apr;9(4):532.
    - *Read for an overview and framework of how infrastructure and development within food systems can effect food environments and nutrition.*

- **Political and economic drivers:**
    - Blankenship J, Brown RS. Food system sustainability: An Academy advocacy priority. Journal of the Academy of Nutrition and Dietetics. 2020 Jun 1;120(6):1054-6.
        - *An overview of how the Academy of Nutrition and Dietetics has pursued policy advocacy efforts related to the food system.*

    - Clapp J, Newell P, Brent ZW. The global political economy of climate change, agriculture and food systems. The Journal of Peasant Studies. 2018 Jan 2;45(1):80-8.
        - *This article provides an overview of political and economic factors that have shaped the framing of our response to climate change within the food system.*

    - Food and Agriculture Organization. Codex Alimentarius. 2020.
        - *The term "Codex Alimentarius" is Latin for "food code." The Codex Alimentarius is a collection of food codes developed and used by United Nations member countries to ensure safe, quality food for their citizens. Because it focuses on food trade across international borders, it affects how food is grown, processed, and marketed in the global food system.*

    - Kraemer K, Cordaro JB, Fanzo J, Gibney M, Kennedy E, Labrique A, Steffen J, Eggersdorfer M. Ten forces shaping the global food system. Good nutrition: Perspectives for the 21st century. 2016 (pp. 19-30). Karger Publishers.
        - *A primer on political and economic considerations in the global food system.*

Image sources: Left: 3bsworld via Getty Images**.** Middle: Thomas Northcut via Getty Images**.** Right: DorSteffen via Getty Images

Slide 45: Additional underlying drivers

Socio-cultural drivers of the food system include culture, social traditions, religion, and rituals. An example of an especially important sociocultural driver is gender equity and women's empowerment. Gender inequities persist throughout the food system. Although women comprise almost half of the agricultural labor force in low and middle income countries (1), they tend to have less access to land ownership, livestock, labor, education, financial and extension services, and technology. Agricultural gender gaps persist across low-, middle, and high-income country settings, and they affect supply chains for crops, livestock, and marine resources. There are also gendered aspects within food environments and related to consumer behavior – for example, think about who shops for and prepares food, who eats first or last, and whose preferences determine the family's meal.

Lastly, demographic drivers include urbanization, globalization, migration, and displacement. Our global human population is rapidly urbanizing: 2007 was the first year when more people in the world lived in urban areas than rural areas (2). Although urban areas tend to have a higher standard of living and more access to services such as healthcare, the urban poor face unique challenges, and issues like climate change may worsen living conditions for those displaced from rural areas.

Sources cited:

1. Quisumbing AR, Meinzen-Dick R, Raney TL, Croppenstedt A, Behrman JA, Peterman A. Gender in agriculture. Springer. 2014;102072(630.717):444. p7.
2. United Nations Population Fund (UNFPA). State of World Population 2007: Unleashing the Potential of Urban Growth. 2007.

Additional resources:

- Alkire S, Meinzen-Dick R, Peterman A, Quisumbing A, Seymour G, Vaz A. The women's empowerment in agriculture index. World Development. 2013;52:71-91.
    - *Read for an overview of the development of the Women's Empowerment in Agriculture Index (WEAI), a measurement tool that is used in research on women's empowerment.*
- Fox EL, Davis C, Downs SM, Schultink W, Fanzo J. Who is the Woman in Women's Nutrition? A Narrative Review of Evidence and Actions to Support Women's Nutrition throughout Life. Current developments in nutrition. 2018;3(1):nzy076.
    - *This is a narrative review of evidence and actions to support women's nutrition throughout the life course.*
- Hannah Ritchie and Max Roser (2020) - "Urbanization". Published online at OurWorldInData.org.
    - *Visit this site for interactive visuals about trends in urbanization.*

Image sources: Left: AGL_Photography via Getty Images**.** Right: Badahos via Getty Images

Slide 46: Transition

[Transition to the next module]

Module 3: A Conceptual Framework of the Food System

Slide 47-48: Transition

[Transition to the module]

Slide 49: Module 3 Introduction

In this module, we transition from our tour through global food systems to a conceptual framework that ties things together.

Image sources: Prototyping by ProSymbols from the Noun Project

Slide 50: Module 3 Learning Outcomes

By the end of this module, you will be able to:

1. Identify the three major components of food systems
2. Identify at least three underlying drivers that influence food systems
3. Describe the Sustainable Development Goals (SDGs), and discuss at least three ways nutrition is important for achieving the Sustainable Development Goals

Slide 51: A conceptual framework of the food system

The conceptual framework we're going to use is from this report by the United Nations High Level Panel of Experts (HLPE) on Food Security and Nutrition (1). The HLPE was created by the United Nations Committee on World Food Security to be an interface between science and policy, and they have developed a series of reports that helps to translate evidence into policy recommendations. Each report in the series is co-authored by experts from relevant disciplines, and it's worth noting that one of the co-authors of this particular report on Nutrition and Food Systems is Dr. Eileen Kennedy, an RDN and Professor at Tufts University.

Sources cited:

1. HLPE. 2017. Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition.
    - *This conceptual framework will be shown throughout this module. This is the twelfth report in a series from the HLPE. The full series of HLPE reports can be found on the HLPE website*

Slide 52: Conceptual framework of food systems

This is the full framework for action, and it may look familiar as we saw a simplified version in the previous module. We're actually going to take another look at that simplified version, to help break down what's going on here.

Slide 53: Breaking down the conceptual framework

Here's the simplified version again.

Slide 54: Breaking down the conceptual framework

The HLPE report describes three major components of the food system: food supply chains, food environments, and consumer behavior. Each of these components has what the HLPE authors call, "multiple entry and exit points for nutrition," meaning that they each have opportunities to enhance or hinder nutritional status.

Slide 55: HLPE Conceptual Framework

If we take a closer look at these three components, we'll see that the food supply chain includes many elements we saw in our food systems tour: production systems, storage and distribution, processing and packaging, and retail

and markets. Though it's not shown here, food loss and waste is part of food supply chains, and it's a good example of what we mean by an "exit point for nutrition" because when food leaves the supply chain we're missing an opportunity to support livelihoods and contribute to nutritional intake.
Within the section on food environments, you'll notice there are several characteristics of food environments detailed here.

- Is food available within the food supply – this refers to whether certain foods have been produced or imported. Within the United States, we have a relatively abundant and year-round food supply, but there are many settings where certain foods are only available seasonally to most of the general public.
- Is food physically accessible – this refers to whether someone lives in close proximity or can travel to acquire something. For example, do you live in a neighborhood with a supermarket, or if not, are you able to use public transportation or a vehicle to reach a supermarket?
- Is food economically accessible – this refers to whether foods are affordable.

I want to note that these characteristics overlap with the four pillars of food security, which are stability, availability, access, and utilization. Utilization does not appear in this section, but it refers to whether people are able to prepare, consume, and subsequently, absorb and fully utilize the nutritional value of their food.

Returning to the concept of food environments, we can also think about what kind of information, promotion, and advertising are present. We can also think about factors that support food quality and safety. For example, is food stored in a way that maximizes shelf life?

The third component is Consumer Behavior, and the diagram details that this refers to the ways people choose where and what food to acquire, prepare, cook, store, and eat.

Additional resources:

1. Food and Agriculture Organization. An Introduction to the Basic Concepts of Food Security. 2008.
    - *This 2-page resource from the FAO provides a high-level overview of the concept of food security.*

Slide 56: Breaking down the conceptual framework

Returning to our simplified framework for a moment, I want to note the cyclical relationship here: the food system shapes our diets, which in turn affect nutrition and health as well as environmental, economic, and social factors. What's really important to note is that these outcomes can also affect the underlying drivers that in turn influence the food system.

For example, one of the environmental impacts of our diets is greenhouse gas emissions. Methane can be produced by livestock or released when food loss and waste decomposes in landfills. Carbon dioxide can be released by agricultural equipment, and by the vehicles that transport our inputs, crops, livestock, and food products. These greenhouse gases contribute to further climate change, which is one of the underlying drivers that influences the components of the food system.

Slide 57: Conceptual framework of food systems

Looking at the full framework, we can see some additional detail, including examples of specific underlying drivers within each category.

Slide 58: Conceptual framework of food system

On the bottom of the framework, I want to point out Political, Program, and Institutional Actions. Examples of these actions are the United States Environmental Protection Agency's commitment to reduce food loss and waste by 50% by the year 2030 (1), or the Scaling Up Nutrition (SUN) Movement led by political leaders who are committed to advancing multi-sectoral action for nutrition (2). These unifying agendas might intervene on certain components of the food system directly, or they might intervene on some of the underlying drivers that influence the food system.

This framework makes a point to specifically call out the United Nations Sustainable Development Goals. The SDGs are a unifying global agenda to help operationalize action on many of the underlying drivers.

Sources cited:

1. United States Environmental Protection Agency. US EPA commitment to halve food loss and waste by 2030
2. Scaling Up Nutrition. SUN movement

Slide 59: The Sustainable Development Goals

The Sustainable Development Goals were developed by the United Nations General Assembly in 2015 for the year 2030. They are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice.

The Sustainable Development Goals replaced the Millennium Development Goals, which were eight global goals established in 2000 for the year 2015. One important shift that occurred with the SDGs was its global scope: whereas the MDGs focused on low- and middle-income countries, the SDGs emphasize the importance of action from all countries. The SDGs acknowledge that many issues in low- and middle-income countries stem from action or inaction of high-income countries. For example, high-income countries generate the majority of greenhouse gas emissions, but low and middle-income countries are most likely to suffer from climate change impacts like sea level rise, crop failure, conflict, and population displacement. A global scope also acknowledges that within high-income countries, there are many populations that struggle with issues such as poverty, hunger, unemployment, and gender inequity.

As you look at the 17 SDGs shown here, pause this self-study, and take a moment to think about and jot down the ways these goals are linked to the food system and nutrition.

Sources cited:

1. United Nations Department of Economic and Social Affairs. United Nations Sustainable Development Goals

Image source: SDG icons downloaded from the SDG Communications Materials website.

Slide 60: Nutrition is essential for the success of all SDGs

Some of the SDGs are focused explicitly on nutrition – for example, SDG 2 is about eliminating hunger. But as you can see in this slide, nutrition is essential for the success of all 17 SDGs.

Think about times you've interacted with the goals of the SDGs in your own work. For example, if you've worked with patients or clients who receive benefits from SNAP or WIC, these are federal programs that address SDG 1 on poverty. If you've worked with child nutrition through the National School Lunch Program, that is linked to SDG 4 on quality education. If you've attended community or policy meetings where they discussed how to limit agricultural runoff into bodies of water like the Chesapeake Bay, you've witnessed SDG 14, on life below water, which is not shown in this graphic but is definitely linked to nutrition. If you've participated in efforts to compost and improve soil quality, this is related to SDG 15, life on land.

Image source: Graphic from SUN Civil Society Network SDG Toolkit

Slide 61: Thought Starter for Modules 1-3

As we wrap up the first three modules, take a moment to jot down your reactions to this Thought Starter.

Think about a food or beverage you've consumed in the past 24 hours.

- Were you able to choose the food you consumed? If so, what were your primary reasons for choosing this food?
- Where did you acquire it? How did you travel to that location?
- What costs were associated with acquiring the item, preparing it, transportation, etc?
- Where did the food originate, and how did the food get to where you acquired it?
- What workers were involved throughout the food system to make this food available to you?

Slide 62: Transition

[Transition to the next module]

Module 4: Sustainable, Resilient, and Healthy Food and Water Systems

Slide 63-64: Transition

[Transition to the module]

Slide 65: Module 4 Introduction

At this point we've introduced the concept of food systems, and now we're going to add in an additional layer: what is a sustainable food system?

Image source:
Sustainability by Emily Rinehart from the Noun Project

Slide 66: Module 4 Learning Outcomes

By the end of this module, you will be able to:

1. Define the concepts of sustainability, resilience, and health on their own and within the context of food systems.
2. Define the concept of equity and discuss how equity is related to sustainability, resilience, and health in the food system
3. Describe the importance of water for food systems and human health

Slide 67: What exactly do we mean by sustainable, resilient, and healthy food and water systems?

The title of this primer uses the phrase "sustainable food systems," which we often use as a shorthand for the longer "sustainable, resilient, and healthy food and water systems." This longer term encompasses several core concepts which we will take the time to unpack in this module.

I want to note that one of the first resources from the Academy of Nutrition and Dietetics to feature the terminology of "sustainable, resilient, and healthy food and water systems" was the 2014 Standards of Professional Performance (SOPP) in the topic (1). A revision of this SOPP was published in the year 2020, and this module will draw upon core concepts presented in the text of the 2020 SOPP (2).

Additional resources:

1. Tagtow A, Robien K, Bergquist E, Bruening M, Dierks L, Hartman BE, Robinson-O'Brien R, Steinitz T, Tahsin B, Underwood T, Wilkins J. Academy of Nutrition and Dietetics: standards of professional performance for registered dietitian nutritionists (competent, proficient, and expert) in sustainable, resilient, and healthy food and water systems. Journal of the Academy of Nutrition and Dietetics. 2014 Mar 1;114(3):475-88.

2. Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Slide 68: Key definition: equity

This module is all about core concepts, and there's one concept that is fundamental to understanding the rest, which is equity.

The World Health Organization defines equity as "the absence of avoidable or remediable differences among groups of people, whether those groups are defined socially, economically, demographically, or geographically" (1).

One helpful way of understanding equity is to think about how it differs from the concept of equality. I really appreciate this quote from Paula Dressel from the Race Matters Institute, who said that "the route to achieving equity will not be accomplished through treating everyone equally. It will be achieved by treating everyone justly according to their circumstances" (2).

The examples shown here illustrate how working towards equity requires that we understand the context of existing differences and gaps, whether those gaps pertain to things like access to services and technology, wages, life expectancy, or availability of nutritious foods.

Sources cited:

1. World Health Organization. Equity.
2. Race Matters Institute. Racial Equality or Racial Equity? The difference it makes.

Additional resources:

- Kelly R, Carr K, Pirog R, Guel A, Henderson J, Wilcox K, Wimberg T, García Polanco V, Babayode D, Watson K, Nelson E. An annotated bibliography on structural racism present in the U.S. food system (8th ed.). Michigan State University Center for Regional Food Systems. 2021. Accessed January 18, 2021. https://www.canr.msu.edu/foodsystems/uploads/files/Annotated-Bibliography-on-Structural-Racism-Present-in-the-US-Food-System-Eighth-Edition.pdf
    - *This annotated bibliography developed by the Michigan State University Center for Regional Food Systems includes over 385 sources with current research and outreach on structural racism in the US food system for food system practitioners, researchers, educators, and advocates. The resource is updated on a recurring basis, and it includes a Zotero library with all references cited.*

- Valley W, Anderson M, Blackstone NT, Sterling E, Betley E, Akabas S, Koch P, Dring C, Burke J, Spiller K. Towards an equity competency model for sustainable food systems education programs. Elem Sci Anth. 2020 Jul 16;8(1).
    - *This paper describes the extent to which sustainable food systems education programs in the US and Canada prepare students to address equity; it also proposes a competency model related to equity, incorporating literature from multiple fields.*

- Meyer A. The Kyoto Protocol and the emergence of "contraction and convergence" as a framework for an international political solution to greenhouse gas emissions abatement. Man-Made Climate Change 1999 (pp. 291-345). Physica, Heidelberg.
    - *For more reading about equity and climate change, the Intergovernmental Panel on Climate Change (IPCC) developed the idea of "contraction and convergence" for how countries should allocate their national targets for greenhouse gas emissions. The idea is that countries with the largest carbon footprint should scale back, whereas countries with the smallest carbon footprints should scale up to the point that they are able to provide their citizens with essential services such as 24/7 electricity. This is a landmark paper about the idea of contraction and convergence in the climate change dialogue.*

Slide 69: Key definition: equity

The graphics shown here place equity in the wider context of equality and also justice, showing that whereas equity is about mobilizing resources in a way that acknowledges people's differing circumstances, justice is about changing those underlying circumstances to address the root causes of inequality. So when you hear people talking about food justice, they're talking about working at a systemic level to change underlying circumstances; for example, ensuring that black and indigenous people and people of color don't face additional barriers in getting loans to start food-related businesses in their communities.

Image source: Images by @lunchbreath, based on Shel Silverstein's Giving Tree, for John Maeda's 2019 Design in Tech Report

Slide 70: Key definition: sustainability

Within the next few slides, as we introduce each aspect of a sustainable, resilient, and healthy food system, we'll talk about how equity relates to each aspect.

Starting with sustainability, if we take the concept in isolation, sustainability refers to the ability of a system to be maintained over the long term.

In the context of the food system, a sustainable food system meets the needs of individuals and communities in the present moment without jeopardizing the ability of future generations to meet their needs. It's a system that can adjust over time to accommodate future generations.

The concept of equity is central to sustainability because whether we are talking about the present moment or the future, it's essential to be aware of groups that are less likely to have their needs met. These groups may include women; Black, indigenous, and people of color; individuals living in communities of low socioeconomic status; communities exposed to environmental contaminants; and people displaced by climate change.

When we think about who is experiencing a disproportionate share of risks or benefits in the food system, we can think about geography– for example, high-income countries have contributed the most to human-caused climate change, yet low- and middle-income countries are the most vulnerable to the impacts of climate change. We can also think about time – are our actions in the current day compromising the ability of future generations to have their food and nutrition needs met?

Slide 71: Sustainability example: importance of soil health

One topic that illustrates the importance of sustainability is soil health. Soil health is "the continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans" (1). Soil health affects human health because we want soil to support adequate plant growth while providing crops with micronutrients and not contaminating crops with heavy metal, pathogens, or other contaminants.

Soil health is determined by many factors including soil structure, salinity, nutrition, compaction, and erosion. Soil erosion occurs when soil is redistributed by water, wind, or gravity – think of what happens to soil on a particularly steep slope, or on a dry day.

The USDA tracks soil erosion on agricultural lands. In 2007, 28% of all cropland was eroding above soil loss tolerance rates. This compares to 40% of all cropland in 1982 (2).

Soil erosion can be reduced through certain soil management practices including less tilling, planting cover crops in the winter, and mulching. Soil health is a good illustration of the importance of sustainability because the soil management decisions that are made today have a very tangible effect on the ability of future generations to grow adequate amounts of nutritious crops.

Sources cited:

1. USDA Natural Resources Conservation Service. Soil Health.
2. USDA Natural Resources Conservation Service. Soil Erosion on Cropland in 2007. Image and statistics about soil erosion from the USDA: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?cid=stelprdb1041887

Additional resources:

- USDA. Summary Report: 2015 National Resources Inventory. Natural Resources Conservation Service, Washington DC, and Center for Survey Statistics and Methodology, Iowa State University, Ames, Iowa. 2015.
    - *The USDA Natural Resources Conservation Services no longer reports on soil erosion separately. This report is more current than the source cited above (2007), but it does not report on soil erosion separately.*

- Iowa Learning Farms. The Cost of Soil Erosion. 2013.
    - *This is an accessible, 4-page overview from Iowa Learning Farms about the dangers of soil erosion in Iowa.*

Image sources: Left: Voren1 via Getty Images. Right: Map from USDA NRS, 2007.

Slide 72: Key definition: resilience

The concept of resilience, on its own refers to the ability of a system to withstand or adapt to disturbances over time. The concepts of sustainability and resilience are inter-related, because in order for something to be maintained over the long term it needs to be able to survive inevitable shocks to the system.

A resilient food system can withstand or rebound more quickly to disruptive events such as climate change, natural disasters, disease epidemics and pandemics, political or economic crises, or rapid urbanization (1). And it's important to note that a community can be facing multiple disruptions simultaneously.

The concept of equity is important within resilience because individuals and communities differ in their ability to withstand or recover from disruptive events. For example, when Hurricane Katrina arrived on the Gulf Coast in 2005, it had a disproportionate impact on New Orleans's most vulnerable communities. Communities that were at a disadvantage due to their racial or ethnic status, family structure, income, or access to stable housing were not only more affected by the hurricane, but they were also displaced from their homes for longer (2).

Sources cited:

1. Tendall DM, Joerin J, Kopainsky B, Edwards P, Shreck A, Le QB, Krütli P, Grant M, Six J. Food system resilience: Defining the concept. Global Food Security. 2015 Oct 1;6:17-23.
2. Finch C, Emrich CT, Cutter SL. Disaster disparities and differential recovery in New Orleans. Population and environment. 2010 Mar 1;31(4):179-202.
    - *See for more information on disparities in recovery from Hurricane Katrina in New Orleans.*

Slide 73: Resilience example: COVID-19 and food supply chains

This primer will be released during the year that the world is dealing with the COVID-19 pandemic, and so many of you may have witnessed firsthand instances of resilience or lack of resilience within the food system around you.

You may have experienced supermarket shortages of items that are not typically out of stock such as toilet paper, meat, or canned goods. In some cases, these shortages may have been due to increased consumer demand, whereas in other cases they may have been due to supply chain bottlenecks such as meat processing facilities not being able to handle their typical volumes because of the number of workers that were sick.

You may have also witnessed local programs such as school meals, food banks, and WIC clinics undergo disruptions in service as they dealt with issues ranging from disruptions in their typical food supplies to the challenges of reducing human contact in order to prevent disease transmission. Here you may have noticed equity issues, as some school districts or locations having the means to resume services more quickly than others.

Understanding resilience through the lens of equity is important to the practice of dietetics because you may encounter patients and clients who are much more vulnerable to things that are going on in the world, whether those things are related to public health crises, access to safe housing during natural disasters, or ongoing effects of environmental racism. It's important to understand how your patients and clients may be differentially affected, and to also think about how you might collaborate with other providers and work at other levels of the system – such as policy change – to help individuals and communities build resilience.

Additional resources:

- *For more information about how the COVID-19 pandemic has affected food supply chains, see:*
  - United Nations. Policy brief: The impact of COVID-19 on food security and nutrition. 2020.
- *For an example of how the City of Baltimore made a plan to increase the resilience of its own food system:*
  - Johns Hopkins Center for a Livable Future. Baltimore food system resilience advisory report. 2017.
    - *This is an advisory report that emerged from a collaboration between researchers and municipal agencies in Baltimore City.*
  - Biehl E, Buzogany S, Huang A, Chodur G, Neff R. Baltimore food system resilience advisory report. Johns Hopkins Centre for A Livable Future and Baltimore Office of Sustainability: Baltimore, MD, USA. 2017 Aug.
    - *This peer-reviewed journal article accompanies the above report, and it details the process of developing the resilience advisory report for a scientific audience.*

Image sources:
The images are screenshots from the following sources:

- Left: https://www.businessinsider.com/how-long-grocery-store-shortages-supply-chain-disruptions-could-last-2020-4
- Middle: https://time.com/5820381/coronavirus-food-shortages-hunger/
- Right: https://www.vox.com/the-goods/2020/4/17/21220016/school-lunch-coronavirus-meal-programs

Slide 74: Key definition: healthy

Moving on to the next part of our definition, the word "healthy" on its own refers to the opportunity for people to attain their full health potential.

In the context of food systems, a healthy food system is one that facilitates well-being and disease prevention for all individuals. For example, a healthy food system makes nutrient-rich foods accessible and affordable for all individuals. It minimizes the contamination of resources such as air and water. And it ensures that people have access to the resources they need for food storage, food preparation, and child feeding and caregiving practices that support child and family health.

For example, do people live in communities where nutritious foods are available, and do they have living wages that help them to afford those foods? Do mothers have access to breastfeeding facilities in their workplaces? Are built environments and neighborhoods walkable and safe enough for people of all ages to participate in outdoor physical activities?

You may have heard of the concept of health equity, and health equity means that everyone has fair and just opportunity to be as healthy as possible (1). Achieving health equity requires addressing historical and contemporary structural inequities including poverty, systemic racism, gender disparities in decision-making, and geographic disparities in access to health services and healthy environments.

Sources cited:

1. Robert Wood Johnson Foundation. What is Health Equity? 2017.

Slide 75: Healthy example: promoting nutrition and health

As an example of what it can look like to promote health within food systems, this diagram shows that nutritional status and health are interconnected and they are both influenced by a variety of factors including access to clean water and sanitation, household income, the availability of food, the characteristics of food environments, individuals' nutrition knowledge and cultural norms, and women's empowerment.

You may have heard of the term "nutrition sensitive interventions," which refers to interventions related to agriculture, education, or social services that may not have the explicit goal of improving nutritional status, but that have a lot of potential to do so (1). There are many opportunities for nutrition professionals to ensure that the work carried out by other sectors is designed to support human nutrition and health. In some cases, not advocating for nutrition within other sectors can be a real missed opportunity. For example, work related to the climate resilience of agricultural communities, women's empowerment, and food environments are all opportunities to promote nutrition and health, and dietitians have a lot to offer in this space.

Sources cited:

1. Ruel MT, Alderman H, Maternal and Child Nutrition Study Group. Nutrition-sensitive interventions and programmes: How can they help to accelerate progress in improving maternal and child nutrition?. The Lancet. 2013 Aug 10;382(9891):536-51.

Additional resources:

- HLPE. 2017. Nutrition and food systems. A report by the High-Level Panel of Experts on Food Security and Nutrition.
    - *Within the HLPE report introduced in Modules 1-3, Figure 6 ("The burden of undernutrition through the life cycle and across generations," page 49) shows how inadequate food, health, and care can affect nutrition outcomes throughout the life course.*

Image source: The diagram in this slide appeared in a presentation from the Food and Agriculture Organization, "Compendium of indicators for nutrition-sensitive agriculture." The original source is: Herforth A, Ballard TJ. Nutrition indicators in agriculture projects: Current measurement, priorities, and gaps. Global Food Security. 2016 Sep 1;10:1-0.

Slide 76: Some common threads between these concepts

When we think about the concepts of sustainability, resilience, and health in food systems, there are many common threads.

These concepts apply to all areas of nutrition and dietetics practice. Whether you work in a clinical setting, in foodservice, in government, in a corporate environment, or with communities directly, these concept are broader than any one practice setting or individual intervention.

These concepts are interconnected, and grounded in the importance of equity.

They require action at multiple levels – not just interventions that target individual changes, which are important, but also interventions on policy, systems, and environments.

And these concepts apply to multiple scales – you might be working with individuals, households, neighborhoods, institutions, cities, countries, regions, or even at a global scale.

Slide 77: The water part of sustainable, resilient, and healthy food and water systems

Returning to the notion of a sustainable, resilient, and healthy food and water systems, let's pause and think about the water part of food and water systems. Water is critically important for human nutrition and health. Our marine environments provide nutrient-rich foods that include both marine plants and animals. Fresh water is necessary for agriculture, whether that water comes from rainfall or from irrigation. Access to clean water is essential for sanitation and hygiene and reducing children's exposure to infectious disease, which we know is linked to poor nutritional status. And access to clean and safe drinking water is essential for direct human consumption; especially as we promote non-caloric beverages for weight management, it is unlikely that people will seek water as a beverage if they don't have free and easy access to safe drinking water from their taps.

Image sources: Top: Simazoran via Getty Images. Bottom: Irenadragan via Getty Images.

Slide 78: Key concepts in water systems

We want to make sure you're equipped with some basic terminology related to water systems. One type of terminology is related to the source of water. There are many categories of sources, and two that we want to introduce here are green water and blue water. **Green water** refers to water that comes from precipitation and is then stored in the soil and available for plants to uptake. **Blue water** refers to water from surface or groundwater sources. Surface sources include lakes and glaciers, and ground water sources include aquifers. The image shown here is a cross-sectional diagram of an aquifer, which is an underground layer of permeable materials such as rock, sand, or silt from which water can be extracted.

Another type of water terminology is related to issues with water use versus water quality. When we talk about **water use,** we're getting at the idea of quantity – do we have enough fresh water? How is water use allocated for agriculture and other purposes? How can water be used more efficiently in industrial practices, agriculture, and in the households of consumers? Remember that 70% of all water that is withdrawn for human purposes is used for agriculture (1).

When we talk about **water quality**, we're talking about whether water is safe enough for drinking, swimming, fishing, agricultural uses like irrigation, and supporting our marine ecosystems. Conversations on water quality involve consideration of how water sources are affected by various contaminants and pollutants. Water contaminants might include the presence of lead from lead pipes. Water pollutants might include industrial or residential waste water, or runoff from agricultural systems that could include nutrients such as nitrates, pathogens such as e-coli, and chemicals from insecticides and herbicides.

We're introducing these terms so that they are part of your vocabulary as we move into a deeper exploration of sustainable food systems in the next module.

Sources cited:

1. Molden, D., et al., 2007. Pathways for increasing agricultural water productivity. In: Molden, D. (Ed.), Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. International Water Management Institute, London: Earthscan.

Additional resources:

- *This slide mentions blue water and green water. Another type of water footprint is "grey water," which is "the amount of fresh water required to assimilate pollutants to meet specific water quality standards." For more on water footprints, see:* Water Footprint Network. What is a water footprint?

- *The following are authoritative reports that provide a high-level overview of issues related to water security and water quality, including implications of climate change:*
  - United Nations Water. UN world water development report 2020. 2020.
  - Chicago Council on Global Affairs. From scarcity to security: Managing water for a nutritious food future. 2020.

- *The following peer-reviewed articles comment on the impacts of poor water quality on human health:*
  - Butler LJ, Scammell MK, Benson EB. The Flint, Michigan, water crisis: A case study in regulatory failure and environmental injustice. Environmental Justice. 2016 Aug 1;9(4):93-7.
    - *In Flint, Michigan, regulatory failures leading to high levels of lead in drinking water is an example of environmental injustice.*
  - Temkin A, Evans S, Manidis T, Campbell C, Naidenko OV. Exposure-based assessment and economic valuation of adverse birth outcomes and cancer risk due to nitrate in United States drinking water. Environmental research. 2019 Sep 1;176:108442.
    - *Nitrates in groundwater have human impacts in agricultural community including methemoglobinemia (blue-baby syndrome).*

- Hanjra MA, Qureshi ME. Global water crisis and future food security in an era of climate change. Food policy. 2010 Oct 1;35(5):365-77.
    - *A peer-reviewed article on how the global water crisis affects food security in an era of climate change.*

Image source: Public domain; this is a vectorized image of materials sourced from the United States Geological Survey, an agency of the United States Department of the Interior. Available at https://en.wikipedia.org/wiki/Aquifer#/media/File:Aquifer_en.svg.

Slide 79: Key definitions: pulling it all together

When we put it all together, "a sustainable, resilient, and healthy food and water system is one in which all individuals have equitable access to a safe, adequate, and secure supply of food and water that supports optimal health, both now and in the future."

This definition comes from the 2020 Standards of Professional Performance (SOPP) (1). The annotated bibliography in the handout contains definitions of sustainable food systems from other organizations, as well as definitions for overlapping concepts such as sustainable agriculture and sustainable diets.

The 2020 SOPP is also the source of the figure shown here, which illustrates that sustainable food systems are at the intersection of four domains: nutrition and health; economic vitality; social, cultural, and ethical capital; and environmental stewardship. The next module will discuss each of these domains in detail.

Sources cited:

1. Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Additional resources:

For completeness, below are definitions of sustainable food systems from other organizations, as well as widely-accepted definitions of overlapping concepts:

- *The UN High Level Panel of Experts on Food Security and Nutrition provides the following definition of a **sustainable food system:** "A food system that ensures food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security and nutrition of future generations are not compromised"* (see: HLPE. 2017. Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition. p.23)

- *The UN Food and Agriculture Organization provides the following definition of a **sustainable diet:** "Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources."* (see: Burlingame B, Dernini S. Sustainable Diets and Biodiversity. Proceedings of the International Scientific Symposium Biodiversity and Sustainable Diets United Against Hunger. Rome: Food and Agriculture Organization of the United Nations. 2010.)

- *The United States Department of Agriculture provides the following definition of sustainable agriculture: "**Sustainable agriculture** is "an integrated system of plant and animal production practices… that will, over the long term – satisfy human food and fiber needs; enhanced environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of*

nonrenewable resources…; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole." (see: USDA National Agricultural Library. Definitions and History of Sustainable Agriculture.)

- *There are a variety of concepts that complement and overlap the concept of sustainable food systems, such as regenerative agriculture and circular economies. Though this self-study doesn't have enough room to do a deep dive on these concepts, we want to note that our discussion of sustainable food systems is intended to be inclusive of these related concepts.*

Slide 80: A few notes about sustainability in the context of food systems

A few final notes to wrap up this module. When you find yourself talking about sustainability with your patients and clients, with other professionals, or with policymakers, you might find that the term sustainability can be quite polarizing, because people have their own definitions of the term. This slide is intended to help us find common ground about what we mean when we talk about sustainability in the context of food systems.

Sustainability is comprised of multiple domains – it's not focused exclusively on one domain over the others.

Sustainability is about ensuring a viable future, but it's also about what's happening now. We currently live in a world where every country is affected by at least one burden of malnutrition, whether that's overweight, micronutrient deficiencies, or childhood stunting (which affects one out of five children globally); where many people struggle to access to affordable, nutritious foods; and where one third of the food we produce goes to waste globally.

Really central to the concept of sustainability is equity – it's not about sustainability for some people or some places, or making sustainability into something that can be purchased. It's about making sure that we're equitably sharing resources, and equitably sharing the burdens that result from failures in the system. Those might be burdens of malnutrition, chronic disease, displacement from climate change, water quality issues, or loss of biodiversity.

Sustainability is related to structural inequities; we cannot achieve the principles of sustainable food systems that appear in this figure if we fail to meaningfully address structural inequities.

Given that we all rely on the food system to meet our needs and that we're all affected by the interconnected domains shown here, food systems sustainability is fundamental to the profession. The food system shapes the options that are available to all of us as consumers, but we also have the power to change the food system, as individuals and as a profession.

This quote from Fred Kirschenmann captures the evolving nature of our understanding of sustainability. He wrote that "sustainability is a process, not a prescription… it is a journey we embark upon together, not a formula upon which we agree" (1).

Sources cited:

- Kirschenmann FL. Food as relationship. J Environ Nutr. 2008;3(2-3):106-121.

Slide 81: Transition

[Transition to the next module]

Module 5: Exploring the Multiple Domains of Sustainable Food Systems

Slide 82-83: Transition

[Transition to the module]

Slide 84: Module 5 introduction

In Module 5, we are exploring the multiple domains of sustainable food systems.

Image source:
- Environmental impact by Made from the Noun Project

Slide 85: Module 5 learning outcomes

By the end of this module, you will be able to:
1. Identify the four domains of sustainable, resilient, and healthy food and water systems
2. Describe principles within each domain
3. Discuss how human diets affect and are affected by environmental, economic, and social factors

Slide 86: Sustainability is multi-dimensional

As we introduced in the previous module, sustainable, resilient, and healthy food and water systems are at the intersection of four domains: nutrition and health; economic vitality; social, cultural, and ethical capital; and environmental stewardship. The figure shown here is from the Academy's 2020 SOPP for RDNs who wish to incorporate the principles of sustainable food systems into their respective areas of practice.

In the next slides we will unpack each of these domains in turn, taking time to discuss how these domains affect each other. For example, we know that the environment affects human diets, and we know that human diets affect the environment.

Slide 87: Nutrition and health

We'll start with the domain that is closest to home for us, which nutrition and health.

If a hypothetical food system was able to deliver on environmental stewardship, economic vitality, and social, cultural, and ethical capital but didn't facilitate nutrition and health, it would not be a sustainable food system.

The principles of this domain from the 2020 SOPP are shown on the right, and what we want to emphasize here is that the domains don't function in isolation; they are dependent on each other.

Nutrition and health help to advance the other domains. Regardless of whether we're working on environmental stewardship or any other aspect of sustainability, it's essential that all humans have fair opportunity to reach their full health potential. For example, well-nourished, healthy people can participate in thriving economies

Similarly, nutrition and health are not possible without the other domains. If we want to promote healthy dietary patterns, that's not possible without ensuring that nutritious foods are available, accessible, and affordable – factors that have environmental, economic, and social components.

Image source: Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Slide 88: Economic vitality

The next domain is economic vitality. We know that economic factors affect human diets, and we need to think about economic considerations for both food producers and food consumers. For consumers (which includes all of us), people are more likely to consume nutritious foods if they are affordable. For producers and other food systems stakeholders like processors and distributors, businesses are more likely to make nutritious foods available to the public in a sustainable way only if it is economically viable for them to do so.

We also know that human diets, nutritional status, and health affect economic outcomes. Malnutrition can lead to economic losses for many reasons: direct losses in productivity, indirect losses in productivity from schooling deficits, and increased healthcare costs. We also know that consumer choices drive the demand for agricultural and food systems livelihoods; when consumers are seeking a certain type of product, new economic opportunities open up for food producers, manufacturers, brands, and retailers.

The connections between economic factors and the other domains of sustainable food systems are fascinating because there are economic aspects to factors like agricultural labor and environmental remediation. The handout provides further resources in this area, including resources related to true cost accounting. The idea behind true cost accounting is that while certain foods may be relatively inexpensive for consumers, various practices along the production and value chain may have externalities, or consequences, such as environmental impact or healthcare utilization that incur costs not reflected in the price of our food.

Additional resources:

- Drewnowski A, Darmon N. The economics of obesity: Dietary energy density and energy cost. The American journal of clinical nutrition. 2005 Jul 1;82(1):265S-73S.
    - *This landmark paper demonstrates that the most inexpensive sources of dietary energy are added sugars and added fats, whereas more nutrient-dense foods such as fish, fresh vegetables, and fruit tend to cost more.*

- Finaret AB, Masters WA. Beyond calories: The new economics of nutrition. Annual Review of Resource Economics. 11;237-259 (2019).
    - *This peer-reviewed article provides an overview on the connections between nutrition and economics. It reviews the economic aspects of concepts including diet quality, nutrient composition, and sustainability.*

- Wellesley L, Eis J, Marjis C, Vexler C, Waites F, Benton TG. The business case for investment in nutrition. Chatham House Report; Energy, Environment, and Resources Programme. 2020.
    - *The take-home message from this report is that effective action from businesses can reduce global deaths from malnutrition while also enhancing economic productivity. This report quantified many of the "hidden costs" of malnutrition; for example, businesses in LMICs collectively lose between $130 billion and $850 billion each year through productivity reductions from malnutrition.*

- *Resources related to "true cost accounting":*

    - Tegtmeier EM, Duffy MD. External costs of agricultural production in the United States. International Journal of agricultural sustainability. 2004 Jan 1;2(1):1-20.
        - *This paper provides an overview and quantifies the externalized costs of agriculture in the United States. They estimate the impact of agriculture on natural resources, wildlife and ecosystem biodiversity, and human health at $5.7 to $16.9 billion annually.*

    - United Nations Environment Program (UNEP), the Economics of Ecosystems and Biodiversity (TEEB). Scientific and Economic Foundations Report. 2018.
        - *This report argues for a systems thinking approach to the food system and presents a framework for how to assess food systems in a way that takes into account not only "produced capital" (including finance and infrastructure) but also natural capital, human capital, and social capital.*

- LaBorde D, Parent M, Piñeiro V. Policy brief: True cost of food. International Food Policy Research Institute. 2020.
  - *This policy brief calls on the G20 (Group of Twenty, an international forum for governments and financial organizations from 19 countries and the European Union) to develop a harmonized approach to measure true costs of food (which they refer to as "social costs of food").*

- Christ KL, Burritt R. Material flow cost accounting for food waste in the restaurant industry. British Food Journal. 2017 Mar 6.
  - *This peer-reviewed article applies the concept of true cost accounting to food waste within foodservice operations.*

Image source: Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Slide 89: Social, cultural, and ethical capital

The next domain is social, cultural, and ethical capital, and again the principles of this domain from the SOPP are shown on the right.

On the one hand, social factors affect human diets. Workers' rights, safety, and fair working conditions facilitate jobs that support the availability of nutritious foods, whether those jobs are in agriculture or restaurant food service. And nutritious foods are more likely to be consumed if they are culturally appropriate. There are a variety of social and cultural factors that affect whether certain foods are considered not only acceptable, but also desirable, and whether food environments and gathering places encourage social diversity and inclusion. Any attempt to intervene on what and how people eat needs to be sensitive and respectful of cultural knowledge, norms, practices, skills, and values.

On the other hand, human diets also affect outcomes in this domain. Consumers can influence the demand for policies, regulations, and voluntary industry standards that support ethical considerations like fair working conditions and animal welfare.

For more reading on some of the topics within this domain, such as ethics, food sovereignty, and the social determinants of health, please see the resources available in the handout.

Additional resources:

- *There are many issues at the intersection of **ethics** and nutrition. These two papers offer a more in-depth exploration of specific ethical issues:*
  - Barnhill A, King KF, Kass N, Faden R. The value of unhealthy eating and the ethics of healthy eating policies. Kennedy Institute of Ethics Journal. 2014;24(3):187-217.
    - *This paper reviews ethical considerations related to policies that limit access to unhealthy foods.*

  - Fanzo J. Ethical issues for human nutrition in the context of global food security and sustainable development. Global Food Security. 2015 Dec 1;7:15-23.
    - *This paper reviews ethical issues related to the nutrition in low- and middle-income countries, specifically examining ethical trade-offs related to environmental sustainability and nutrition goals.*

- ***Food sovereignty*** *has been defined as "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems." For a thorough discussion of the origins and evolution of the concept of food sovereignty, see:* Patel R. Food sovereignty. The journal of peasant studies. 2009 Jul 1;36(3):663-706.

- *For an overview of issues related to* ***agricultural labor*** *in the food system, see:*

    - Clayton ML, Clegg Smith K, Neff RA, Pollack KM, Ensminger M. Listening to food workers: Factors that impact proper health and hygiene practice in food service. International Journal of Occupational and Environmental Health. 2015;21(4):314-327.

    - Rodman SO, Barry CL, Clayton ML, Frattaroli S, Neff RA, Rutkow L. Agricultural exceptionalism at the state level: Characterization of wage and hour laws for U.S. farmworkers. Journal of Agriculture, Food Systems, and Community Development. 2016;6(2):89-110.

- *The concept of* ***social determinants of health*** *refers to the conditions that affect health risks and outcomes, such as economic stability, social and community context, education, neighborhood and environmental factors, and healthcare. For a landmark paper on this topic from the Lancet Commission on Social Determinants of Health,* see: Marmot M, Friel S, Bell R, Houweling TA, Taylor S, Commission on Social Determinants of Health. Closing the gap in a generation: Health equity through action on the social determinants of health. The Lancet. 2008 Nov 8;372(9650):1661-9.

Image source: Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Slide 90: Environmental stewardship: introducing key terms

The next domain is environmental stewardship, and before showing the principles within this domain, there are a few key terms are helpful to introduce.

One set of key terms is related to climate change.

To start with, **greenhouse gases** are gases that trap heat and make the planet warmer (1). These include carbon dioxide, methane, nitrous oxide, and fluorinated gases. Greenhouse gases can be emitted or sequestered. Examples of **emissions** are that cars emit carbon dioxide as well as nitrous oxide and methane; nitrous oxide is emitted when fertilizer is applied to soil; methane is emitted from enteric fermentation by cows, and is also emitted when livestock manure decomposes anaerobically, as in manure lagoons; and methane is emitted when food and other organic materials break down anaerobically in landfills. Globally, agriculture accounts for 11% of all greenhouse gas emissions (2).

The opposite of emissions is **sequestration.** Carbon sequestration refers to processes where carbon dioxide is removed from the atmosphere through photosynthesis and stored as carbon. The ocean, soil, and biomass (such as trees and plants) all serve as **carbon sinks** that sequester carbon.

Climate change is a process by which increased levels of greenhouse gases contribute to atmospheric warming, which affects ocean temperatures, sea level, precipitation patterns, and extreme weather events (3). One key characteristic of climate change is volatility, with extreme weather events becoming more frequent and severe, and these extreme weather events can involve not only increased temperatures and droughts but also more severe winter storms.

There are many possible pathways by which climate change can affect human diets, human nutrition, and human health. The annotated bibliography provides resources with a more comprehensive overview, but some of the major pathways are that climate change can affect not only the ability to produce an adequate supply of food, but it can also affect the nutrient content of foods and food prices. Scarcity in food supplies and volatility in food prices

can cause further issues such as conflict and displacement, which can lead to other issues with a direct impact on human health such as rapid urbanization and crowding and heightened susceptibility to infectious disease and undernutrition.

It's worth noting that the impacts of climate change will differ between and within regions of the world, and that whereas the majority of anthropogenic (human-caused) climate change has originated in high-income, industrialized nations, climate change will have a disproportionate impact on low- and middle-income countries and on more vulnerable populations within all countries.

Sources cited:

1. United States Environmental Protection Agency. Sources of greenhouse gas emissions.

2. Global Emissions. Center for Climate and Energy Solutions website. https://www.c2es.org/content/international-emissions/. Accessed March 25, 2020.

3. Spiker ML, Ickes SB, Fanzo J. (Forthcoming Summer 2020) Underlying Determinants of and Solutions for Malnutrition in Low- and Middle-Income Countries. In Jones-Smith (Ed.) Public Health Nutrition: Essentials for Practitioners. Baltimore, MD: Johns Hopkins University Press.

Additional resources:

- Myers SS, Smith MR, Guth S, Golden CD, Vaitla B, Mueller ND, Dangour AD, Huybers P. Climate change and global food systems: potential impacts on food security and undernutrition. Annual review of public health. 2017 Mar 20;38:259-77.
    - *A comprehensive overview of mechanisms by which climate change may impact food security and human health. Figure 2 is especially helpful.*

- *For peer-reviewed articles on the potential impact for increased levels of atmospheric carbon dioxide to decrease the micronutrient content of certain crops, see the following two papers. Some studies have found decreased concentration of protein, zinc, and iron in wheat, rice, and barley, and decreased concentration of iron and zinc in field peas and soy beans. The projected decreases are small, around 4-8%, but could contribute to decrements nutrient availability for populations that depend on staple grains for the bulk of their diets.*

    - Myers S, et al. Rising CO2 threatens human nutrition. Nature. 2014 June 5; 510(7503): 139–142.

    - Medek DE, Schwartz J, Myers SS. Estimated effects of future atmospheric CO 2 concentrations on protein intake and the risk of protein deficiency by country and region. Environ Health Perspect. 2017 Aug 2;125(8):087002.

Slide 91: Environmental stewardship: introducing key terms

Another key environmental concept is biodiversity, which refers to the biological diversity of genes, species, and ecosystems.

At the ecosystems level, biodiversity looks like a variety of different habitats, communities, and ecological processes. For example, there is a multitude of different types of pasture habitats including grassland, prairies, and rangeland.

At the species level, biodiversity looks like a variety of different species present in any given ecosystem or population. For example, there are thousands of different species of seaweed in the Pacific Ocean.

At the genetic level, biodiversity looks like a variety of different genetic characteristics within a species that can help organisms to adapt to environmental changes. For example, within any given species such as wheat, soy, or rice, different cultivars may be more or less resilient to heat, or drought, or floods.

There are so many ways that biodiversity is important for agriculture, nutrition, and human health. Biodiversity ensures that soils are productive, it promotes the resilience of food production systems to climate change, and it allows for a diversity in nutrient composition. For example, if a farm is producing sweet potatoes, some cultivars may be especially resilient to drought, and other cultivars may be especially high in beta-carotene.

Additional resources:

- Food and Agriculture Organization, Commission on Genetic Resources for Food and Agriculture. State of the World's Biodiversity for Food and Agriculture. 2019.
    - *The FAO publishes an annual report on the state of the world's biodiversity.*

Slide 92: Environmental stewardship: introducing key terms

The last set of key terms before we dive into the rest of the environmental domain is related to land use. When thinking about land, one key consideration is whether it can even be used to grow food. **Arable land** refers to land that can grow crops, whereas **marginal land** is land where it would be very difficult to grow crops. There are a number of factors that might make land unsuitable for agriculture, such as steep terrain, poor soil quality, low rainfall and lack of access to irrigation, or pollution from industrial activities.

Another consideration related to land is how much of our land we should use to grow food. Currently it's estimated that 34% of global land use is for agriculture (1). There are two major schools of thought. According to the **land sharing** approach, rather than pursuing intensive agriculture where we maximize the yield per acre, we should keep yields low so that we can maintain more biodiversity within an agricultural landscape (2). For example, a farmer might choose to grow shade-grown coffee in a forested environment that also includes a lot of native vegetation, where the coffee is sharing land with a variety of other plants that each attract their own unique animals, insects, and microbes. According to the **land sparing** approach, we would maximize agricultural yields so that we can leave more natural habitat completely untouched by agriculture (2). An example of this might be intensively managed row crops that have a high yield, existing alongside uncultivated forested land that maintains its original biodiversity. Both approaches have the goal of protecting biodiversity, and determining which approach is best depends on the local context.

Another key concept is **land use conversion:** when we convert uncultivated land such as forests to agricultural land or pastureland, this typically results in net greenhouse gas emissions. If trees or other native plants are removed through burning, the burning process itself emits greenhouse gases. Disturbing soil to cultivate crops is another process can that emit greenhouse gases. And the greatest impact is that forests that had previously served as a carbon sink are replaced by agricultural land that has less capacity for carbon sequestration.

Sources cited:

1. Ramankutty N, Evan AT, Monfreda C, Foley JA. Farming the planet: Geographic distribution of global agricultural lands in the year 2000. Global Biogeochemical Cycles. 2008 Mar;22(1).

2. Grau R, Kuemmerle T, Macchi L. Beyond 'land sparing versus land sharing': environmental heterogeneity, globalization and the balance between agricultural production and nature conservation. Current Opinion in Environmental Sustainability. 2013 Oct 1;5(5):477-83.

Additional resources:

- Hannah Ritchie and Max Roser (2019) - "Land Use". *Published online at OurWorldInData.org*
    - *Visit for interactive visuals about agricultural land use. Note that many of the visuals have a slider to show change over time.*

Image source: Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Slide 93: Environmental stewardship

With some of those foundational concepts in our vocabulary, let's return to how environmental stewardship fits within sustainable food systems.

The big picture is that the environment affects human diets, and human diets affect the environment.

As just one of example of how the environment affects human diets, growing crops, animals, and marine food sources requires specific environmental conditions such as healthy soil, healthy marine ecosystems, biodiversity, adequate rainfall or water for irrigation, and land suitable for grazing. Within these natural resources many are finite, such as freshwater, and ecological changes such as climate change can introduce unpredictability that affects crop yields, nutrient content, and more.

And let's think about the ways that human diets affect the environment. Because we require natural resources in order to produce, distribute, acquire, and prepare foods, our diets have an environmental footprint. Different foods and farming and supply chain practices vary in their resource intensity and their effects on the environment, and the coming slides will provide a few examples.

Image source: Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Slide 94: Environmental stewardship examples: greenhouse gas emissions

For example, foods may differ in their greenhouse gas emissions. There are interesting differences in greenhouse gas emissions both between and within food groups.

- For example, rice tends to have higher carbon dioxide emissions per kilogram than potatoes, because flooded rice fields release methane (1)
- Beef tends to have higher carbon dioxide emissions per kilogram than poultry, because ruminant livestock release methane, and more land is required for grazing and growing feed to get cattle to their market weight (1)
- But even within a single food, things can be nuanced: beef finished on grass tends to have higher carbon dioxide emissions per kilogram than beef finished on feedlots, because cattle eating grass take a longer time to reach market weight than cattle eating corn-based rations. (2)
- And the same food can have a different footprint based on supply chain factors: transporting foods by air may emit 50 times more carbon dioxide than transporting foods by boat (3)

Sources cited:

1. Clune S, Crossin E, Verghese K. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. 2017 Jan 1;140:766-83.
    - *Note that determining the exact carbon footprint of foods is challenging because it requires a high resolution of data on "farm-to-form" or "cradle-to-grave" activities from a variety of geographic locations and different agricultural styles. But there is clear hierarchy of relative carbon footprints: grains, fruits, and vegetables tend to have lower greenhouse gas emissions per kilogram, whereas ruminant meats have the highest, and dairy and poultry products in the middle. This paper is a systematic review on this topic. Note that the research continues to evolve on how to assess carbon footprints in relation to nutrient composition and other factors.*
2. Pelletier N, Pirog R, Rasmussen R. Comparative life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States. Agricultural Systems. 2010 Jul 1;103(6):380-9.
3. Ritchie, H. You want to reduce the carbon footprint of your food? Focus on what you eat, not whether your food is local. 2020.

Additional resources:

- United States Environmental Protection Agency. Greenhouse Gas Inventory Data Explorer. 2020.
  - *On this site you can interactively explore the EPA's greenhouse gas inventory, create custom visuals, and examine trends over time.*
- Reinhardt SL, Boehm R, Blackstone NT, El-Abbadi NH, McNally Brandow JS, Taylor SF, DeLonge MS. Systematic review of dietary patterns and sustainability in the United States. Advances in Nutrition. 2020 Mar 13.
  - *While the examples on this slide talk about the carbon footprint of individual foods, there is a growing body of literature that compares the carbon footprint of whole dietary patterns. This is a rapidly evolving area, with new studies and reviews each year. This is an example of a systematic review that highlights the tradeoffs between healthy dietary patterns and dietary patterns with a low carbon footprint.*

Image sources: Astrid860 via Getty Images.

Slide 95: Environmental stewardship examples: water use

Foods may also differ in their water use.

1. For example, producing rice requires more water than producing potatoes, because rice cannot germinate and grow unless paddy fields are flooded. (1)
2. Producing meat requires more water than producing vegetables, due to the water required to grow animal feed, whether that water is from irrigation or rainfall. (2)
3. And compared to beef finished on feedlots, beef finished on grass requires less blue water (which is water from irrigation) but more green water (which is water from rainfall). (3)

Sources cited:

1. Chapagain AK, Hoekstra AY. The blue, green and grey water footprint of rice from production and consumption perspectives. Ecological Economics. 2011 Feb 15;70(4):749-58.

2. Kim BF, Santo RE, Scatterday AP, Fry JP, Synk CM, Cebron SR, Mekonnen MM, Hoekstra AY, De Pee S, Bloem MW, Neff RA. Country-specific dietary shifts to mitigate climate and water crises. Global environmental change. 2020 May 1;62:101926.

3. Gerbens-Leenes PW, Mekonnen MM, Hoekstra AY. The water footprint of poultry, pork and beef: A comparative study in different countries and production systems. Water Resources and Industry. 2013 Mar 1;1:25-36.

Image sources: North-Tail via Getty Images.

Slide 96: Environmental stewardship examples: water quality

To add even more complexity, foods differ not just in how much water they use, but also in how their production affects water quality.

For example, excessive application of fertilizer on crops can cause nutrients such nitrogen and phosphorous to run into freshwater and marine waterways (1). As a result of this, excessive nutrient runoff can lead to excessive nitrates in public water supplies, as well as algae blooms and anoxic dead zones in bodies of water (1).

But in some cases food production practices can actually improve water quality. For example, bivalves – which include oysters, clams, mussels, and scallops – are filter feeders, meaning that they can remove excess nitrogen from the water. One adult oyster can filter 50 gallons of water per day (2), and New York's Hudson Bay used to have an oyster population that was large enough to filter the entire bay (3).

Sources cited:

1. Robertson GP, Vitousek PM. Nitrogen in agriculture: balancing the cost of an essential resource. Annual review of environment and resources. 2009 Nov 21;34:97-125.

2. National Oceanic and Atmospheric Administration (NOAA). Oyster Reef Habitat Conservation. 2020.

3. Nigro C. History on the Half-Shell: The Story of New York City and its Oysters. New York City Public Libraries Blog. 2011.

Image sources: Shutterphuma via Getty Images.

Slide 97: How should we use this information?

Taking a step back, now that you are familiar with the four domains of sustainable food systems and you have a deeper understanding of the principles within each domain and how they are interconnected, what can you do with this information?

I find this framework helpful for reinforcing the point that optimal nutrition and health are dependent on other domains, and vice versa. This framework can help nutrition professionals see the importance of not working in isolation, and it also helps our colleagues working in other domains to see the value of nutrition.

Recognizing the multiple domains of sustainability motivates us to ensure that interventions to promote sustainability consider a multitude of factors ranging from an intervention's environmental impact and its economic costs to its ethical considerations.

Rooting sustainable food systems within these multiple domains makes it very clear that we need to work in collaboration with people who have expertise in other parts of the food system.

This framework also encourages us to think about potential co-benefits and trade-offs, which is something we'll cover in the next module.

Additional resources:

The following are similar or overlapping frameworks that discuss the multiple dimensions of sustainable food systems and how they can be measured:

- Gustafson D, Gutman A, Leet W, Drewnowski A, Fanzo J, Ingram J. Seven food system metrics of sustainable nutrition security. Sustainability. 2016 Mar;8(3):196.
    - *This paper proposes seven metrics of sustainable nutrition outcomes within food systems, and each metric has a suite of indicators: food nutrient adequacy, ecosystem stability, food affordability and availability, sociocultural wellbeing, food safety, resilience, and waste and loss reduction.*

- Béné C, Fanzo J, Prager SD, Achicanoy HA, Mapes BR, Alvarez Toro P, Bonilla Cedrez C. Global drivers of food system (un) sustainability: A multi-country correlation analysis. PLoS one. 2020 Apr 3;15(4):e0231071.
    - *Within four dimensions (environment, economic, social, and food and nutrition), this paper propose a system of measuring sustainability that includes components (e.g., components of the environmental dimension include energy and biodiversity), domains (e.g., domains of biodiversity include crop diversity and wildlife diversity), and indicators (e.g., indicators of crop diversity include the crop diversity index).*

- United Nations Environment Program (UNEP), the Economics of Ecosystems and Biodiversity (TEEB). Scientific and Economic Foundations Report. 2018.
    - *This report argues for a systems thinking approach to the food system and presents a framework for how to assess food systems in a way that takes into account not only "produced capital" (including finance and infrastructure) but also natural capital, human capital, and social capital.*

Image source: Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Slide 98: Thought start for modules 4 & 5

In modules 4 and 5 we unpacked the definition of a sustainable, resilient, and healthy food and water system and looked at each of the domains of sustainability. To reflect on these two modules, take a moment to think about a food or beverage you've consumed in the past 24 hours.

How might this food or beverage have affected your nutrition and health? Environmental stewardship? Economic vitality? And social, cultural, and ethical capital? In thinking about this, consider how the food was produced, processed, distributed, prepared, consumed, and possibly wasted.

Slide 99: Transition

[Transition to the next module]

Module 6: Understanding Complexity in the Food System

Slide 100-101: Transition

[Transition to the module]

Slide 102: Module 6 introduction

In Module 6, we'll talk about the "systems" part of "food systems."

Image sources:
Network by Meaghan Hendricks from the Noun Project

Slide 103: Module 6 learning outcomes

By the end of this module, you will be able to:

1. Define a complex system.
2. Describe at least three characteristics of complex systems.
3. Discuss how systems thinking can be used to approach issues in nutrition.
4. Provide at least one example of a co-benefit and one example of a tradeoff within the food system.

Slide 104: What is the systems part of food systems?

When we talk about a "**system**," we're referring to any network of interconnected parts that operate towards a purpose (1). The word "interconnected" is key within this definition – it refers to the idea that changing one part of a system affects other parts.

There are different types of systems, and just a few are shown here (2). A **simple system** may have just a few elements, and those elements are connected by relationships that are known, stable, and predictable. For example, the way a valve opens to let air into the engine of your car when you press the gas pedal is a relationships that is known, stable, and predictable.

In a **complicated system**, many well-defined relationships co-exist with each other. For example, think about the many mechanical actions and chemical reactions that take place when your car is operating. Though there can be some unpredictability and your car can break down, the overall behavior of the system is fairly stable and predictable.

In a **complex system**, there are many coexisting relationships, but those relationships may not well-defined, or they may not be knowable at all, and the nature of those relationships may change and adapt over time. For example, think about the way that humans interact with automobiles and the transportation industry, and the way that transportation has changed the way humans lives their lives.

When we think about the food system that we saw in previous modules, the food system is a great example of a complex system.

The next few slides will describe some of the characteristics of complex systems. We're not going to describe an exhaustive set of all characteristics – for example, we won't cover things like emergence and adaptation. But we're going to cover a few fundamental characteristics of complex systems that may give words to phenomena you've encountered in your practice and in the world at large.

Sources cited:

1. Peters DH. The application of systems thinking in health: Why use systems thinking? Health Research Policy and Systems. 2014 Dec;12(1):51.
    - *This peer-reviewed article defines systems thinking and provides an overview of systems thinking theories, methods, and tools. It is a great resource for introducing the concept of systems thinking within health.*

2. Spiker ML, Ickes SB, Fanzo J. (Forthcoming Summer 2020) Underlying Determinants of and Solutions for Malnutrition in Low- and Middle-Income Countries. In Jones-Smith (Ed.) Public Health Nutrition: Essentials for Practitioners. Baltimore, MD: Johns Hopkins University Press.
    - *This textbook chapter focuses on "nutrition-sensitive interventions" for malnutrition in low- and middle-income countries, but it also contains some introductory material about systems thinking in the context of nutrition.*

Image sources: Middle icon by Magicon, right icon by Meaghan Hendricks, both from the Noun Project.

Slide 105: Characteristics of complex systems – bidirectional feedback

One characteristic of complex systems is bidirectional feedback, where two components may affect one another.

For example, Undernutrition makes children more susceptible to infectious disease, and infectious disease makes children more susceptible to undernutrition.

Or, the food supply affects demand, because people grow accustomed to eating what is commonly available around them. But at the same time, demand can also affect supply – based on what consumers value and are willing to pay for, food producers, processors, and retailers might adapt their practices to provide what people want. The photo shown on the right is a field of quinoa growing in Argentina, and in response to an explosion of consumer demand for this whole grain with complete protein, the number of countries growing quinoa increased from 40 countries in 2010 to 75 countries in 2014.

Additional resources:

Related to example 1: For more reading on the concept that undernutrition and infectious disease can spur each other on, the follow publications explore the relationship between undernutrition and measles, as one example:

- Caulfield LE, de Onis M, Blössner M, Black RE. Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. The American journal of clinical nutrition. 2004 Jul 1;80(1):193-8.
- Reddy V. Interaction between nutrition and measles. The Indian Journal of Pediatrics. 1987 Jan 1;54(1):53-7.

Related to example 2: For more reading on the case study of quinoa as a crop where growing consumer demand has catalyzed increased production:

- Bazile D, Jacobsen SE, Verniau A. The global expansion of quinoa: Trends and limits. Frontiers in Plant Science. 2016 May 9;7:622.
- Bedoya-Perales NS, Pumi G, Mujica A, Talamini E, Domingos Padula A. Quinoa expansion in Peru and its implications for land use management. Sustainability. 2018 Feb;10(2):532.

Image Sources: Left: Loop by Hare Krishna from the Noun Project. Middle: Michael Blann via Getty Images. Right: Estivillml via Getty Images.

Slide 106: Characteristics of complex systems – bidirectional feedback, continued

The idea of bidirectional feedback is exemplified in the concept of "**feedback loops.**"

Some feedback loops are **balancing loops**, where two relationships bring each other back to a state of equilibrium. A biological example of a balancing feedback loop is the regulation of blood glucose: an increase in blood glucose triggers the release of insulin from beta cells of the pancreas. The release of insulin triggers a decrease in levels of blood glucose, until normal levels are reached.

Some feedback loops are **reinforcing loops**, where two relationships amplify each other's effects. Example 1 from the previous slide is a reinforcing loop: undernutrition makes children more susceptible to infectious disease, and infectious disease makes children more susceptible to undernutrition. In colloquial language, you might hear people to refer to this type of phenomenon as a "vicious cycle" or a "downward spiral."

Another example of a reinforcing loop is the ripening of fruit: as they ripen, many fruits begin to produce ethylene – a gaseous plant hormone. This is autocatalytic, meaning that exposure of fruit to ethylene causes it to produce more ethylene and ripen faster. We can actually use this biological phenomenon to our advantage: to speed up ripening, we can put fruit in a closed container with ripe fruit. To slow down ripening, we can either ensure that fruit is not exposed to ethylene (for example, shipping bananas while they are green) or we can separate ripe fruits from fruits that we do not want to ripen quickly.

You'll notice from these examples that feedback loops can occur within biological systems, but they can also occur at the level of individual behavior, communities, and whole ecosystems. An ecosystems-level example of a reinforcing loop is global warming: rising atmospheric temperatures cause ice to melt in polar regions, and bare ground absorbs more heat which causes even more ice to melt.

Additional resources:

- Tip T. Guidelines for drawing causal loop diagrams. Systems Thinker. 2011 Feb;22(1).
    - *The diagrams that visually illustrate a few example feedback loops on this slide use notations that are common to causal loop diagrams. This is a brief primer on how to create causal loop diagrams to illustrate feedback loops and other phenomena.*

- *Additional peer-reviewed articles on specific examples of bidirectional feedback and feedback loops in the food system:*

    - Bajželj B, Richards KS. The positive feedback loop between the impacts of climate change and agricultural expansion and relocation. Land. 2014 Sep;3(3):898-916.

    - Clancy K. Digging deeper: Bringing a systems approach to food systems: Feedback loops. Journal of Agriculture, Food Systems, and Community Development. 2013 Jun 17;3(3):5-7.

    - Rodin J. Insulin levels, hunger, and food intake: An example of feedback loops in body weight regulation. Health Psychology. 1985;4(1):1.

    - Sundkvist Å, Milestad R, Jansson A. On the importance of tightening feedback loops for sustainable development of food systems. Food policy. 2005 Apr 1;30(2):224-39.

Slide 107: Characteristics of complex systems – time-delayed responses

Another characteristic of complex systems is time-delayed feedback: some actions may have impacts that are not felt immediately.

Shown is a photo from the Dutch Hunger Winter. During World War II, the western region of the Netherlands was cut off from food supplies over the winter and spring of 1944, and during this time residents had a few as 400-800 calories per day. By tracking children who were in gestation during this time, researchers have found that

exposure to environmental stressors such as undernutrition during gestation or early life may increase the likelihood of obesity or chronic disease in later life. This is an example of a very time-delayed response, where there is a big lag between an event and its outcome. If you're interested, the handout contains more resources on the **developmental origins of health and disease.**

Time delays in complex systems can take months, years, generations, or centuries to manifest. Another example of a time delay is that when carbon dioxide is emitted into the atmosphere, the full effect of those emissions on rising global temperatures may take several decades to emerge. This means that actions taken today to reduce carbon dioxide emissions will not only benefit us, but they will also benefit future generations. It also means that if we do not take action today, the negative consequences of greenhouse gas emissions may still be felt for generations.

Another example of a time-delayed response is the incubation period for infectious diseases. For the novel coronavirus, COVID-19, the incubation period can vary widely, ranging from 3 to 14 days, meaning that after people are exposed they may not show symptoms for up to two weeks (1). During this long pre-symptomatic period when virus particles are being shed, taking part in the activities of daily life may expose other people, which has been one of the key challenges in attempting to contain and mitigate the spread of the virus throughout the globe.

Sources cited:

1. Qin J, You C, Lin Q, Hu T, Yu S, Zhou XH. Estimation of incubation period distribution of COVID-19 using disease onset forward time: A novel cross-sectional and forward follow-up study. medRxiv. 2020 Jan 1.

Additional resources:

Related to example 1: The "Development Origins of Health and Disease" (DOHaD) refers to the hypothesis that early-life environmental exposures affect an individual's long-term health, and potentially also that of their offspring. The concept was formerly known as "the Fetal Origin of Adult Disease" and, before that, as the Barker Hypothesis, named after David Barker who conducted studies about the Dutch Hunger Winter.

- Heindel JJ, Vandenberg LN. Developmental origins of health and disease: A paradigm for understanding disease etiology and prevention. Current opinion in pediatrics. 2015 Apr;27(2):248.
    - *This is a good introduction on the concept of DoHAD.*

- Schulz LC. The Dutch Hunger Winter and the developmental origins of health and disease. Proceedings of the National Academy of Sciences. 2010 Sep 28;107(39):16757-8.
    - *A short, peer-reviewed Commentary on how the Dutch Hunger Winter aided in our understanding of the development origins of health and disease.*

- Barker DJ, Lampl M, Roseboom T, Winder N. Resource allocation in utero and health in later life. Placenta. 2012 Nov 1;33:e30-4.
    - *A more in-depth exploration of how allocation of nutritional resources in utero affects long-term health, written by David Barker himself.*

- Rickard IJ, Courtiol A, Prentice AM, Fulford AJ, Clutton-Brock TH, Lummaa V. Intergenerational effects of maternal birth season on offspring size in rural Gambia. Proceedings of the Royal Society B: Biological Sciences. 2012 Oct 22;279(1745):4253-62.
    - *A more in-depth exploration of inter-generational influences.*

Related to example 2 (time lag between carbon dioxide emissions and global warming):

- Zickfeld K, Herrington T. The time lag between a carbon dioxide emission and maximum warming increases with the size of the emission. Environmental Research Letters. 2015 Mar 10;10(3):031001.
    - See this paper f*or discussion of the time delay between carbon dioxide emissions and rising global temperatures.*

Image Sources: Left: delay by ibrandify from the Noun Project. Middle: Public domain, photo by Menno Huizinga. Right: AvigatorPhotographer via Getty Images.

Slide 108: Characteristics of complex systems – nonlinear relationships

Another characteristic of complex systems is nonlinear relationships. Sometimes a change in one part of the system may not correspond with a constant change in another part of the system.

A non-linear relationship can take many forms. One type of non-linear relationship is **a synergistic relationship**, where an outcome is greater than the sum of its parts. As an example of a synergistic relationship in nutrition, in low- and middle-income country settings with high rates of multiple micronutrient deficiencies, it has been observed in some studies that micronutrient supplementation and psychosocial stimulation are both effective on their own, but in combination they are even more effective. Psychosocial stimulation includes things like early childhood play activities that provide sensory and emotional input; see the handout for some specific studies in this area.

Another type of non-linear relationship is a **tipping point**, where once a system crosses a certain threshold it can lead to large or potentially irreversible changes in the state of the system. A good example of an ecological tipping point is the collapse of wild fish stocks. The term fish stock refers to a population of a particular species of fish. A fish stock can collapse, meaning that its population abruptly declines, due to factors like over-fishing, loss of species diversity within marine environments, and destruction of marine environments. Though the collapse of some fish stocks can be predicted, in some cases they occur even after what appear to be years of relative stability.

Additional resources:

Related to example 1 (synergistic effects of micronutrient supplementation and psychosocial stimulation):

- Hurley KM, Yousafzai AK, Lopez-Boo F. Early child development and nutrition: A review of the benefits and challenges of implementing integrated interventions. Advances in Nutrition. 2016 Mar;7(2):357-63.

- Beets MW, Brazendale K, Weaver RG. The need for synergy between biological and behavioral approaches to address accelerated weight gain during the summer in children. International Journal of Behavioral Nutrition and Physical Activity. 2019 Dec;16(1):39.

Related to example 2 (tipping points and the collapse of fish stocks):

- Serrao-Neumann S, Davidson JL, Baldwin CL, Dedekorkut-Howes A, Ellison JC, Holbrook NJ, Howes M, Jacobson C, Morgan EA. Marine governance to avoid tipping points: Can we adapt the adaptability envelope?. Marine Policy. 2016 Mar 1;65:56-67.
    - *Discusses tipping points in the context of ecological systems.*

- Mullon C, Fréon P, Cury P. The dynamics of collapse in world fisheries. Fish and fisheries. 2005 Jun;6(2):111-20.
    - *Provides more information specifically on marine systems and the collapse of fisheries as an example of tipping points.*

Image Sources: Left: Sinusoid by Yohann Berger from the Noun Project. Middle: DGLimages via Getty Images. Right: Irenadragan via Getty Images.

Slide 109: Characteristics of complex systems – convergence

Complex systems can also involve convergence, which is a phenomenon where many different routes can lead to the same outcome.

One example of convergence is that there are many factors that can lead to a change in body weight. If a person gains or loses weight, it can be difficult to isolate a single driving factor. Contributing factors may include changes in dietary intake, changes in physical activity, or changes in health status such as a reduction in nutrient absorption or an acute infectious disease that limits appetite. You have likely thought through many of these factors when writing nutrition diagnosis statements for patients and clients.

Another example of convergence is that there are many factors that can lead to changes in population-level diet quality. The **nutrition transition** refers to the idea that the diets of people in low- and middle-income countries tend to shift towards a more "Westernized dietary pattern" as countries undergo economic development. There is no single factor that creates the nutrition transition. Contributing factors may include increased household income, modernization of supply chains and supermarket retail, the expansion of global food manufacturers, and increased marketing and advertising for certain foods.

People are often searching for a single reason for why a person has gained or lost weight, or why a whole population has experienced a shift in its dietary patterns, and the property of convergence tells us that there may not be a single driving force.

Additional resources:

Related to example 1 (multiple factors that can lead to changes in weight):

- Hall KD, Hammond RA, Rahmandad H. Dynamic interplay among homeostatic, hedonic, and cognitive feedback circuits regulating body weight. American journal of public health. 2014 Jul;104(7):1169-75.
    - *This article provides an overview of some of the biological complexity of changes body weight.*

- Lee BY, Bartsch SM, Mui Y, Haidari LA, Spiker ML, Gittelsohn J. A systems approach to obesity. Nutrition Reviews. 2017 Jan 3;75(suppl_1):94-106.
    - *This article describes some of the environmental and social drivers of changes in body weight.*

Related to example 2 (multiple factors that can lead to changes in population-level diet quality):

- Drewnowski A, Popkin BM. The nutrition transition: New trends in the global diet. Nutrition reviews. 1997 Feb 1;55(2):31-43.
    - *The concept of the nutrition transition was first written about in this landmark paper by Adam Drewnowski and Barry Popkin.*

- Popkin BM. Relationship between shifts in food system dynamics and acceleration of the global nutrition transition. Nutrition reviews. 2017 Feb 1;75(2):73-82.
    - *This is a more recent article on the nutrition transition where Barry Popkin explicitly discusses the relationship between food systems and the nutrition transition.*

- Regmi A, Takeshima H, Unnevehr L. Convergence in global food demand and delivery. United States Department of Agriculture, Economic Research Service, Report Number 56. 2008.
    - *This is a data-driven report from the USDA on how dietary patterns are shifting in middle- and high-income countries.*

Image Sources: Left: Converge by Hare Krishna from the Noun Project. Middle: Rostislav_Sedlacek via Getty Images. Right: ClaudineVM via Getty Images

Slide 110: Characteristics of complex systems – divergence

The last characteristic of complex systems we'll discuss is divergence – one route can produce many different outcomes.

An example of divergence is that a single intervention can have many outcomes – they may be positive or negative, and they may be intended or unintended. Take, for example, the intervention of removing sugar-sweetened beverages (SSBs) from school vending machines. One possible outcome of this intervention is that school children consume fewer SSBs at school. But there has been evidence that in some settings, after SSBs are removed from school vending machines, children consume additional SSBs servings per week outside of school settings, and they consume fast food more frequently.

Another example of divergence is that keeping domestic food animals can have both positive and negative consequences. In low- and middle-income country settings where subsistence agriculture is very common, some interventions have provided livestock or poultry to agricultural families in an effort to promote livelihoods and health. Possible positive outcomes include income generation from selling eggs, milk, or meat; improved dietary diversity from consuming animal source foods more frequently; and improved nutritional status as a consequence of both income generation and improved dietary quality. However, children's exposure to *Campylobacter* bacteria from poultry can also increase risk of **environmental enteric dysfunction** and impaired growth. Whether keeping domestic food animals has a net positive or negative impact on nutrition and health status depends on a number of factors such as whether animals are kept inside or outside of the home, how much time young children spend in close contact with animals, and whether the household has access to clean water and soap for hand washing.

What's important about the concept of divergence is it reminds us to always consider that our work may have both intended and unintended consequences. Ideally, a systems thinking approach gives us tools to anticipate and mitigate some of the negative unintended consequence9.

Additional resources:

Related to example 1 (unintended consequences related to SSBs in school vending machines):

- Taber DR, Chriqui JF, Vuillaume R, Chaloupka FJ. How state taxes and policies targeting soda consumption modify the association between school vending machines and student dietary behaviors: A cross-sectional analysis. PLoS One. 2014;9(8).
    - *Evidence form a cross-sectional study about the possibility that removing SSBs from school vending machines can have unintended consequences.*

Related to example 2: Environmental enteric dysfunction is a condition of subclinical infection hypothesized to be associated with chronic exposure to poor sanitary environments. Poor sanitary conditions may be associated with childhood stunting because frequent exposure to diarrheal disease may contribute to chronic inflammation and decreased nutrient absorption, which may impair growth.

- George CM, Oldja L, Biswas SK, Perin J, Lee GO, Ahmed S, Haque R, Sack RB, Parvin T, Azmi IJ, Bhuyian SI. Fecal markers of environmental enteropathy are associated with animal exposure and caregiver hygiene in Bangladesh. The American Journal of Tropical Medicine and Hygiene. 2015 Aug 5;93(2):269-75.
    - *Evidence form a cross-sectional study that having food animals in the household is associated with environmental enteropathy in children in Bangladesh.*

Image Sources: Left: diverge by Hare Krishna from the Noun Project. Middle: Althorn via Getty Images. Right: Kailash Kumar via Getty Images.

Slide 111: Why learn about complex systems?

In this module we've covered a few characteristics of complex systems, but not an exhaustive list. The handout contains more resources on the characteristics of complex systems in the context of food and nutrition.

You might be wondering, now that we know some of the characteristics of complex systems, what do we do with this information?

Having the language of complex systems helps to see that improving the nutritional status of individuals and communities may not be as straightforward as we imagined. For example, time delays and nonlinear relationships make it challenging to assess causal relationships. Convergence and divergence make it challenging to isolate causal factors, or guarantee that an intervention will produce uniform results without unintended consequences.

Additionally, this knowledge of complex systems helps us to see that nutrition and dietetics professionals are one of many stakeholders that need to act in order to improve nutrition and health outcomes. The root causes of nutrition issues are multi-faceted; they are not based solely on biology or behavior, but also involve things like urban planning, neighborhood safety, and the realities of natural processes such as weather and marine ecosystems. And few nutrition issues can be improved with a single solution; complex nutrition issues such as stunting or diet-related chronic disease require multi-pronged approaches.

Additional resources:

- National Research Council. A framework for assessing effects of the food system. National Academies Press; 2015 Jun 17. P. 289.
    - *This report provides another perspective on the food system as a complex adaptive system.*

Slide 112: How can we help address complex systems issues?

As RDNs and NDTRs, this doesn't mean that we as individuals need to be wholly responsible for planning and executing these multi-pronged approaches to complex nutrition issues.

The graphic shown here is the Obesity Systems Map, which was developed by the United Kingdom's "Foresight" group to illustrate the complex causal web that underlies obesity (1). People often show this systems map to illustrate the complexity of issues like obesity, but this diagram can provoke a sense of futility or helplessness – if things are so complex, how can we be expected to intervene?

By developing a sense of how things fit together at a systems level, as individual practitioners we are better equipped to identify collaborators in other parts of the system. For example, in a clinical setting we know when it's time to refer a patient to a physical therapist or a social worker, and it's well established that no single professional can meet all of a patient's needs. In the same way that we depend on our inter-professional colleagues in clinical settings, when we're addressing larger food systems issues like urban food access or childhood stunting, we also need to recognize that we're part or a broader interprofessional team where our collaborators might include agronomists, economists, and specialists in behavior change.

Taking a systems approach also allows us to identify the most effective ways to leverage our unique skillsets. As RDNs and NDTRs we each specialize in a range of skills that may include medical nutrition therapy, behavior change, foodservice operations, business management, education, research, grant writing, policy advocacy, and more.

A systems approach also helps us to establish role clarity between different sectors, disciplines, and professions. Think about a race car pit crew (2). A pit crew is so efficient because the team has established role clarity: the person in charge of re-fueling is not trying to change the tire, and vice versa. Each person is very focused on carrying out their role efficiently, and they are constantly scanning the horizon so that they know when to step out of the way. As nutrition and dietetics professionals we have access to a range of roles throughout the food system and at all levels of leadership. Regardless of our role, it's always important to develop clarity around our role as individuals and the roles of the organizations we lead in collaborative efforts in the food system.

Sources cited:

1. Finegood DT, Merth TD, Rutter H. Implications of the foresight obesity system map for solutions to childhood obesity. Obesity. 2010 Feb;18(S1):S13-6.
    - *This peer-reviewed article provides more context on the development and applications of the Foresight Obesity Systems Map.*

2. The analogy of a pit crew as a good example of role clarity comes from a session by Dr. Teddie Potter at the Planetary Health Alliance meeting, September 4-6, 2020.

Image sources: The graphic on this slide is the Foresight Obesity Systems Map. A high-resolution version of the map can be viewed at this link, and the main page for the Foresight Obesity project is here.

Slide 113: Systems thinking

Throughout this module we've alluded to the idea of systems thinking, but what exactly do we mean by systems thinking?

Systems thinking is a perspective of seeing and understanding a system as a whole, rather than as a collection of parts (1).

It may seem abstract, but there are many ways you can practice systems thinking in your day-to-day work. When working to address nutrition issues with your patient populations, you can think through root causes of the issues you're seeing, as well as downstream effects of your nutrition interventions. Within your scope of work you may not be able to address all of the root causes and downstream effects, but you can be in communication with other stakeholders in the system who can. These stakeholders might include people like local or state policymakers, farmers and other food producers, food retailers and other business owners, educators, and researchers.

When collaborating with stakeholders from other parts of the food system, take time to learn each other's professional languages – you may be using different terminology to describe the same phenomenon. For example, whereas one person may use the term "pediatric malnutrition," others may refer to "stunting" or "inadequate linear growth."

Also take the time to listen and learn the priorities of other stakeholders and find common ground. For some stakeholders, nutrition may not be their top priority, but there may be ways that improved nutrition can support their own priorities.

You can also share your expertise with people working in other parts of the system. In some settings, you may find that you are the only person with nutrition and dietetics expertise. For example, if you are serving on a city's food policy council, you may be the only RDN and are in a unique position to share your expertise with others.

Sources cited:

1. Peters DH. The application of systems thinking in health: Why use systems thinking? Health Research Policy and Systems. 2014 Dec;12(1):51.

Additional resources:

- *The definition of "systems thinking" offered here is just one of many. For a detailed comparison of different definitions, see:* Arnold R, Wade J. A Definition of Systems Thinking: A Systems Approach. Procedia Computer Science. 2015 Dec 31;44:669–78.

- *A helpful exercise for identifying root causes is the "**5 Whys**," where you identify a problem and continue to ask "why?" five times to help you identify root causes. For example: a 24-hour diet recall with a patient might show poor diet quality. Why do they have poor diet quality? Perhaps they are consuming mostly*

pre-prepared convenience foods. Why are they consuming mostly pre-prepared convenience foods? Perhaps they do not have time to shop for and prepare foods at home. Why do they not have time to shop for and prepare foods? Perhaps they are working multiple jobs. Why are they working multiple jobs? Perhaps the jobs available given their location and educational achievement are primarily minimum-wage jobs. You can continue to ask "why" to reveal more layers of root causes.

Slide 114: More systems thinking tools: co-benefits and trade-offs

Before wrapping up this module, we'll add another set of tools to your systems thinking toolbox, co-benefits and trade-offs.

Co-benefits are benefits or synergies that occur alongside each other (1). For example, you might recommend that someone walk or bicycle to work for cardiovascular health, but this also has the co-benefit that transitioning away from fossil-fuel intensive commutes can also contribute to climate change mitigation. The terminology "co-benefits" emerged from the climate change community, but it can be applied to other areas as well.

Trade-offs refers to the idea that when two outcomes are at odds with each other, achieving one goal makes it difficult to achieve the other (2). For example, in low- and middle-income country settings, building new roads in rural areas may drive economic development for farmers who now have more access to markets, but it also may involve environmental trade-offs (such as previously forested land being used for roads).

The handout provides examples of papers that discuss co-benefits related to agriculture and conservation, the sustainable development goals, and developing value chains in LMICs. In the next slide, we'll talk about examples of co-benefits and trade-offs related to food loss and waste.

Sources cited:

1. Intergovernmental Panel on Climate Change. Climate change 2007 synthesis report. 2007.
    - *The concept of "co-benefits" originated in the climate change community, where the 4th Assessment Report of the Intergovernmental Panel on Climate Change defined co-benefits as other positive benefits that would be produced as a result of reducing greenhouse gas emissions. The term can also be used in other contexts, and some may also view it interchangeably with the term "synergy."*

2. Matthewson J, Weisberg M. The structure of tradeoffs in model building. Synthese. 2009 Sep 1;170(1):169-90.

Additional resources:

Examples of papers that discuss co-benefits and trade-offs related to the food system:

- Singh GG, Cisneros-Montemayor AM, Swartz W, Cheung W, Guy JA, Kenny TA, McOwen CJ, Asch R, Geffert JL, Wabnitz CC, Sumaila R. A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals. Marine Policy. 2018 Jul 1;93:223-31.
    - *Discusses co-benefits and trade-offs related to the SDGs.*

- Verspecht A, Vandermeulen V, Ter Avest E, Van Huylenbroeck G. Review of trade-offs and co-benefits from greenhouse gas mitigation measures in agricultural production. Journal of Integrative Environmental Sciences. 2012 Nov 1;9(sup1):147-57.
    - *Discusses co-benefits and trade-offs related to climate change and agricultural production.*

- McCornick PG, Awulachew SB, Abebe M. Water–food–energy–environment synergies and tradeoffs: major issues and case studies. Water Policy. 2008 Mar;10(S1):23-36.
    - *Discusses co-benefits and trade-offs related to the water-food-energy-environment nexus.*

Slide 115: Examples of co-benefits and trade-offs: food waste

Reducing food loss and waste is an area where there are many co-benefits and trade-offs within food systems.

One example of a co-benefit between waste reduction and nutrition is that smaller portion sizes for packaged foods can reduce waste from uneaten food, and smaller portion sizes may also assist with patient's goals for weight management.

An example of a co-benefit between waste reduction, food safety, and economics is that when consumers have more knowledge about food safety, they may be less likely to unnecessarily discard foods that are still safe to consume. Fewer unnecessary discards can help to save money, and food safety knowledge can reduce risk of foodborne illness.

A trade-off between waste reduction and the environment is that refrigerating and freezing perishable foods reduces spoilage, but it also requires energy use. In some settings, older refrigeration systems may leak refrigerants that are greenhouse gases (such as hydrofluorocarbons, HFCs)

Another trade-off related to waste reduction is that food donations can reduce waste, but an inability for food banks and pantries to control the nature of food donations may mean that recipients may receive food in undesired amounts or types, or at undesired times.

Additional resources:

- Neff RA, Kanter R, Vandevijvere S. Reducing food loss and waste while improving the public's health. Health Affairs. 2015 Nov 1;34(11):1821-9.
    - *Most of the co-benefits and trade-offs shown in this slide were adapted from the following article, which provides a more comprehensive analysis on the topic.*

- Nordhagen S, Beal T, and Haddad L. The role of animal-source foods in healthy, sustainable, and equitable food systems. Global Alliance for Improved Nutrition (GAIN). Discussion Paper Series #5. Geneva, Switzerland, 2020.
    - *See this discussion paper for an example of co-benefits and trade-offs related to the production and consumption of animal source foods. Figure 6, on page 26, provides a concise visual synthesis of the many trade-offs related to health outcomes, environmental outcomes, and livelihoods associated with dairy, eggs, seafood, and meat.*

Image source: Left: Idea by Olena Panasovska from the Noun Project. Right: Scale by MC, SE from the Noun Project.

Slide 116: Why think about co-benefits and trade-offs?

The challenges we see on the previous slide don't mean that we shouldn't try to reduce waste, but that a systems approach can help us to explore co-benefits and mitigate trade-offs.

The food system is full of co-benefits and trade-offs. That knowledge shouldn't make us feel paralyzed by inaction, but it should motivate us to strengthen our skills as systems thinkers.

We should be prepared for the reality that promoting human nutrition and health may not always be a win-win with other outcomes, and it may not align with the priorities of other stakeholders. For example, looking at the principles of sustainable food systems, there may be situations where a strategy that promotes nutrition has environmental or economic trade-offs. But, a systems approach can help us to discover co-benefits we may not have explored.

Additional resources:

- Steinmetz J and Cummings J. Exploring Malnutrition Through the Lens of Systems Thinking. Webinar with the Academy of Nutrition and Dietetics Foundation, Future of Food Initiative. 2019.
    - *In this webinar, Jasia Steinmetz, PhD, MS, RD, and Joanna Cummings, MS, RDN, CNSC, provide two case studies of malnutrition – one in an agricultural community in Laos, and one in an urban area in the United States – and teach listeners to conduct an impact analysis to think about how nutrition interventions can have larger consequences throughout the food system. The downloadable materials include an educational guide to facilitate the use of this webinar within a dietetic internship or other educational settings. You can use this exercise with students as a way of also exploring co-benefits and trade-offs related to different nutrition interventions.*

Image source: Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Slide 117: Transition

[Transition to the next module]

Module 7: Strategies for RDNs and NDTRs to Create Food Systems Change

Slide 118-119: Transition

[Transition to the module]

Slide 120: Module 7 introduction

In this module, we'll talk about specific strategies for nutrition professionals to create positive change in the food system.

Image source:
Image source: Influencer by Alequinho from the Noun Project

Slide 121: Module 7 learning outcomes

By the end of this module, you will be able to:

1. Identify five entry points through which RDNs and NDTRs can leverage their knowledge and skills to cultivate sustainable food systems
2. Identify cross-cutting skills that are common to nutrition and dietetics practice that can help RDNs and NDTRs to promote sustainable food systems
3. Locate reliable resources related to sustainable food and water systems for RDNs and NDTRs

Slide 122: How can RDNs and NDTRs leverage their skills?

In this module, we draw from a framework for action that was published in the Academy's Journal (1) in 2020 that emerged from a roundtable meeting and input from stakeholders within and beyond the profession. The framework for action addresses the question, how can RDNs and NDTRs leverage their skills in nutrition and dietetics to cultivate sustainable food systems?

Sources cited:

- Spiker ML, Knoblock-Hahn A, Brown K, Giddens J, Hege AS, Sauer K, Enos DM, Steiber A. Cultivating sustainable, resilient, and healthy food and water systems: A nutrition-focused framework for action. Journal of the Academy of Nutrition and Dietetics. 2020 Jun 1;120(6):1057-67.

Slide 123: Framework for action

The framework for action has two major take-home messages.

The first message is that building the capacity of our profession to advance sustainable food systems requires coordinated efforts between the cross-cutting areas of education and training, research, practice, and policy. In the slide, you can see this in the connections between the four major areas, which are described in more detail in bullet points on the left and right sides.

For example, public policy advocacy can result in legislative appropriations that fund more research related to food systems. Or, practitioners who have real-world experience in the food system can share their expertise with students through education and training.

It's worth noting that these cross-cutting areas can experience bottlenecks as well – sometimes practitioners are in need of clear, evidence-based messaging for the public, but the research to support that evidence base is still emerging. This framework is valuable because it helps us to build on synergies and make plans to address bottlenecks.

The second takeaway message from the framework is that there are many avenues through which nutrition professionals can leverage their expertise to cultivate sustainable food systems. The framework refers to five specific "entry points." In the slide, you can see these entry points in the center.

These entry points are in the way that RDNs and NDTRs can shape and deliver dietary guidance to support both nutrition and sustainability, in our work to improve food and nutrition security and water security, in the way we can seek alignment between food production and nutrition goals, in our efforts to optimize supply chains and food environments to support both nutrition and sustainability, and in our efforts to reduce waste of food, water, and other resources.

In the following slides we'll walk through each entry point, describing how each entry point is relevant to dietetics practice and how it has potential for impact in the food system. The following slides also provide a few examples of how each entry point can be operationalized through education, research, practice, and policy. Know that these are just illustrative examples intended to spark new thinking, and that for every example here there are so many more opportunities to do this work.

Additional resources:

*The following resources are related to **education and training:***

- *The Academy of Nutrition and Dietetics Foundation has released a Sustainable, Resilient, and Healthy Food and Water Systems curriculum for dietetics interns and students: Link to curriculum*
- *The following papers describe efforts to increase sustainable food systems knowledge among nutrition and dietetics students and practitioners in a variety of countries:*
    - Carino S, McCartan J, Barbour L. The emerging landscape for sustainable food system education: Mapping current higher education opportunities for Australia's future food and nutrition workforce. Journal of Hunger & Environmental Nutrition. 2019 Mar 14.
    - Carlsson L, Callaghan E, Broman G. Assessing Community Contributions to Sustainable Food Systems: Dietitians Leverage Practice, Process and Paradigms. Systemic Practice and Action Research. 2020 Oct 10:1-27.
    - McCormack J, Noble C, Ross L, Cruickshank D, Bialocerkowski A. How do foodservice dietitians and dietetic students learn about environmental sustainability? A scoping review protocol. BMJ open. 2019 Nov 1;9(11).
    - Wegener J. Equipping future generations of registered dietitian nutritionists and public health nutritionists: a commentary on education and training needs to promote sustainable food systems and practices in the 21st century. Journal of the Academy of Nutrition and Dietetics. 2018 Mar 1;118(3):393-8.
- *Iowa State University and the USDA Agricultural Marketing Service have collaborated to develop core competencies related to food systems for practitioners in a variety of fields:*
    - *A 2-page overview:* USDA Agricultural Marketing Service. Food System Core Competencies Program (summary). 2020.
    - *A comprehensive report:* Long C, Chase C. Food System Core Competency Project. 2020.
    - *Additional information and links:* Long C. Building on local and regional efforts: Project supported by agreement between USDA and ISU Extension and Outreach. 2020.
-

- *There are efforts underway to develop interprofessional competencies related to planetary health for health professionals, including physicians and nurses.*
    - *Description of 12 cross-cutting planetary health principles:* Stone SB, Myers SS, Golden CD. Cross-cutting principles for planetary health education. The Lancet Planetary Health. 2018 May 1;2(5):e192-3.
    - *Early description of efforts to incorporate planetary health principles into clinical education:* Walpole SC, Barna S, Richardson J, Rother HA. Sustainable healthcare education: Integrating planetary health into clinical education. The Lancet Planetary Health. 2019 Jan 1;3(1):e6-7.

*The following resources are related to **research:***

- Fleischhacker SE, Woteki CE, Coates PM, Hubbard VS, Flaherty GE, Glickman DR, Harkin TR, Kessler D, Li WW, Loscalzo J, Parekh A. Strengthening national nutrition research: Rationale and options for a new coordinated federal research effort and authority. The American journal of clinical nutrition. 2020 Sep 1;112(3):721-69.
    - *This paper summarizes how federal nutrition research can be harnessed to address diet-related disease, and it includes discussion of food systems research.*

- Fanzo J, Bellows AL, Spiker ML, Thorne-Lyman AL, Bloem MW. The importance of food systems and the environment for nutrition. The American journal of clinical nutrition. 2020 Nov 24.
    - *This paper summarizes the emerging field of food systems research and describes relevant research gaps in the field of nutrition.*

*The following resources are related to **policy:***

- Blankenship J, Brown RS. Food system sustainability: An Academy advocacy priority. Journal of the Academy of Nutrition and Dietetics. 2020 Jun 1;120(6):1054-6.
    - *An overview of how the Academy of Nutrition and Dietetics has pursued policy advocacy efforts related to the food system.*

Slide 124: Shape and deliver dietary guidance

The idea behind the entry point of shaping and delivering dietary guidance is that we know the food system shapes human diets, and we know that human diets influence the sustainability of the food system.

When we talk about “shaping” dietary guidance, this refers to the presence of nutrition and dietetics professionals in the research and policy efforts that lead to population-level dietary guidance. When we talk about “delivering” dietary guidance, this refers to the many ways we translate and share nutrition science to our patients, clients, and the public. Nutrition education, menu planning, and food procurement decisions are all moments where we deliver dietary guidance and we have the opportunity to support both nutrition and sustainability.

One example of what this entry points can look like is that we might expand our education and training to include the concept of sustainable diets. There is a growing body of research on this topic, and the evidence is far from conclusive because it involves multiple scientific disciplines and new research questions. In light of this, one of the most important skills we can build is critically interpreting research in this area, which may involve methods such as life cycle assessment, which comes from the field of environmental science. The contents of Module 5 just barely scratched the surface of introductory knowledge in this area, and there’s a lot of opportunity to expand our familiarity in this area.

Additional resources:

- Burlingame B, Dernini S. Sustainable Diets and Biodiversity. Proceedings of the International Scientific Symposium Biodiversity And Sustainable Diets United Against Hunger. Rome: Food and Agriculture Organization of the United Nations. 2010.)
    - *The UN Food and Agriculture Organization provides the following definition of a **sustainable diet:** "Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources."*

- Jones R, Vogliano C, Burlingame B. Chapter 16: Sustainable diets and food-based dietary guidelines. Sustainable diets: Linking nutrition and food systems. 2018 Dec 10:158.
    - *These authors documented 11 countries that incorporated sustainability into their food-based dietary guidelines as of 2019: Australia, Brazil, China, Estonia, France, Germany, the Netherlands, Qatar, Sierra Leone, Sweden, and the United Kingdom.*

- Special collection of articles in Current Developments in Nutrition: Diet, Nutrition and Sustainability: Promoting a Healthy Planet and Healthy People
    - *This special collection of four articles describes discussion from sessions at the American Society for Nutrition's annual meeting, Nutrition 2019, on the topic of "promoting a healthy planet and healthy people."*

- Reinhardt SL, Boehm R, Blackstone NT, El-Abbadi NH, McNally Brandow JS, Taylor SF, DeLonge MS. Systematic review of dietary patterns and sustainability in the United States. Advances in Nutrition. 2020 Mar 13.
    - *There is a growing body of literature that compares the environmental impact of whole dietary patterns. This is a rapidly evolving area, with new studies and reviews each year. This is an example of a more recent systematic review in this area.*

Slide 125: Improve food and nutrition security and water security

The next entry point is improving food and nutrition security and water security. We know that malnutrition does not happen in isolation; it is critically linked with hunger and food insecurity. These issues are also connected to water security; we need clean, safe water for drinking, sanitation, and agriculture. And whether we're talking about food or water, sustainability underpins many concerns related to the availability, access, utilization, and stability of food and water supplies.

One way you can practice this entry point is that you can lead, support, or advocate for services that meet the needs of under-resourced individuals, such as food pharmacies or mobile markets. Recognizing that the roots of food insecurity and water insecurity are in structural factors related to income, built environments, and systemic racism, you can also bring nutrition expertise to food policy councils and other coalitions that can advocate for policy changes that affect structural factors.

Additional resources:

- United Nations Committee on World Food Security. Thirty-ninth session of the UN Committee on World Food Security: Coming to terms with terminology. 2012.
    - *The UN Committee on World Food Security states, "**food and nutrition security** exists when all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services, and care, allowing for a healthy and active life."*

- UN-Water. Water security & the global water agenda: A UN-Water analytical brief. Ontario, Canada: United Nations University; 2013.
    - *UN-Water defines **water security** as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability."*
- Berry EM, Dernini S, Burlingame B, Meybeck A, Conforti P. Food security and sustainability: Can one exist without the other? *Public Health Nutrition.* 2015;18(13):2293-2302.
    - *Background reading on how **sustainability and food security** are interconnected.*

Slide 126: Align food production and nutrition

The entry point of aligning food production and nutrition starts with the broader recognition that food production is essential for human nutrition and health. Crop, livestock, and marine food production practices determine the quantity, quality, diversity, and safety of foods available for human consumption. The goal is that our food production practices not only provide a nutritious food supply that supports human health, but that they also protect and renew environmental, economic, and societal resources.

There are a variety of ways to operationalize this entry point. Some nutrition professionals are food producers, and some work closely with communities of food producers through commodity and trade organizations. Food production can take place on a large or a small scale, and there is also much to be gained from being involved with urban farms, community gardens, and teaching gardens in hospitals or schools. There are many compelling research questions within this area that benefit from nutrition expertise, such as assessing how climate change might impact the nutrient content of crops and the subsequent nutritional status of people. Or, researching how policy incentives for certain agricultural practices or pricing affect the nutritional composition of our food supply.

Additional resources:

- Finley JW, Dimick D, Marshall E, Nelson GC, Mein JR, Gustafson DI. Nutritional sustainability: Aligning priorities in nutrition and public health with agricultural production. Advances in Nutrition. 2017 Sep;8(5):780-8.
    - *A peer-reviewed article that summarizes linkages between agricultural production and dietary consumption in the United Sates, with a focus on the importance of systems approaches.*

Slide 127: Optimize food supply chains and food environments

The entry point of optimizing food supply chains and food environments recognizes that RDNs and NDTRs work in many settings where foods are processed, packaged, distributed, and made available to individuals. Whether working with food manufacturing companies or brands, or with restaurants, supermarkets, or foodservice settings in schools, hospitals, or workplaces, these are all points of intervention for promoting nutrition while investing in capacity for sustainable food production and supply chain practices.

For example, a dietitian who works as a director for food and nutrition services might be a natural choice for overseeing new sustainability initiatives within an organization. That dietitian might work to ensure that equipment purchases, food procurement decisions, and the cafeteria set-up and signage all facilitate both sustainability and health.

Additional resources:

- Carino S, Porter J, Malekpour S, Collins J. Environmental Sustainability of Hospital Foodservices across the Food Supply Chain: A Systematic Review. Journal of the Academy of Nutrition and Dietetics. 2020 Feb 21.
    - *A systematic review that describes research on how hospital food supply chains can prioritize and evaluate sustainability, including discussion of opportunities for credentialed nutrition and dietetics practitioners to contribute.*

- Carlsson L, Williams PL. New approaches to the health promoting school: Participation in sustainable food systems. Journal of Hunger & Environmental Nutrition. 2008 Dec 11;3(4):400-17.
    - *A review of strategies that public schools can use to procure food from sustainable food systems, including school food gardens, farm to school programs, and food procurement policies. Includes discussion of the potential role of credentialed nutrition and dietetics practitioners.*

Slide 128: Reduce waste (of food, water, and other resources)

The final entry point is that nutrition professionals can reduce waste of food, water, and other resources. Approximately one third of all food that is produced ultimately goes to waste without being consumed by humans. RDNs and NDTRs are well positioned to reduce waste throughout the food system, whether working with food producers, with food supply chains, at retail and other food environments, within foodservice settings, or with consumers who can reduce their own waste at the household level.

Food waste is a complex issue at the intersection of food safety, dietary intake, and the behavior of individuals and organizations. Dietitians are uniquely positioned to champion this critical issue. For example, when working with patients and clients, we might incorporate food safety and waste reduction messaging into nutrition education. This messaging might include information about how to cook with more parts of the plant, interpreting date labels, and food safety information about when to remove affected portions of a product rather than discarding it completely, and including healthy canned and frozen options that are less perishable.

Additional resources:

- Food and Agriculture Organization. The state of food and agriculture: Moving forward on food loss and waste reduction. 2019.
    - *This report summarizes estimates of the amount of food loss and waste across various levels of the food supply chain across the globe, and describes connections between food loss/waste and food security, environmental sustainability, economic viability, and policy.*

- National Resources Defense Council (NRDC). Food waste: What's at stake. 2020.
    - *The NRDC curates a variety of educational materials related to food waste reduction.*

- Rethink Food Waste Through Economics and Data (ReFED). 27 Solutions to Food Waste. 2020.
    - *The ReFED think tank contains a growing library of materials. Their homepage includes an interactive visualization of how the top 27 food waste reduction strategies compare to each other in terms of waste diverted, meals recovered, financial benefit, emissions reduced, waster saved, and jobs created. Their growing list of resources include a database of food waste reduction entrepreneurs, a database of federal and state level policies, and reports including their Roadmap to Reduce UW Food Waste by 20 Percent.*

- United States Environmental Protection Agency. Wasted food programs and resources across the United States. 2020.
    - *This growing list of resources is listed by region, so that you can find policies and programs near you.*

- Vogliano C, Henneman A. Tossed Treasures: America's Wasted Food Problem, and How Dietetics Professionals Can Help. Academy of Nutrition and Dietetics Foundation. 2016.
    - *This presentation was developed by dietitians as part of the Academy of Nutrition and Dietetics Foundation's Future of Food initiative. Resources include a presentation and handout with a quiz and fact sheet.*

Slide 129: How can just one person create systems change?

In thinking about these entry points to the food system, I hope it is clear that promoting sustainable food systems is something that requires collective action from many stakeholders, and that as individuals and as a profession dietitians hold a lot of power to catalyze positive change.

Thinking about these cross-cutting areas, whether you work in education, research, practice, or policy, there is so much you can do as an individual that contributes to broader food systems change and also spurs the growth of our profession in this area.

Slide 130: Individual plus Policy, Systems, and Environmental Change (I+PSE) Conceptual Framework for Action

One tool that can assist RDNs and NDTRs is the I+PSE Conceptual Framework for Action. As mentioned previously, the five entry points within sustainable food and water systems point to complex multidimensional issues. As such, there needs to be multidimensional approaches to support broader and more impactful change.

The Individual plus Policy, Systems, and Environment (that is where we get I+PSE) Conceptual Framework for Action is a roadmap for dietetic practitioners to develop and implement multidimensional strategies using a systems orientation to achieve greater responsiveness to adaptive challenges and realize greater impacts. The seven action components provide the backbone for planning and implementing a continuum of strategies. When strategies are implemented across the seven components, it produces a more sustained and collective impact.

The I+PSE Conceptual Framework for Action is highly adaptable and can be tailored to any nutrition or public health challenge as well as to any area of dietetic practice, including education and training, research, practice, and policy. This framework better positions dietetic practitioners to address these adaptive challenges and to lead the transformation needed to restore and build systems that better support nutrition and health.

As a component of this module, there is a handout with cross-cutting examples that highlights two of the five entry points – food, nutrition and water security; and reduce waste. Example strategies are provided for each of the seven components of the I+PSE Conceptual Framework for Action.

Additional resources:

- ***See Supplement 2 available for download as part of this primer*:** Individual plus Policy, Systems, and Environmental Change (I+PSE) Conceptual Framework for Action – Cross-cutting Examples to Support Sustainable, Resilient, and Healthy Food and Water Systems

- *Forthcoming publication:* Tagtow A, Herman D, Cunningham-Sabo L. Next generation solutions to address adaptive challenges in dietetic practice: The I+PSE Conceptual Framework for Action. *J Acad Nutr Diet.* (forthcoming)

- Tagtow, A. Gaining ground: Applying individual, policy, system & environmental change to sustainable food systems initiatives. Webinar with the Academy of Nutrition and Dietetics Foundation, Future of Food Initiative. 2019.
    - *In this webinar, Angie Tagtow, MS, RD, introduces the concept of the I+PSE approach and provides instructions and a worksheet for helping listeners apply individual, policy, system, and environmental approaches to sustainable food systems initiatives. The downloadable materials include an educational guide to facilitate the use of this webinar within a dietetic internship or other educational settings.*

Slide 131: Cross-cutting skills that support sustainable food systems

As we think about the multitude of ways that nutrition professionals can support sustainable food systems, there are cross-cutting skills that are valuable within the context of sustainable food systems but also highly transferable to other practice settings including clinical nutrition.

One set of skills is related to evidence-based practice. All RDNs and NDTRs have an obligation to stay current with an evolving evidence base in order to uphold standards of evidence-based practice. In the context of food systems, it's importance to note that the evidence may come from a variety of other disciplines outside of nutrition science, and so depending on your specific interests within the food system you may need to deepen your knowledge within complementary fields such as economics, environmental science, and racial equity.

The profession of nutrition and dietetics has the unique of challenge of needing to not only understand and translate population-level dietary guidance, but to also adapt that guidance so it is appropriate for the specific subpopulations and individuals we work with. For example, there are dietary patterns that might have a lower environmental footprint, but might be nutritionally or culturally inappropriate for a population with specific nutritional needs such as a geriatric population in a long-term care facility. It's the unique role of our profession to determine what is appropriate for the unique goals, context, and resources of people we serve.

Sustainability is a topic that involves complexity, uncertainty, and emotion, and this calls us to deepen our ability to communicate clear, evidence-based messaging with the public. This is not unique to sustainability; even topics that are firmly within the bounds of nutrition science, such as the effect of saturated fats on cardiovascular health, are hotly debated. Developing our ability to help people "find the signal through the noise" is a boon to any topical area within the profession, and that applies to sustainability as well.

Slide 132: Cross-cutting skills that support sustainable food systems

It's also important to develop cross-cutting skills related to interprofessional collaboration.

A strength of the profession is that we are accustomed to collaborating as part of interprofessional teams – we would never approach a patient on our own and expect that we could meet their needs without including others on the healthcare provider team. In the context of food systems, we may need to widen our network of collaborators to include not just healthcare providers, but also food producers, climate scientists, and policymakers. There are so many stakeholders in the food system, and it's important to always be asking – whose voice is missing from this team?

Another cross-cutting skill is getting nutrition on the agenda. This applies to the clinical world, where we often find ourselves advocating for a patient's nutritional needs on a team that may have a wider set of priorities. And this also applies when we're working on food systems issues with policymakers, business owners, food producers, nonprofit organizations, government agencies, or professionals from other fields – everyone may have their own priorities, and how do we make sure that nutrition is on the agenda? You may find yourself as the only nutrition professional in a group, and being able to advocate for nutrition is a skill that is valuable in any practice setting.

Related to this is the ability to be a champion of critical issues. There may be an issue, like food waste in your workplace, where you don't have the primary expertise needed to solve the problem. But you can champion the issue and identify collaborators who have the complementary skills you're missing. For an issue like food waste, you might liaise with collaborators including culinary professionals, facilities and operations staff, and city agencies or private providers of composting services.

Slide 133: Cross-cutting skills that support sustainable food systems

There are also a number of cross-cutting skills related to systems thinking that have broad applicability to food systems and nutrition at large.

Stretch yourself to always think about not just immediate causes of nutritional issues, but underlying causes as well. Sometimes it can be frustrating to dig deep and think about underlying causes, because they are things we

don't have control over within our own scope of work. For example, the reason a person's diet consists mostly of ultra processed foods might have less to do with their nutrition knowledge and desire to eat nutritious foods, and more to do with their ability to access and afford those foods. The underlying causes might include a lack of living wages, an unreliable public transportation system, and a public disinvestment from low-income neighborhoods that includes a history of racially-motivated redlining policies that have left certain areas without access to healthy food options. You would probably not write these underlying causes in a nutrition diagnosis statement, but when you're committed to work at the systems level you can initiate collaborative efforts with others who can help to address these underlying causes. For example, as the resident expert on nutrition on a food policy council, you might amplify the experiences of your patient populations to help advocate for the importance of policy changes.

An important part of developing skills in systems thinking is learning from people with different perspectives. Whether those are your collaborators, or populations you serve, take advantage of every opportunity you have to learn about other people's priorities, challenges, and the language they use to describe their experience. This learning might be experiential, or it might involve making sure that your reading list and podcast list are full of voices that differ from your own.

Slide 134: Building sustainable food systems requires collaboration

We've talked a lot about the need to identify and work with collaborators across and beyond the profession of nutrition and dietetics, and this figure from the framework for action provides a few ideas for what your collaborative network might look like.

Image source: Spiker ML, Knoblock-Hahn A, Brown K, Giddens J, Hege AS, Sauer K, Enos DM, Steiber A. Cultivating sustainable, resilient, and healthy food and water systems: A nutrition-focused framework for action. Journal of the Academy of Nutrition and Dietetics. 2020 Jun 1;120(6):1057-67.

Slide 135: I'm excited about food systems! Where do I begin?

As we wrap up this module, I want to emphasize that food systems is an area where there are many opportunities to both broaden and deepen your practice. It might be the case that your practice focuses in a different area and you want to equip yourself with a working knowledge of basic issues in food system, or it might be the case that you're looking to focus your dietetics practice on sustainable food systems. In any case, I want to share a few resources from the Academy to help you get started.

We've mentioned the Academy's standards of profession performance (SOPP) in the area of sustainable food systems, and this figure from the SOPP illustrates that in any area, you can transition from competence to proficiency to expertise, and the SOPP provides tools to help you chart a course for what that might look like in your own career (1).

Sources cited:

1. Spiker M, Reinhardt S, Bruening M. Academy of Nutrition and Dietetics: Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems. Journal of the Academy of Nutrition and Dietetics. 2020 Sep 1;120(9):1568-85.

Slide 136: Academy resources: publications and curricula

The SOPP is one important resource from the Academy, as is the framework for action that we've described in this module.

The Academy's Foundation has also created two separate curricula for dietetics education programs: one on sustainable, resilient, and healthy food and water systems, and one on food insecurity and food banking. Both curricula include a variety of stand-alone activities that can be implemented on their own or as part of a rotation or concentration.

Additional resources:

- Link to Revised 2020 Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient, and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems.
- Link to framework for action
- Link to Sustainable, Resilient, and Healthy Food and Water Systems Curriculum
- Link to Food Insecurity / Food Banking Curriculum

Slide 137: Academy resources: websites and communities

New resources in this area are being created all the time, and there are a few places to check for new resources: one is the Academy's Food Security and Sustainability landing page on eatrightPRO.org, which includes a list of Academy resources as well as links to relevant external organizations. Another is the Academy Foundation's Future of Food page, which includes links to the two curricula and a variety of webinars and toolkits. Another place to check is the home pages and regular communications from relevant DPGs and MIGs.

If you're not already connected, there are a number of groups within the Academy that are engaged with work related to sustainable food systems. Two that are particularly prominent are the Hunger and Environmental Nutrition DPG, as well as the Agriculture Subgroup within the Food and Culinary Professionals DPG. Sustainable food systems cuts across so many different practice roles, however, that a variety of DPGs and MIGs work on networking events and new content that it is relevant to this space, and we encourage you to collaborate across groups to create new resources that are truly collaborative, in the spirit of sustainable food systems work.

Additional resources:

- Link to Academy's Food Security and Sustainability page
- Link to Academy Foundation's Future of Food Page
- Link to Academy's list of DPGs
- Link to Academy's list of MIGs

Slide 138: Thought starter for modules 6 & 7

As we come to the end of this module and this self-study, I encourage you to take a few moments to reflect, before you move on to the rest of your day. You might jot these things down on a piece of paper, message them to a friend or colleague, or share them with through your DPG listserv.

What is one thing you learned in this self-study that surprised you?

What is one thing you want to know more about?

What is one action you can commit to in your current or future work to support sustainable, resilient, and healthy food and water systems?

Slide 139: Thank you!

Thank you so much for your time!

For questions related to the logistics or continuing education for this activity, please contact the Academy Foundation.

For questions related to the content of this primer, you can contact me at the email address shown here (mspiker@uw.edu).

We encourage you to share this primer with your networks, let us know how you've been using it, and be on the lookout for additional resources from the Academy and its Foundation.

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