Chapter 1: Introduction to Food Systems

"Vision without systems thinking ends up painting lovely pictures of the future with no deep understanding of the forces that must be mastered to move from here to there."
- Peter Senge, The Fifth Discipline

The food system is extremely complex. If food systems were linear, at one end of the human continuum would be farmers, or producers, and on the other end would be consumers. Or food waste managers could be on the far end, and if some of them were composters, they’d connect back to the farmers, creating a circular food system. But food systems aren’t linear nor are they circular. They are webs of people and the resources and behaviors they affect. Producers, consumers, processors, distributors, wholesalers and retailers interact with people working in education, social services, research and so forth. These people may be advocates, entrepreneurs, or employees of institutions and businesses; they function in the for-profit and non-profit sectors. Some deal directly with food and some deal with infrastructure; they offer technical assistance, manage natural resources, provide inputs such as fuels and fertilizers, or develop and implement policies and regulations. Together they create the food system, which can be broken down into myriad smaller systems.

Food System Models

The food system has been defined as “an interconnected web of activities, resources and people that extends across all domains involved in providing human nourishment and sustaining health, including production, processing, packaging, distribution, marketing, consumption and
disposal of food. The organization of food systems reflects and responds to social, cultural, political, economic, health and environmental conditions and can be identified at multiple scales, from a household kitchen to a city, county, state or nation."

Individual perspectives determine how that web will be envisioned and described. A relatively simple depiction, for example, considers only the various types of markets for food (Figure 1.1). This reflects the economic measures that are often used to evaluate food systems: how much is produced, how much is sold, and to which markets.

Figure 1.1. Market levels of the food system. View of the food system with a focus on the different market channels for which food is produced.

Alternatively, the food system can be depicted as a much more complex and broad-reaching set of interactions, which go far beyond the production, processing and distribution of food to include the connection of food to the health of people and the environment (Figure 1.2).

Figure 1.2. Complex diagram of the food system. This view of the food system has a focus on food, people and the environment, as well as factors that influence their interactions in the system, which uses inputs and generates outputs.
When human and environmental interactions are included, the economic impact of a food system is much greater than the market value of the food sold. Holistic assessments of the food system may reveal many other kinds of positive economic impacts, such as improved nutrition and ecosystem services. They may also reveal negative impacts not accounted for by simple market prices, such as the effect on health care costs due to excessive consumption of low quality foods, or the cost of cleaning up water pollution resulting from agricultural runoff. The positive and negative impacts that are not captured by the market are known as externalities.  

There is widespread concern about negative externalities from the food system, in particular the impact of a poor diet on human health. Efforts are underway to understand how the food system can be changed to alleviate food-related illness. From the perspective of people for whom the effect of dietary behavior on human health is a priority, it’s important to describe the food system in a way that captures the ‘ingredients’ they can work with to improve the situation (Figure 1.3.)

Figure 1.3. Human health and the food system. This view of the food system has a focus on dietary behavior and human health. Note that food production and distribution are depicted as
a small part of this system, just one of many practices, whereas in Figure 1.2 they are shown as a primary part of the system.

In addition to concerns about human health, there are many initiatives underway to strengthen local and regional food systems. In these cases a primary consideration is often which facets of the system can be influenced by local or regional policies. Thus the descriptions of food systems in these plans usually focus on the governing unit’s ‘sphere of influence’ such as the activities of various industries and markets, rather than human behavior or environmental outcomes (Figure 1.4).

Figure 1.4. Food system components affected by policy. This view of the food system has a focus on industries and activities that can be influenced by local and regional government through policy.
Another way that food systems can be described is in terms of desired outcomes for a healthy community (Figure 1.5). This doesn’t provide detail about how the system actually functions, but it articulates a set of broad, inter-related results that can then be stated as measurable goals.

Figure 1.5. Food system community outcomes. This view of the food system emphasizes the goals a community may have that are related to food.
Systems within the Food System

Systems have hierarchies. That is, within the overall food system is an array of smaller systems. These include farming systems, agricultural ecosystems, economic systems, and social systems. Within those are further subsets of water systems, energy systems, financing systems, marketing systems, policy systems, culinary systems, and so on. If you are accustomed to organizing your files on a computer, it may be helpful to think of the larger systems as directories, which contain an overview of the more detailed files, which are the smaller systems.

For example, farming systems describe the manner in which natural, technological and human inputs are managed on farms that use a certain set of practices to produce desired outputs as well as environmental impacts and wastes (Figure 1.6).

Figure 1.6. A farming system. This diagram depicts how a farm functions, without reference to larger systems outside the farm that affect the supply of inputs, demand for outputs, and interactions with the environment.

Within the farming system (a system ‘file’ in the food production ‘directory’) there are ‘sub-files’ that address its components, such as the soil system, the pest system, the labor system, the waste system, and so forth. That’s the level where most people work, on relatively focused, incremental change in the food system. Working higher up in the system, for example on re-
designing an entire farming system, can lead to more transformational change which is much harder to achieve.

Environmental or ecological systems overlap with the food system, and they can be explored at different levels, from a single field, to a whole farm, to the local, regional, or global food system. The flows and cycles of carbon, energy, nutrients, pollutants, water and a host of other features can be described as individual systems. Most of these flows occur both inside and outside the food system. Figure 1.7 is an example of one of these cycles, the nitrogen cycle.

Figure 1.7. The nitrogen cycle. The flow of N takes place both on farms through activities such as fertilization, manure application and crop harvest as well as through biological processes such as mineralization (the release of plant-available forms of N from carbon-based compounds). The N cycle includes the off-farm environment through atmospheric and watershed-level phenomena.
Economic systems within our food system are powerful drivers of decisions and measures of success. We have many tools for assessing short term, market-based economic value, and very few for understanding other forms of wealth. For example, clean water has value but market mechanisms often fail to monetize that value, so it is a positive externality without a ‘price.’ Polluted water is a negative externality of some farming systems; it has economic impact but there is no market ‘cost’ associated with it. Regulations, fines and taxes may be used to account for negative externalities and hold those responsible for their costs. Some mechanisms have also been developed to reward farmers and others for positive externalities such as ecosystem services. For example, hayfields in the Northeastern U.S. provide nesting grounds for migratory songbirds like bobolinks and eastern meadowlarks. The Bobolink Project uses community contributions to pay farmers to manage their hayfields to provide habitat for grassland-nesting birds. Creating market mechanisms for externalities helps society capture the ‘true’ values of different farming and food system practices, by placing them in a traditional economic context. Figure 1.8 describes this economic system of exchange of money for products and services.

Figure 1.8. Diagram of the conventional economic system. This diagram depicts the flow of household labor and capital to firms (industries), in return for payment as wages and capital income. Households also receive goods and services from firms, in exchange for payment.
Social aspects of the food system include culinary, dietary and cultural factors. Figure 1.9 shows how a variety of factors interact to form a region’s food culture. There is often a disconnect between people working on these aspects of the system and those working on production and economic issues. This is slowly changing as scientists and policy makers start to recognize the advantages of systems thinking that is not limited to the perspective of a single subject matter discipline.

Figure 1.9. View of the factors that interact to create a region’s food culture. History, prevailing flavors, and culinary etiquette are important factors for this type of system.
Using Systems Thinking to Analyze the Food System

While a system is a set of things that are connected to work together, systems thinking is aimed at understanding the underlying structure of the connections, not just the individual parts. It’s an approach that focuses on interactions, cycles, flows and patterns rather than characteristics of separate pieces. This can reveal leverage points for change, and inform decisions that lead to desired outcomes instead of unintended consequences.

Systems thinking has been used for thousands of years, perhaps as the most common form of human thinking until the development of western rational thought. Many indigenous people involved an appreciation for systems in their cultural traditions and ways of life, especially around nature. Today, the need for systems thinking is clear if modern society is to learn how to protect the systems that comprise the natural world. However, specialized, reductionist thinking (which simplifies complex ideas to the point of distorting or obscuring them) is deeply entrenched in many organizations and professional disciplines. People don’t switch easily from reductionism to systems approaches.

It can be a challenge to apply systems thinking to something as complex as the food system. Any action in the system will inevitably generate a side effect or an unanticipated consequence that may or may not be acceptable. Thus the system as a whole can’t be tightly managed, even though that may be one’s intent. For example, changing a cropping system to no-till agriculture may reduce soil erosion and conserve carbon in the soil, which are good for the environment; but it may also require more herbicide use and alter soil chemistry so that more greenhouse gases are generated compared to tillage, which are bad for the environment.

Systems thinking is useful for understanding the larger context of a problem, or a proposed solution. It is an approach that recognizes the inherent difficulty in managing complex
sets of interactions. For people charged with managing some part of a system, the idea is to try and anticipate the consequences of an intervention, keep an eye out for surprises once it’s made, and then makes adjustments.

All systems have certain characteristics; these are present whether one is looking at a business system, a food production system or an ecosystem. System boundaries define what area one is analyzing or try to affect; this determines what parts of the overall system are left in, and which are left out. For example, one may be trying to improve a dairy farm’s economic system. The boundary could be at the cow level (genetics, feed management, etc.), the farm level (cost and returns from various inputs, management skills of the farmer, etc.) or the societal level (milk supply and demand, land use, labor, etc.)

The overall system of dairy farming comprises a hierarchy of systems with different boundaries. The cow is a living system, and it is part of the dairy herd which can be analyzed as a system. The herd is part of the farming system that includes crop, land and facilities management. The farm is imbedded in the local or regional dairy farming community, which is a system within the national dairy industry system.

Systems are not usually closed; they have inputs and outputs. Sticking with the dairy farm example and simplifying: feed, fuel, sunshine and water come in; manure, milk and nutrients go out. Money is both an input (income) and an output (expenses). Systems have feedback loops, too. For example, when the price of milk is high farmers may increase milk production, so they can make more money. They make more milk and more money for a while; then the additional supply of milk causes the price to drop and farmers react to that.

Emergent properties of a system are characteristics that appear at a certain level of complexity but do not exist in smaller parts of the system, lower in the hierarchy. The cow is
alive but its component parts such as the reproductive system or digestive system, by themselves are not. The farm generates revenue but that property emerges as a result of the cows, the crops, farm infrastructure and the market.

**Levels of the Food System**

Food systems function at the individual, household, local, regional, national, and global levels (Figure 1.10). The levels, or scales, in this hierarchy are often operational at the same time, and they interact. For example, consider coffee. More than half of American adults (individuals) choose to begin their day with a cup of coffee. Some coffee drinkers prefer free-trade organic coffee and they are willing and able to pay more for it. They might buy coffee at a local café which buys its beans from a regional distributor. That distributor may in turn buy from regional grower cooperatives in Latin America and Africa. For other coffee drinkers, their household budget might limit spending on coffee, so they buy inexpensive national brands of coffee at a supermarket owned by a global corporation. Those brands contain beans purchased as a commodity traded on the international market. Decisions made about a morning ‘cup of Joe’ have the potential to affect one’s individual condition, a household budget, the revenues of local, regional and national companies selling coffee, and the livelihoods of coffee producers and their communities on different continents. The same is true for most everything we eat and drink.

Figure 1.10. Levels of the food system. The food system has a hierarchy of levels, or scales, and each reflects and responds to social, cultural, political, economic, health and environmental conditions, whether in a household kitchen or through a nation’s food policies.
*Individual food systems.* This level of the food system is focused on personal decisions about food, which include how to acquire, prepare, serve, give away, eat, store and clean it. These decisions and resulting behaviors are influenced by many factors including life experience; cultural and social factors; and the need to balance different values such as affordability and quality. The decisions a person makes about food can differ depending on the situation, and they can change over time. For example, people often follow a different diet when they eat out compared to cooking at home, and few people eat the same way they did as a teenager once they reach middle-age.

There are many ways to categorize people’s eating habits and interactions with the food system. For example, in the United States, 5% of people consider themselves to be vegetarians, and 2% say they are vegans. About 3% of Americans buy kosher food. Although only 4% of all food and beverage sales are for organic products, 75% of U.S. consumers say they use organic products. In western North Carolina a survey found that more than half the respondents spent at least 10% of their food budget on local food. A statewide study in Florida found 53% percent of respondents purchased local foods at grocery stores, and 62% purchased local foods at
farmers’ markets, roadside stands or U-pick operations. About 15% of Americans are served by SNAP, the supplemental nutrition assistance program, formerly called food stamps. Individual decisions about food can be aggregated at the household level, helping us understand how families interact with food systems.

*Household food systems.* Most households are groups of people, often related, that live together and function as a unit. In terms of food, they may eat together, share a household food budget, and affect one another’s eating behaviors, especially through parental influence on children. The household food system can be described by a variety of measures. For example, about 15% of U.S. households are food insecure some time during the year, and nearly 6% percent have very low food security, meaning that their food intake is disrupted at times because they lack money or other resources for food. Twenty percent of households with children are food insecure.

As income rises, households spend more money on food but food expenses are a smaller portion of their total income than in poorer households. Households in the middle of the income scale spend an average of $5,620 per year on food, or 12% of their annual income, while the lowest income households spend $3,547 on food, or 36% of their income. Almost one-third of all U.S. households participate in food gardening and about 3% of all households raise chickens. These measures help us understand food systems at the household level, and they can be used to help paint a picture of food systems on a larger scale, at the local, regional and national level.

*Local food systems.* Although there is a lot of interest in local food, there are many different definitions of it. With no universally accepted definition of a local food system, local foods are often based on a geographical concept related to the distance between food producers
and consumers. In addition to geographic proximity of producer and consumer, local food may also be considered to include certain social and production characteristics, such as fair treatment of workers and sustainable production methods.

Local food systems are frequently associated with direct marketing from the farm to the consumer or to retailers and institutions in the same geographic location as the farm. Direct-to-consumer markets include farm stands, farmers’ markets, and community supported agriculture, while direct-to-retailer sales include convenience markets, supermarkets and restaurants. Institutions include colleges, hospitals, prisons, schools and senior centers.

A recent analysis of the Los Angeles County food system found that it produces $326 million dollars of fresh produce annually and is home to 1,734 commercial farms. It also contains 1,261 urban agricultural sites. Looking beyond a single county to the 10-county foodshed within 200 miles of downtown Los Angeles, the report found 23,000 farms that sell $16 billion of crops. This food system (it could be called local or regional, depending on one’s definition) employs 1.3 million people in farm work, food processing, distribution, food service and retail, accounting for one in every 7.5 jobs in the area.

Regional food systems are place-based, as are local food systems, but ‘place’ is conceived more broadly. There is no bright line, no distinct boundary between local and regional food systems. Local is often thought to mean a city, town or a few counties--but to some it is a state. Regional may also mean a cluster of counties, or a cluster of states. In general, regional food systems aggregate smaller local communities in order to accommodate larger scales of production and economic activity. In a regional food system, direct marketing is not paramount; rather, regional identity has value in the food marketplace to consumers and producers.
“An ideal regional food system describes a system in which as much food as possible to meet the population’s food needs is produced, processed, distributed, and purchased at multiple levels and scales within the region, resulting in maximum resilience, minimum importation, and significant economic and social return to all stakeholders in the region. This is known as ‘self-reliance’—as opposed to ‘self-sufficiency’ wherein everything eaten is supplied within the target area...local is a necessary but not sufficient component of a regional food system. Regional is larger geographically and in terms of functions—volume/supply, food needs, variety, supply chains, markets, land use, and policy. A regional food system includes multiple “locals” within a state, and those that cross state boundaries.”

Regional food systems can be delineated and measured in many ways, one of which is the nature of their agricultural production. The United States Department of Agriculture (USDA) has identified nine ‘resource regions’ of the country that share patterns of farming, financial performance of farms and economic well-being of farm households. These commonalities within a region, and differences among the regions, stem from the effects that climate, soil, water, and topography have on the types of crops and livestock that thrive in a region. For example, the Heartland region, with its deep soils and open spaces contains 27% of all U.S. cropland, 22% of all farms and accounts for 23% of the value of all farm production, mostly as grains and cattle. The Eastern Uplands region located in Appalachia features mountainous terrain that limits farm size and production. It contains the most small farms of any regions, 15% of the nation’s total. Many of these are part-time and produce cattle, tobacco, and poultry. The Fruitful Rim is a non-contiguous region that spans the milder climates of the coastal West and South. It accounts for 22% of U.S. farm production value, largely from high-value fruit, vegetable,
nursery and cotton farms. Together, regional food systems within the United States make up the national food system.

*National food systems.* The food system of a country is in easier to define than a local or regional food system because the geographic boundaries are clear. In addition, many features of the food system as a whole are set up on a national basis, such as most food policies and regulations. In the U.S., farm labor, food safety, pesticide use, and product labeling are all guided by federal regulations to which regional and local food systems must adhere. Cooperative Extension, the Department of Agriculture, the Department of Health and Human Services, the Department of Labor, the National Institute for Food and Agriculture, and many other national entities have enormous influence on lower levels of our food system. Market agreements for certain commodities like apples and milk affect supply and prices on the national level. A common platform for advertising, language, labeling, packaging, and transportation creates a relatively uniform playing field for food system actors across a huge geographic area.

Characteristics of national food systems can be described and compared by their agriculture, dietary intake and much more. For example about half the land in China, Mexico and the U.S. is in agriculture, while in Canada, Egypt and Sweden less than 10% of the land is arable. The U.S., Austria and Greece lead the world in caloric intake per capita at over 3,500 calories per person, while people in the Democratic Republic of the Congo, Eritrea and Burundi consume the fewest calories, fewer than 2,000 per day. All nations combined make up the global food system.

*The global food system.* Food at this level of the system can be measured by overall production, its movement around the planet, and food security of the world’s population. For example, total world production of corn is about 900 million metric tons (MMT) annually; wheat
production is about 700 MMT, rice and oilseed crops average about 500 MMT and soybean production is in the 250 MMT range.27 The total cost of imported food is about $1.1 trillion, $675 million of which is for developed countries and $415 of which is for developing nations. Globally, well over 800 million people, or 12% of the world’s population, do not have a diet that meets their metabolic energy requirements.28 The vast majority of hungry people live in developing regions. Some progress has been made to alleviate hunger over the last 20 years as food availability has risen faster than the average dietary energy requirements, and the quality of diets has improved.

Even in the days when all food systems were primarily local, hundreds of years ago, efforts were made to import spices and exotic foods that were not available nearby. The list of imported foods has of course greatly expanded to include many high-value imported products such as coffee beans, cocoa/chocolate, oils, seafood, fruits, and vegetables. U.S. imports of agricultural products exceed $100 billion annually.29 Meanwhile, U.S. exports of agricultural products have tripled during the past decade to nearly $140 billion. Grains, oilseeds and livestock products top the list of exports; China, Canada and Mexico are currently the largest buyers.

Clearly, just about everyone is a participant in the global food system and it has significant influence on the diets, economies, environmental quality, and policies of national food systems as well as on the smaller levels of the food system within each nation.

**Why Study Food Systems?**

The food system in the U.S. today provides unparalleled productivity. However, it has led to concerning levels of diet-related health problems, food-borne disease, hunger and agricultural pollution. A quick look at the numbers shows some of the problems with this system:

- 67 percent of U.S. adults are overweight and 34 percent are obese.30
• 17 million households have difficulty obtaining enough food at some time during the year;\textsuperscript{31}
• Food-borne illness affects an estimated 76 million people each year.\textsuperscript{32}

Meanwhile, the agricultural landscape in the U.S. is under threat, seriously challenging the sustainable production of food: 42 million acres of farmland have been lost since 1987 and just 2.6 percent of all farms now account for 59 percent of the nation’s gross agricultural sales.\textsuperscript{33}

This consolidation means that we’re highly reliant on fossil fuel for transportation and storage and vulnerable when that fuel supply is threatened or becomes prohibitively expensive.

Likewise, food safety risk is amplified by aggregating food. Just think of how many people can be made ill from the meat of one contaminated cow when it’s pooled with meat from thousands of other cows to produce ground beef. In addition, runoff from fertilizer- and pesticide-intensive agriculture is responsible for polluting 48\% of the nation’s river miles and 41\% of lake acres; 18\% of U.S. estuaries have impaired water quality.\textsuperscript{34}

The range of food system issues having significant economic, environmental and social consequences for society is staggering, with both positive and negative outcomes. New approaches are needed that use systems thinking to re-design major components of the food system in order to avoid undesirable side effects. Part of this thinking involves accounting for and placing value on externalities not captured by the current market value of food.

\textbf{Working to Improve the Food System}

The food system is an enormous, complicated entity. It can be thought of and analyzed from many perspectives. Co-mingling these perspectives to understand the interactions and connections among different components requires systems thinking. The food system also includes a wide range of scales, from individual people and their households, to local and regional communities, to nations and global trade. Activities at these scales overlap and affect one another, so it is simplistic to discuss them as if they functioned independently.


