SUMMARY  Meeting global goals for nutrition and sustainability will require joint solutions tailored to diverse situations. Value chain analysis provides a promising framework for understanding effective interventions to achieve better outcomes for both health and environment.

IMPROVING NUTRITION AND FOSTERING ENVIRONMENTAL SUSTAINABILITY are critical development challenges that the world has pledged to take on via the recently adopted Sustainable Development Goals (SDGs). Of the 17 SDGs, 11 address improved access to nutritious food and 13 require improved stewardship of the world’s natural resources. Overall, the SDGs, launched by the United Nations to guide the post-2015 development agenda, acknowledge that these two goals are intertwined; in fact, SDG 2 (zero hunger) specifically calls for achieving food security and improving nutrition while promoting sustainable agriculture.

Existing food systems combined with rising incomes and changing food demand are putting increasing stress on the world’s natural resources. 1 At the same time, a significant share of the world’s poor suffer micronutrient deficiencies even as the proportion of people who are overweight or obese is growing in almost every country. 2 This situation points to the need for new initiatives to increase consumption of nutritious foods among populations currently unable to afford a healthy diet, while reducing demand for unhealthy, low-nutrient foods and foods developed through unsustainable supply chains. There is no one-size-fits-all solution—initiatives must account for heterogeneity in economic, environmental, and social contexts that affect diets and sustainability.

VALUE CHAINS, NUTRITION, AND SUSTAINABILITY

Agricultural value chains encompass all actors and activities involved in food production, so understanding how they bring food from farm to table can help policymakers identify feasible solutions to the challenge of simultaneously

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improving nutrition and the environment. In addition to providing a framework for characterizing several dimensions of a food system—including agricultural production, the diversity of food supply, and food affordability—value chain analysis can also reveal points of entry for catalyzing improvements in both nutritional outcomes and environmental impacts. Figure 1 provides a simple illustration of the stages and actors in a milk value chain.

Although value chain analysis was developed to highlight the flow of economic value, it can also demonstrate the flow of nutritional value, how it is enhanced or diminished, and how sustainability is affected at each step along the value chain. Nutritional value refers to the micronutrient content of food that is consumed. Undernutrition, the primary focus in this chapter, is a lack of adequate micronutrients in the diet and is most critical for women of childbearing age and children under age five. Overweight and obesity, the result of a diet with too many calories, can occur in conjunction with a lack of adequate nutrients, especially among children. While 161 million children under five years old suffer stunting (that is, they are too short for their age) as a result of chronic undernutrition, an estimated 43 million children under five were overweight in 2011. In broad terms, improved nutrition is not just a result of increased nutrient content in individual foods but, more critically, of improvements in overall diet quality.

Sustainability requires that short-term actions not jeopardize the long-term productive capacity of a system. Therefore, a sustainable food value chain is one that is profitable over the longer term while not permanently depleting natural resources. Sustainable diets are diets that can adapt to a changing climate, fluctuations in the availability of land and water resources, and overall social and economic development—all of which are context specific. Because sustainability is a broad concept, the discussion here is primarily limited to the economic and environmental characteristics of food systems. The context and incentives shaping food value chains can play a central role in improving both sustainability and nutrition.

**USING VALUE CHAINS TO ACHIEVE MULTIPLE GOALS**

A complex range of factors can shape nutritional and environmental outcomes in food systems, including agricultural production, supply and demand for nutritious foods, and price transmission through the chain. Choices related to food production and consumption reflect market conditions, habits, cultural preferences, environmental factors, government policies, religious beliefs, income levels, and risk tolerance. All of these factors can be explored and better understood through value chains.

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**FIGURE 1 A milk value chain**

Looking first to nutrition, agricultural production—the base of a food value chain—is one of many factors that affect the availability and consumption of adequate nutrients. Low-income households typically subsist on monotonous, staple-based diets. This lack of dietary diversity is strongly associated with inadequate intake and risks of micronutrient deficiencies. Increasing diversity in agricultural production can improve diversity in diets, but the relationship is not necessarily straightforward. Analyzing value chains can help clarify why that’s so—in part because dietary choices also depend on markets. Food is stored, distributed, processed, marketed, prepared, and consumed in a range of ways that affect the access, acceptability, and nutritional quality of foods for the consumer. Prices also play a key role in the accessibility of nutritious food. For example, many households in developing countries are both consumers and producers of food, meaning that food price increases can have diverse impacts on production and consumption decisions. While some interventions could create economic, environmental, and nutritional benefits, a detailed analysis of any potential intervention is needed to determine whether it presents win-win options or entails trade-offs among the desired outcomes.

One example of an intervention with multiple goals is efficiency improvement in temperature-controlled supply chains—known as “cold chains.” Cold chains can improve economic returns to vegetable- and animal-sourced food production by maintaining the nutritional content longer and reducing both losses to spoilage and risks of contamination. However, the economic benefits may be limited if consumers do not value the additional nutrient density (that is, the proportion of nutrients in a food relative to calories) or improved food safety. Because nutritional content and food safety are invisible, consumers may not be willing to pay more for these qualities without some form of third-party endorsement, whether public or private, such as information campaigns or consumer reporting. Nevertheless, in theory, diets would be expected to improve with investments in cold chains as a result of a drop in prices for nutrient-dense foods. The environmental effects, on the other hand, may be mixed. Reduction in food loss and waste would increase the sustainability of the food system by reducing resource use throughout the chain. However, overall resource use might increase because of the nature of the food system: cold chains require energy, vegetable production typically uses pesticides, and animal-sourced foods are resource intensive.

Value chain interventions to increase sustainability can target actors able to implement location-specific sustainable management practices in agriculture, namely smallholder farmers, farmer organizations, and local businesses. Understanding the context-specific constraints and opportunities at the level of farmers and farmer organizations can support the design of more efficient policies that enable sustainability and long-term growth. Smallholders, for example, can play an important role in improving sustainability and nutrition, but also present a challenge in terms of scaling up interventions. Smallholders have a comparative advantage in crops that require high labor inputs, such as dairy products, tree crops, and vegetables. But to achieve economic success, crop processing, transport, and marketing often need to be aggregated to reduce transaction costs, and proper storage is required to avoid spoilage. To support production of nutritious crops, contractual relationships between smallholders or smallholder groups and buyers, such as food processors, can promote investments, reduce risk, and stabilize prices and production. Linking such contractual relationships to sustainable management targets and labeling can increase economic and environmental sustainability. Strong public programs can help ensure both economic and environmental sustainability where the private sector might not.

Attention to gender—that is, considering gender roles in agricultural tasks such as sowing, weeding, harvesting, and marketing, as well as the roles played by men and women in choosing what foods to grow, eat, and prepare—can play a significant role in making interventions for nutritious and sustainable value chains successful. Including women in the management of natural resources can lead to more economically and environmentally sustainable outcomes. As women become more empowered in agriculture, nutrition outcomes improve among children. However, there are also potential negative consequences. For example, women who
are more engaged in commercial agriculture or non-farm income-generating activities may have less time to care for their children. Additionally, although supermarket supply chains for vegetables have grown, their positive effects on nutrition have been muted because revenues from vegetable sales, which were previously controlled by women, are now controlled by men, who typically spend less on nutrition and dietary quality.

A VALUE CHAIN TYPOLOGY FOR INTERVENTIONS

Value chain interventions can be divided into four categories based on the profile of supply and demand for nutritious foods that characterize particular contexts (Figure 2). The typology identifies where interventions can achieve the greatest nutritional impacts for particular situations; it is also useful for analyzing sustainability investments.

Interventions to increase food supply
Ample demand for specific nutritious foods may exist in places where supply is limited (Figure 2, top left quadrant). Poor production practices, a lack of infrastructure that results in high transaction costs, or a lack of trust among actors in the value chain can all contribute to inadequate supply. In this case, interventions should aim to enhance supply by improving production practices, organizing production and postharvest activities to increase efficiency, and facilitating expansion of market opportunities. An ongoing project in eastern India, run by the social enterprise eKutir, is working with microentrepreneurs to provide retail outlets and distribution channels to support both increased production of vegetables and increased access to a varied diet for poor households. By addressing constraints in the market distribution of vegetables, the project aims to reduce loss of perishable products and make the value chain more sustainable.

When both supply and demand for diverse foods are weak, intensive investments will be required on both the production and consumption sides (Figure 2, bottom left quadrant). Introducing new types of nutritious foods can address this situation—interventions must both develop a stable source of supply and promote demand for the new food. The introduction of biofortified crops, such as orange sweet potato in the HarvestPlus Reaching End Users project, fits this description. Orange sweet potato was bred for high vitamin A levels to address a common micronutrient deficiency. The project integrated production, demand creation, and market improvements to stimulate production and consumption of the new crop. An impact evaluation of the project reported increased vitamin A intake among children in both Mozambique and Uganda. Fostering demand presented little difficulty because consumers enjoyed the taste of orange sweet potatoes; on the supply side, making planting material available to farmers was crucial to success.

Interventions to change food demand
In some cases, nutritious foods are widely produced but are not consumed by the target populations, as a result of habits or relative costs (Figure 2, bottom right quadrant). Interventions should focus on changing consumption, health, and nutrition practices to address both undernutrition and overnutrition (obesity and overweight). Food transfers or public procurement programs, such as school meals, can directly create demand for nutritious food. Mass media or behavior change communication (BCC) can indirectly increase demand. In India, a partnership between PRADAN, a nongovernmental organization, and iKure, a social enterprise, is promoting vegetable and pulse consumption using a mix of seed provision and communication schemes. Pulses provide an important source of iron, and they offer a protein source that is relatively sustainable in environmental terms, with low carbon emissions and soil-degradation rates.

Malnutrition is often a product of unbalanced diets, including overconsumption of processed foods such as refined grains, sugars, and unhealthy fats, alongside underconsumption of fruits, vegetables, and whole grains. And so interventions should aim to reduce both supply and demand for highly processed foods. In institutional settings, such as schools and hospitals, setting nutrient- and food-based standards can improve diets. For private consumers, BCCs teaching targeted nutrition messages can decrease demand for low-nutrient foods.
Other means of addressing overnutrition include fiscal measures; in Mexico, for example, taxes imposed on soft drinks resulted in increased prices and decreased demand for soft drinks relative to water.\textsuperscript{16}

BCCs can have a broad impact on health by combining the promotion of nutritional foods with education about healthy behaviors and care and feeding practices for infants and young children. For example, in the PRADAN/iKure project, health camps offer women information on dietary diversity, hygiene practices, and anemia, as well as time allocation and household decisionmaking roles. BCCs have proved effective in a homestead gardening program in Burkina Faso that was designed to reduce undernutrition.\textsuperscript{17} However, there is no evidence yet that BCCs can reduce overnutrition or the pressure overconsumption may put on natural resources.

**Interventions to enhance value chain organization and performance**

Where both demand and supply exist for nutritious food, interventions should focus on optimizing the nutrient flow along the value chain (Figure 2, top right quadrant). Optimizing the value chain implies maximizing efficiency and minimizing waste in the existing chain while maintaining or enhancing the nutritional content of foods. For example, in Vietnam, distrust between milk producers and milk-collection agencies led to poor quality and low producer prices in the milk industry, because smallholder producers...
generally did not expect fair payments from collection depots. As a result of an intervention offering third-party testing to smallholders, threat of regulation increased both milk quality and producer prices and reduced the amount of wasted milk.18

Providing quality assurance and improving regulatory frameworks are other fruitful supply-side interventions. Regulation of the private sector, when properly enforced, can benefit consumers’ health.19 Both nutritional fortification and regulations for food safety, for example, are often mandated by public policy and can be implemented on a large scale.

Other targeted interventions can enhance information flows along the chain. Better access to information can improve supply by increasing efficiency or boost demand by increasing consumers’ knowledge of and willingness to pay for nutritious and safe foods. Success is more likely when these interventions are supported by government regulations but implemented with private sector participation. A school meal program in Chile, for example, improved tendering regulations for public procurement of foods in 1999, which reduced transaction costs and sparked private sector involvement. Meal quality, meal-service infrastructure, and labor conditions among food handlers all improved, and the promotion of a sustainable, local supply chain reduced the program’s environmental footprint.20

DESIGNING BETTER VALUE CHAIN INTERVENTIONS
Research and practice are just beginning to explore the nexus of nutrition and sustainability. Achieving the SDGs will require that we move quickly to find interventions that will both improve nutrition and ensure sustainability. A number of challenges must be addressed, including filling knowledge gaps, managing trade-offs among goals, and engaging the private sector in support of improved diets and sustainability.

Filling knowledge gaps
As a first step, gaps in our knowledge about nutrition and sustainability interventions must be identified and addressed. Broadly speaking, there is still much to learn about how to improve agricultural productivity alongside diet quality and environmental sustainability.

On the production side, key questions concern the feasibility of targeting interventions toward the poorest smallholders and least formal enterprises along the value chain. For example, how can contracts between smallholders and crop buyers be profitable while promoting better nutrition and sustainability? How can credible, effective, and affordable means of certification for nutritional value and food safety be provided without excluding smallholders and the informal sector?

On the consumption side, research is needed on ways to stimulate the consumption of nutritious foods. How can the most vulnerable be assured access to more nutritious food? How can over-consumption, which has deleterious effects on both health and natural resources, be addressed? Current understanding of how diets respond to changes in prices, incomes, or opportunity costs is limited, especially for less developed countries. Data on dietary intakes provide a good starting point for planning and adopting a nutrition-sensitive value chain approach, but such data are expensive to collect and context specific to a small area. In addition, not enough is known about how consumers’ attitudes and food practices evolve in response to better information about nutrition and healthy diets.

Designing feasible, cost-effective scaled-up strategies to promote improved nutrition and reduced environmental impacts will require further research and empirical evidence. For example, a pilot study in Kenya provided microfinance, irrigation, and agricultural training to encourage vegetable production in the dry season, in an effort to both improve the availability of nutritious foods and increase smallholders’ resilience to environmental shocks.21 The pilot showed that strong partnerships are essential for scaling up microfinance.

Managing trade-offs
Goals for nutrition, sustainability, and economic development will not always be complementary; to meet multiple goals, interventions will need to manage trade-offs and constraints. Support for diversifying and increasing the output of nutritious foods must take account of the limits of land and water
inputs, as well as any potential risks from climate change. Economic incentives may lead smallholders to produce crops that are profitable in the short term, without considering nutritional value or long-term sustainability. To overcome this constraint, interventions could prioritize development of reliable marketing channels for nutritious, sustainable smallholder products. Seasonality may be an important constraint as well. Many smallholders are net buyers for part of the year, so they are affected by both consumer and producer prices—meaning that any interventions that affect prices can have both positive and negative effects for this population.

Win-win outcomes for smallholders and consumers may be possible but are far from certain, and the trade-offs require careful, context-specific analysis. For example, targeting consumers to improve nutrition outcomes may not be cost-efficient or compatible with sourcing from smallholders in a sustainable way, at least in the short term. However, clearly identifying the costs and effects of interventions may justify commitment of additional resources for pro-smallholder engagement or provide insights on longer-term solutions, such as partnerships with smallholders to increase sustainability.

Time allocation trade-offs must also be taken into account. Processing food, for example, may provide new, more nutritional products that are easier to prepare, which would potentially save time for women and, if the nutritional products also require less cooking, also reduce fuel use. Such products could still have environmental costs, however, if, for example, the required processing is water intensive. Careful examination of these trade-offs is a priority for future research.

**Engaging the private sector**

Value chain interventions for improved nutrition and sustainability must engage a range of stakeholders, including the private sector. Private actors in food value chains range from vertically integrated multinational corporations to individuals who transport, store, aggregate, or sell food. While the private sector can be engaged to support goals of improved nutrition or sustainability, such interventions are most likely to be successful if profit incentives are aligned with the desired goals. Policymakers should engage with the private sector to find ways to align public and private objectives related to nutrition and sustainability.

Several efforts are currently underway that involve the private sector in interventions designed to provide economic benefits and increase access to sustainable and nutritious diets. For example, in 2014, the PepsiCo Foundation announced a five-year, US$5 million grant to the Inter-American Development Bank to launch the Sustained Program to Improve Nutrition (SPOON). This program is designed to prevent undernutrition and reduce the risk of obesity among infants in poor areas of Colombia, Guatemala, and Mexico. It focuses on improving infant-feeding practices and promoting the use of a nutritional supplement. A behavior change strategy will encourage healthy feeding habits.

**A VALUABLE FRAMEWORK**

With the SDGs set for 2030, comprehensive strategies are needed to identify win-win scenarios to reach economic and nutritional goals while ensuring the long-term sustainability of the world’s food systems. Value chains provide a unique framework to support strategic evaluation of the opportunities for and constraints to improving diets, and to identify the trade-offs and complementarities among the goals of higher incomes, better nutrition, and improved sustainability.

Diverse interventions are underway using value chains to address specific dietary goals. The knowledge generated by these interventions should lead to more sustainable and lasting solutions for improved nutrition. But further research is required to address the twin challenges of sustainability and better nutrition. How do diets respond to interventions at various points in the value chain, from producer to consumer, and across a variety of contexts and countries? What are the constraints along the value chain to improved nutrition and sustainability? Where must trade-offs be made among major goals? And where are the opportunities for rapid improvements? Value chain analysis can help answer these questions and provide a valuable framework to improve both nutrition outcomes and the sustainability of global diets.