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# ALIGNING THE FOOD SYSTEM TO MEET DIETARY NEEDS: FRUITS AND VEGETABLES

JULY 7, 2018

USAID
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HORTICULTURE INNOVATION LAB

UC DAVIS
UNIVERSITY OF CALIFORNIA

# Aligning the Food System to Meet Dietary Needs: FRUITS AND VEGETABLES

**JULY 7, 2018**
This white paper is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The Horticulture Innovation Lab is funded by USAID as part of the U.S. Government's global hunger and food security initiative called Feed the Future. The contents are the responsibility of the Horticulture Innovation Lab and do not necessarily reflect the views of USAID or the United States Government.

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**COVER PHOTO:**
Vegetable market in Siem Reap, Cambodia. Horticulture Innovation Lab photo by Brenda Dawson/UC Davis

**RECOMMENDED CITATION:**
Horticulture Innovation Lab, World Food Center & Program in International and Community Nutrition. 2018. Aligning the Food System to Meet Dietary Needs: Fruits and Vegetables. Davis, CA: University of California, Davis.

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## Executive Summary

Poor diet is the leading cause of disease worldwide, and by 2020 it is projected that nearly 75% of deaths will be due to diet-related causes (1). This projection will likely impact both higher and lower-income groups, as well as urban and rural populations, including the 64.6% of poor working adults in agriculture (2). To tackle this issue, leading scientists, nutritionists and economists from academia, agriculture, government, industry, and non-governmental organizations spent two days at the University of California, Davis discussing strategies for increasing the production and consumption of fruits and vegetables as a path to obtaining adequate diets and increased incomes in domestic and transitional economies.

Although often neglected in calorie counts, eating horticultural crops provides critical nutrients for a balanced diet. Diets low in fruits and vegetables contribute significantly to some of the world's most widespread and debilitating nutrient-related disorders. Farmers growing high-value crops, such as fruits, vegetables, flowers and/or herbs, consistently earn more than those growing other commodities. Horticulture can be an engine for agricultural and economic diversification.

As the world sees higher rates of disease, decreased arable land, and possible food shortages, production choices are critical to health and to the social and economic mobility of farmers. Continued and increased investment in horticulture for nutrition and small-scale farmer income is critical. Strategies that governments, non-governmental organizations, and others can employ to increase fruit and vegetable consumption include better production practices, increased agribusiness and entrepreneurial activity, reduction in postharvest losses, and greater awareness and education about the benefits of fruits and vegetables.

# Introduction

On June 2-3, 2017, the UC Davis World Food Center, in collaboration with the Program in International and Community Nutrition and the Horticulture Innovation Lab, convened a group of stakeholders to provide guidance to increase nutrient-dense fruit and vegetable consumption and offer consensus on research gaps that could improve program and implementation effectiveness. This paper summarizes the main points from the conference, "Aligning the Food System to Meet Dietary Needs: Fruits and Vegetables," with the intent of continuing the dialogue and momentum for greater investment in fruits and vegetables from both the nutrition and agriculture sectors.

Meeting materials, including presentations, can be accessed here:
http://horticulture.ucdavis.edu/event/nutrition-2017/

# Why fruits and vegetables are important

## Fruits and vegetables: the health case for investment

**Increased fruit and vegetable consumption positively impacts health.** Poor diet is the leading cause of disease worldwide, and by 2020 it is projected that nearly 75% of deaths will be due to diet related causes (1). Of the 11 leading global disease risk factors, six of the top nine are linked to poor quality diets (3). While poor diets are a key driver of malnutrition and growing rates of obesity globally, fruits and vegetables are among the few food groups with positive outcomes for both undernutrition (e.g. micronutrient deficiencies) and over nutrition (e.g. cardiovascular disease, overweight and obesity) (4). For undernutrition, fruits and vegetables contribute to dietary diversity and provide essential micronutrients, which are key for nutrient adequacy and preventing malnutrition, especially for women and children (5, 6). To combat overweight and diet-related disease, WHO recommends at least 400 grams of fruits and vegetables per person per day (7). Current consumption, however, falls short in every region of the world, except East Asia (8). One study showed that 78% of survey respondents, primarily from low and middle-income countries (LMICs), consumed less than the minimum recommended amount of fruits and vegetables (9). These consumption behaviors deviate from pre-historical dietary habits; pre-agriculture diets were very high in fruits and vegetables, as well as animal-source foods and total fats, with almost no cereals, and no refined sugars (10). In many low-income countries today, diet trends are now the opposite, with 62% of the world's obese population now living in LMICs (11). Increased fruit and vegetable consumption, however, can help reverse these trends, with positive implications for health.

**Fruit and vegetable consumption can prevent weight gain and reduce risks for chronic disease, including cardiovascular disease and type 2 diabetes.** Studies show that as fruit and vegetable consumption increases, weight tends to decrease (12). One reason could be that fruits and vegetables contain high amounts of water and dietary fiber, which may prevent overweight by promoting satiety (13, 14). Weight gain is linked to other chronic diseases, and studies show that increased consumption of fruits and vegetables reduces the risk of coronary heart disease (15). Moreover, potassium, which is generally high in fruits and vegetables, has been associated with lowering blood pressure and dietary fiber may also be linked to lowering blood pressure, thereby potentially decreasing the risk for stroke (16, 17). The risk of type 2

diabetes decreases with consumption of whole fruits, especially substituting fruit juice with specific whole fruits (e.g. blueberries, grapes and apples) (18). Increasing daily intake of leafy greens has the potential to reduce the risk of type 2 diabetes (19). In addition, dietary fiber, found in plant-based foods including fruits and vegetables, may also contribute to insulin regulation (20) (21), which may impact type 2 diabetes risk.

**Fruits and vegetables can reduce the risk of cancer (22).** Phytochemicals and antioxidants found in many fruits and vegetables may reduce cancer risk by preventing oxidative damage to cells (23). Certain types of vegetables such as leafy greens may protect against certain types of cancers including mouth, throat, esophagus and stomach cancers (24). Another example is tomatoes, specifically lycopene in tomatoes, which may offer protection against prostate cancer (25).

## Fruits and vegetables: the economic case for agricultural investment

**Fruit and vegetable production can create economic opportunities for small farms, creating opportunities for women and youth.** With diverse crops, intercropping, and short growing cycles, vegetable production can provide income to smallholders and reduce risk, building the economic resilience of farms in the face of climate change (26). Farmers can choose to consume the fruits and vegetables they grow and/or sell them to earn income, which they can use to purchase other goods such as animal-source foods, contributing to both food and nutrition security. In addition, income from fruit and vegetable sales has the potential to accrue to women, as compared to staple grains or cash crops that tend be culturally-identified as male. This economic benefit was demonstrated in one study in Tanzania, where income from leafy greens and onions tended to go to women, despite the fact that men and women were equally involved in their production (27). In addition, youth may be more attracted to vegetable production because it requires less land, has exciting technological prospects (e.g. mobile phone integration and packaging and processing technologies), and potentially quicker economic returns (26).

**The production of fruits and vegetables can generate greater income, particularly on smaller landholdings, than cereal crops.** Fruits and vegetables are high value crops that can typically earn a greater income on smaller landholdings than cereals (28), benefitting households with less land. Data from Niger, Vietnam and Cambodia reveal that profits per hectare are 3-14 times higher in vegetable production as compared to rice production (29). Moreover, farmers who produce fruits and vegetables often have higher net farm incomes than those who produce only cereal crops; up to 5 times higher per family member as demonstrated by a study in Kenya (29). Because vegetable production and handling is more labor intensive, vegetables tend to generate more employment per hectare than cereals (30), especially considering jobs along the value chain in packing houses and processing.

Compared to cereals and commodity crops, investments in fruits and vegetables are tremendously low. The 2014 U.S. Farm Bill outlaid $700 million for *indirect* spending on fruits and vegetables ("specialty crops"), while nearly five billion dollars was directly spent on commodity crops (31). Internationally, CGIAR does not have a fruit and vegetable-specific research program and spent approximately $220M in 2012 on research for only three crops: rice, maize, and wheat (8). Furthermore, in 2013, the World Vegetable Center (previously known as

AVRDC), a non-governmental agricultural research institute, had a total budget of only $13 million, about 1% of CGIAR's research funds (32).

However, upon comparing the total farm gate value and production area for commodity crops and horticultural crops, horticultural crops account for about 23% of the total production value on less than 3% of agricultural land (33). In California alone, specialty crops represent a 20-billion-dollar industry (34), and production of fruits and vegetables is increasing across the U.S. Continued and increased investment in horticulture for nutrition and small-scale farmer income is critical.

Fortunately, advances in management practices and technologies, such as drip irrigation and minimum tillage, reduce water and fertilizer requirements for horticulture production, and these technologies are becoming more accessible to farmers of different production scales. Thus, given the under-emphasis on fruits and vegetables in the food system, there is ample room for increasing market share for producers who choose to take this route.

## Strategies to increase fruit and vegetable consumption

While projections indicate that total global production of fruits and vegetables will nearly double from 2010 to 2050, consumer demand is also increasing, especially in LMICs, where per capita consumption of fruits and vegetables is projected to exceed that of high-income countries by 2050 (35).

Recognizing the importance of fruits and vegetables as both a source of nutritional benefits as well as income for smallholder farmers, it is imperative to stress both increased cultivation and consumption of a wide variety of fruits and vegetables. Achieving this goal requires a combination of interventions, including increasing availability, affordability, and demand for fruits and vegetables.

### Increased production and reduced postharvest losses of fruits and vegetables

**Using agrobiodiversity to increase availability of fruits and vegetables and to promote dietary diversity:** While the global food supply is becoming increasingly homogeneous, genetic diversity, in both wild and cultivated species, has been used by plant breeders for centuries to improve yields of fruits and vegetables. Agrobiodiversity can also be used to provide a portfolio of micronutrients and allows a source of important traits for breeding stress-tolerant, nutritious crops. Agrobiodiversity contributes to climate change resilience through many, often combined, strategies: protection and restoration of ecosystems, sustainable use of soil and water resources, agroforestry, diversification of farming systems, various adjustments in cultivation practices, use of stress-tolerant crops, and crop improvement (36).

**Increased production to meet increasing consumption:** If everyone in the U.S. were to eat the recommended daily amount of fruits and vegetables, the U.S. would need to more than double the number of acres in fruit production (an estimated 4.1M acre increase from 3.5M to 7.6M) and increase the number of acres in vegetable production by 137% or 8.8M acres (from

6.5M acres to 15.3M acres) (37). This situation also exists in low income countries and poses a significant challenge to our global food system.

Potential solutions to increase production include:

- Increasing yield on existing land (i.e. agricultural intensification)
- Inter-cropping or mixed cropping systems
- Home vegetable gardens
- Promoting urban and peri-urban agriculture
- Growing a range of early and late-maturing varieties adaptable to different conditions and climates
- Using protected cultivation (e.g. greenhouses, high tunnels, and temporary structures) to protect against cold temperatures or heavy rainfall

**Reducing postharvest losses of fruits and vegetables:** While food losses in the U.S. and other high-income countries tend to occur at the retail and consumer levels, in low-income countries, most losses occur before food gets to the consumers. Postharvest losses in vegetable value chains in low-income countries are estimated to be 30-50% of the farm production volume (38), reducing producer income and compromising food security.

In lower income countries, postharvest losses are most often caused by:

- Inadequate (or no) cooling of the produce after harvest
- Physical damage along the supply chain (often due to improper packaging)
- Insufficient drying and dry storage

**Simple, low-tech, on-farm innovations and management practices can reduce postharvest losses:**

- Shade structures to hold recently harvested products
- Reusable plastic cartons to protect products during postharvest handling
- Evaporative coolers, including charcoal coolers and zero energy cool chambers (ZECC), in climates with low relative humidity
- Small-scale insulated rooms powered by AC units with a CoolBot™ controller (https://horticulture.ucdavis.edu/coolbot), which are less costly than commercial cold rooms
- Analogous to the "cold chain" for refrigerated storage of perishables, the "dry chain" (www.drychain.org) is a concept that involves drying food products soon after harvest and ensuring they are adequately dried for storage in moisture-proof containers (39).
    - Solar drying, a simple method that has been used for hundreds of years to stabilize products. The UC Davis Chimney Solar Dryer (https://horticulture.ucdavis.edu/chimney-solar-dryer) is an example of an efficient design.
    - The DryCard™ (https://horticulture.ucdavis.edu/drycard), a simple tool based on a strip of cobalt chloride that indicates if products have been sufficiently dried to prevent the growth of toxin-producing molds during storage.

## Access and affordability

Global food production is adequate to provide roughly 2,800 kilocalories per person, per day (40), yet supply of fruits and vegetables falls 22% short of the recommended amount, and in low-income countries, this deficit is even higher at 58% (41). Another key constraint to increased fruit and vegetable consumption is affordability. In some countries, it may take 40-70% of household income to purchase fruits and vegetables (42), and fruit and vegetable price projections show a 30% increase (without climate change); with climate change, projected prices could be even higher, impacting affordability and accessibility (43).

Affordability is essential to increasing consumption. Although increasing production and supply could decrease prices, increased demand could help maintain a stable equilibrium. Thus, it is also important to decrease unit costs of production for fruits and vegetables. Data from Bangladesh, however, indicate that people are willing to spend a greater portion of income to diversify their diets (44).

## Demand and dietary intake

Consumers' preferences and their perceptions of quality drive fruit and vegetable consumption. Research shows that while higher incomes in emerging economies lead to slightly higher fruit and vegetable consumption, income also correlates with significantly increased consumption of energy-dense, empty-calorie foods, which negatively impact human nutrition (45, 46).

Improved information, access, and desirability can increase fruit and vegetable demand, and must be combined in order to achieve and sustain diet change (47).

- Increasing the availability and affordability of fruits and vegetables in homes, schools, workplaces and communities leads to greater consumption (48).
- Educational programs that include goal setting and small groups are particularly effective in increasing fruit and vegetable consumption (49).
- First-time parents, school-aged children, and individuals with recently diagnosed health conditions are most apt to change their dietary practices (50, 51).
- Financial incentives (e.g. cash or vouchers) can encourage low-income consumers to purchase a greater diversity of foods, including vegetables (26).

## For further research

Throughout the conference, presenters and participants discussed gaps in the literature and made recommendations for future research. Some of the emerging researchable questions proposed included:

### *How can we ensure sufficient supply of fruits and vegetables to meet nutritional needs globally and locally?*

- What innovations (e.g. new technologies for maintaining cold chains, dry chains and other systems) or policy changes (e.g. subsidies) can reduce food losses and waste to increase availability and decrease consumer prices?

- What are the efficacy, feasibility, and cost-effectiveness of technologies that reduce postharvest loss/food waste in the food supply chain?
- How will climate change affect production and availability (e.g. modeling research)?
- Given the need for more evidence-based and food-based dietary guidelines, how can production and consumption be better linked in ways that are locally appropriate?

***How can we reduce the cost of fruits and vegetables to consumers without negatively affecting producers?***

- What are the roles of formal vs. informal markets in fruit and vegetable supplies in low and middle-income countries?
- How might informal markets need to change, especially in urban areas, to improve access for rural and urban consumers?
- How would reduced postharvest losses and improved quality affect market prices and farmer income?

***How can we better track demand and consumption of fruits and vegetables around the world?***

- What is fruit and vegetable intake globally and across different countries and age groups?
- What are the environmental, economic, and psychosocial factors (e.g. convenience) that drive consumer demand for fruits and vegetables?
- What is the impact of changing the food environment, instead of, or in addition to, focusing on behavior change in promoting fruit and vegetable consumption? Are certain strategies highly effective?

## Summary

**Why invest in fruits and vegetables?** Investments should be made into fruits and vegetables because they are critical for human health, addressing both under and over nutrition, including reducing micronutrient deficiencies and risks for chronic disease and cancer. Production of fruits and vegetables can also generate significantly more economic benefits for smallholder farmers, including women and youth, and have the potential to earn more income than cereal crops, even on small plots of land.

Strategies to increase fruit and vegetable consumption should be rooted in systems thinking, including increasing agrobiodiversity to promote resilience against climate change, using all available land for smallholder production (home gardens, urban agriculture, etc.) and reducing postharvest losses through innovative low-cost technologies. However, affordability and accessibility are crucial for increasing demand and consumption of fruits and vegetables. Investment in fruits and vegetables will significantly increase production and consumption through creative, collaborative and evidence-based solutions.

## About the Conference Organizers:

The **World Food Center (WFC)** mobilizes the research, educational and outreach resources of UC Davis, in partnership with consumers, public and philanthropic entities, and the agricultural, marine and food industries, to promote innovative, sustainable and equitable food systems. Based in the College of Agricultural and Environmental Sciences, the World Food Center works on local, national and global scales to support scientific research and policy development leading to implementation of food production and distribution systems that support the health of people and the environment while addressing the challenges of population growth and climate change. https://worldfoodcenter.ucdavis.edu/

The **UC Davis Program in International and Community Nutrition (PICN)** was established in 1987 to coordinate research and training activities concerning human nutrition problems of low-income countries and of ethnic minorities and disadvantaged groups in the United States. In 1994, the Program became an Organized Research Unit (ORU) under the Office of Research. https://picn.ucdavis.edu/

The **Horticulture Innovation Lab's** global research network advances fruit and vegetable innovations, empowering smallholder farmers to earn more income while better nourishing their communities. The program team and its projects help the world's poorest people break out of a persistent cycle of poverty by improving smallholder farmers' abilities to grow and sell high-value crops. Improving livelihoods — through higher profits and diversified, nutrient-rich diets — is a primary goal for the Horticulture Innovation Lab's research efforts around the world. The program's work is guided by ensuring gender equity, improving information access, targeting innovative technologies and increasing research capacity. The program is funded by the U.S. Agency for International Development and led by a team at the University of California, Davis, as part of the U.S. government's Feed the Future initiative. http://horticulture.ucdavis.edu/

**Speakers and Session Chairs (in order of appearance in the program):**

- Amy Beaudreault, UC Davis
- Jan Hopmans, UC Davis
- Kathryn Dewey, UC Davis
- Timothy Sulser, IFPRI
- Andrew Jones, University of Michigan
- Zach Conrad, USDA, Agricultural Research Service
- Joanne Arsenault, UC Davis
- Emmy Simmons, Global Panel on Agriculture and Food Systems for Nutrition
- David Tschirley, Michigan State University
- Gina Kennedy, Bioversity International
- Elizabeth Mitcham, UC Davis
- Mario Ferruzzi, North Carolina State University
- Reina Engle-Stone, UC Davis
- Anna Herforth, Columbia University
- Selena Ahmed, Montana State University
- Anju Aggarwal, University of Washington, Seattle

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