Food Systems and Environmental Change: Navigating the Two-way Street**

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Summary
While advances in food production have largely kept pace with demand on a global basis, nearly 1 billion people are hungry, and about 2 billion more lack sufficient nutrients. Paradoxically, more than 2 billion are overweight or obese. Meanwhile, current methods of producing, processing, packaging, transporting, retailing, and consuming food are significantly contributing to degrading the natural resource base upon which our food security depends. Food system outcomes related to both food security and environment are currently significantly suboptimal. A host of research opportunities spanning the whole food system exists to address this situation, balancing the traditional "production" viewpoint with a stronger "consumption" viewpoint.

The ultimate goal is resource-efficient food systems. Intermediate goals are improving input use efficiency (from the production side), and reducing food waste (from the consumption side). Key research areas span technical, institutional and behavioral domains, and the full set of food system stakeholders (policy, business, civil society, and researchers) need to be engaged to ensure research outputs are appropriate and viable.

A food systems approach promotes innovative research and policy agendas by (i) systematically relating the full set of food system activities to their food security and environment outcomes; (ii) raising awareness of the potential unintended consequences of policy and/or practice interventions aimed at enhancing food system outcomes; and (iii) allowing for a systematic analysis of synergies and tradeoffs between potential winning and losing strategies. The foods system approach thereby helps to navigate the food security/environment "two-way street."

Current realities

Food production has historically outpaced food demand on a global basis, although the rate of increase is now slowing and there are marked regional differences. The problems of lack of calories and inadequate nutrition for billions of people are essentially due to lack of access to an adequate, balanced diet. For most, this inaccessibility is primarily caused by inequity and poverty; food affordability is central to food security. Paradoxically, because of a set of economic, cultural, and behavioral issues, more than 2 billion people are overweight or obese. Recent trends in incomes and food marketing, and hence diets, coupled with other lifestyle changes, indicate this number will grow substantially in coming decades.

Meanwhile, current activities related to producing food are already seriously undermining the natural resource base upon which our food security depends. For example, agriculture and fisheries account for more than 20% of greenhouse gas emissions; about 25% of global land area is degraded, largely due to food production, and about 75% of fresh water extraction is for irrigation; and about 70% of fish stocks are either fully or over exploited, or depleted.

The production of food is, however, just part of the food sector. Other food system activities (i.e. processing, packaging, transporting, retailing, and preparing food, collectively the food chain) also all have a significant environmental footprint. For example, about 40% of U.S. and 60% of U.K. food-related greenhouse gas emissions originate from post-farm activities; food processing accounts for 5% to 10% of industrial water use, and food processing effluent often pollutes water courses; and about 8% of aluminum is used in food and drink packaging.

There are growing concerns regarding increases in food demand, the threats of climate change undermining food production, and the impacts of land and marine management aimed at producing food on biodiversity and ecosystem functioning. This means that interactions between food security and environment are now center stage.

Scientific opportunities and challenges

The summary statistics above demonstrate that the food security/environmental issues are not only about food production, but relate to how the food system as a whole operates. Food systems include the full set of activities from "plough to plate": (i) producing food; (ii) processing food; (iii) packaging and distributing food; and (iv) retailing and consuming food. A full food system approach also includes the outcomes of these activities for (i) food and nutrition security, including access to, and utilization of food, in addition to food availability; (ii) other socioeconomic outcomes (e.g., employment and wealth); and (iii) the environment (Figure 1).

There is an urgent need to improve food systems to (i) enhance food security (and health) outcomes, (ii) improve their efficiency, and (iii) reduce their environmental impacts. Reducing food waste, which occurs in all food system activities, would help achieve all three. Adopting a food systems research approach helps to identify a host of scientific opportunities and challenges spanning all food system activities and outcomes, and helps to build a comprehensive understanding of system drivers and feedbacks (Figure 2). Research falls into three general categories: technical, institutional, and behavioral.

Technical research opportunities relate to (i) reducing the "yield gap" for many cropping systems by both reducing biotic and abiotic yield reducing factors and improving nutrient and water use efficiency to raise attainable yields; (ii) developing cultivars with enhanced nutrient profiles to help address hidden hunger; (iii) maintaining food safety and taste while reducing salt, fat, and sugar contents; and (iv) enhancing, and rapidly and accurately preventing, detecting, and controlling novel, emerging, and re-emerging pathogens to enhance food safety.

Institutional research opportunities relate to (i) reducing barriers to uptake of innovative technologies; (ii) understanding governance arrangements within and among the wide array of state and nonstate food system actors; (iii) reversing policies promoting the use for human-edible food being used for industrial and biofuels; (iv) enhancing intraregional trade; and (v) enhancing strategic food reserves.

Behavioral research opportunities relate to (i) overcoming resistance to innovative technologies (e.g., new cultivars, genomics, and genetic modification); (ii) reducing food waste by reducing both the "buy and bin" phenomenon and excess consumption in more affluent societies; (iii) increasing acceptability of novel foods (i.e., derived from algae and insects); (iv) awareness among consumers of balanced social, economic, and environmental sustainability issues; and (v) reducing "prophylactic" use of herbicides and pesticides in arable systems, and antibiotics in intensive animal systems, both of which lead to resistance build-up.

An overriding research challenge lies in developing frameworks and tools to assess the synergies and trade-offs among different societal goals of implementing the results of such research opportunities. Policy makers need to be able to gauge the impacts on both winners and losers of any technical, institutional, or behavioral change. As food is largely being produced, processed, distributed, and sold by private actors, ranging from smallholder farms to large food and retail companies, engaging private actors is crucial in the transition towards more sustainable food systems.

Policy issues

Food system activities are contributing significantly to environmental change. Environmental change is undermining the natural resource base upon which our food security depends, and will increasingly affect food supply, food quality, and food safety. Policies must be developed to help all food system stakeholders better navigate this two-way street so as to engender "resource-use efficient food systems."

Government policy makers need to build a more conducive "policy environment" to encourage technical, institutional, and behavioral changes aimed at enhancing food security while reducing negative environmental impacts. They also need to challenge the political lobby from vested interests for the status quo (e.g., biofuel quotas and trade tariffs).

Private sector actors need to increase their effort in assessing the resource-use efficiency of their activities. Many major food companies are already actively engaged in this as it makes good business sense: enhance the sustainability of the feedstock to ensure supply; enhance the sustainability of the customer base by promoting best practice.

Civil society needs to engage in the sustainability debate, including a more serious discussion about dietary change, through NGOs and social media. This will need encouragement from both industry and policy. Advertising, labelling, and peer pressure are key factors, and regulation (e.g. a fat tax) can also be an important driver of societal change.

Researchers need to develop better whole-system models of food systems that can be used to assess both the nutrition and environmental outcomes of given policy interventions. A wide range of stakeholders needs to be engaged to both determine information need and assess the usability of such a model(s).

In undertaking such work, all stakeholders need to recognize:

- the importance of nutrition, not just calorie, to reduce poor mental and physical development, especially in the population under the age of five;
- the increasing crisis of overconsumption, which has substantial negative economic, social, health, and environmental impacts;
- the increasing value addition in food chains, which is leading to more choice but at a higher price, and hence reducing affordability and thereby access to food for many;
- how urbanization is both lengthening food chains, and reducing the ratio of producers to consumers; and
- the value of urban horticulture (rather than agriculture) in enhancing nutrition, livelihoods, and waste recycling, and in reducing food losses of highly perishable produce in transport.

References

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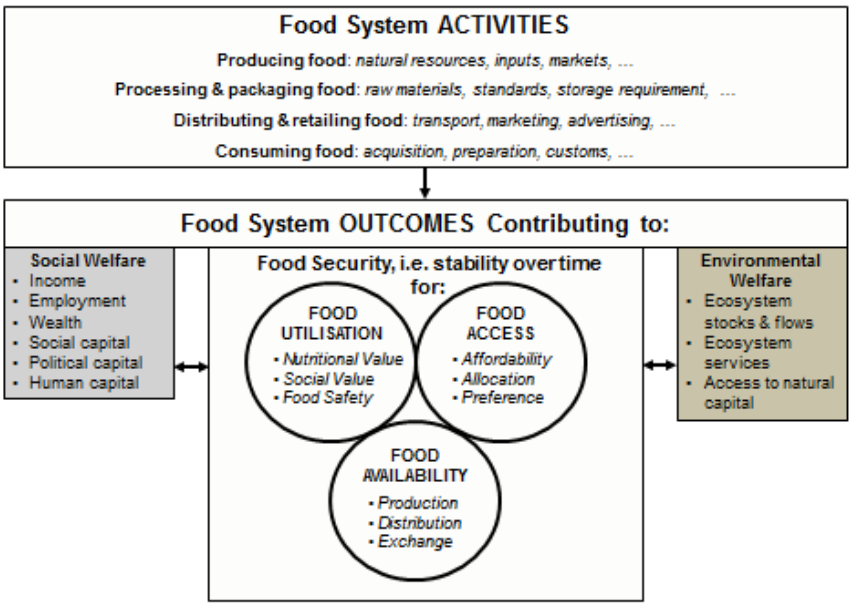

Figure 1 shows the range of food system *activities* (with example determinants); and their *outcomes* in relation to nine food security elements (conveyed in the bullet points in the circles), all of which underpin food security. All nine elements are derived from the FAO World Food Summit definition. Food system activities also have other socioeconomic and environmental outcomes (from Ingram, 2011).

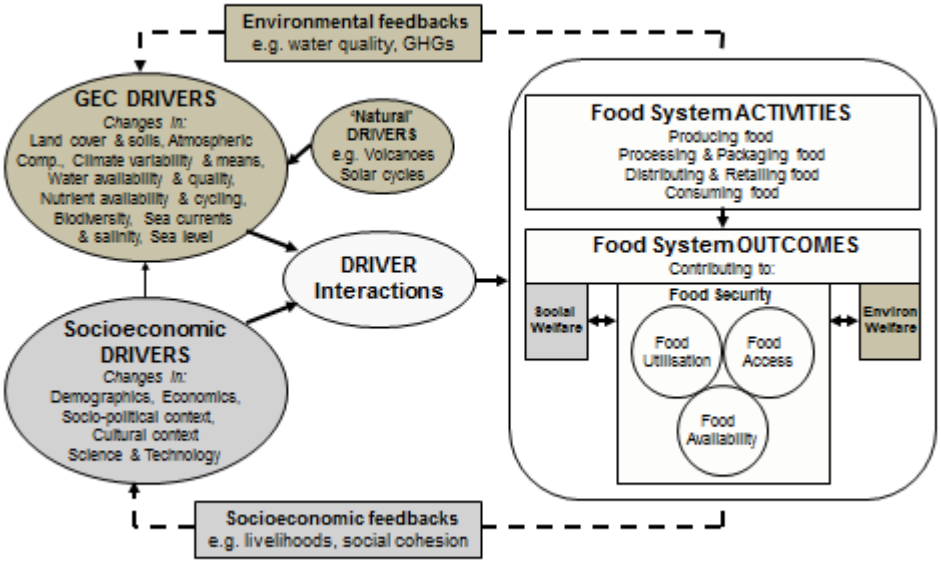

Figure 2 shows how socioeconomic and global environmental change (GEC) drivers interact to affect the food system activities and outcomes, and the feedbacks to these sets of drivers by current and adapted activities (from Ingram, 2011).