

Places to Intervene to Make Complex Food Systems More Healthy, Green, Fair, and Affordable

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A Food Systems and Public Health conference was convened in April 2009 to consider research supporting food systems that are healthy, green, fair, and affordable. We used a complex systems framework to examine the contents of background material provided to conference participants. Application of our intervention-level framework (paradigm, goals, system structure, feedback and delays, structural elements) enabled comparison of the conference themes of healthy, green, fair, and affordable. At the level of system structure suggested actions to achieve these goals are fairly compatible, including broad public discussion and implementation of policies and programs that support sustainable food production and distribution. At the level of paradigm and goals, the challenge of making healthy and green food affordable becomes apparent as some actions may be in conflict. Systems thinking can provide insight into the challenges and opportunities to act to make the food supply more healthy, green, fair, and affordable.

KEYWORDS *complex systems, food systems, leverage points, feedback loops, healthy food, sustainable agriculture, farm diversity, food prices*

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INTRODUCTION

The Food Systems and Public Health Conference held April 1-3, 2009, at the Airlie Center in Warrenton, Virginia, convened a multidisciplinary group of researchers and practitioners in sustainable agriculture, public health, health care, obesity, economics, food systems, and other relevant fields to discuss opportunities to intervene to promote healthy diets, address health disparities, and promote diversification of agricultural production.¹ Presentations and discussion included improving food systems and leveraging the supply chain to promote healthy diets and prevent obesity. To insure that this multidisciplinary group was well prepared, the conference was supported by manuscripts prepared for and distributed to conference participants prior to the meeting.

Speakers in the session on building a good food toolkit each addressed one of 4 themes: healthy, green, fair, and affordable. These presentations were followed by one on how systems thinking could help to frame the challenges and opportunities for improving the food supply. In this commentary, we apply one of the complex systems frameworks presented in this session to describe the content of the material provided to conference participants. This exercise enabled us to elucidate some of the linkages and differences between food systems that are healthy, green, fair, and affordable.

COMPLEXITY IN FOOD SYSTEMS

The preconference papers and the dialogue during the conference made clear that the challenge of evolving food systems to create food supplies that are healthy, green, fair, and affordable is complex.^{2,3} Systems that are complex, rather than just complicated, have a number of characteristics including nonlinear dynamics, heterogeneity, stochastic behavior, interdependence of variables, and the presence of feedback loops.⁴ Although the food supply chain is often described in a linear fashion, beginning with production, processing, and distribution and continuing with marketing, retail, and consumption, the specific variables in each of these subsystems interact with each other in a nonlinear fashion, with many interdependencies and both balancing and reinforcing feedback loops. Some of this complex behavior is illustrated in the obesity system map developed by the Foresight Programme in the UK,⁵ but this stakeholder-developed concept map lacks many of the variables relevant to food system structures, especially at the production, processing, and distribution end of the supply chain. Variables such as the power and influence of large retail chains and large food processors, government agricultural policies, and technological advances all increase further the complexity of the food systems landscape.^{2,3}

When tackling a complex problem, the tendency is to oversimplify the problem and the causal linkages or pathways that give rise to outcomes of interest.⁴ But for systems where variables have many inputs and outputs, and multiple interacting components create both balancing and reinforcing feedback loops, the outcomes of interest emerge from the system as a whole. Outcomes like (1) ubiquitous and cheap nutrient-poor, calorie-dense food⁶; (2) concentration of power in specific parts of the food chain³; or (3) common agricultural practices that harm the environment² may not result from specific, identifiable causal pathways. As a result, an understanding of causal relationships may not be sufficient, possible, or even necessary.⁷ Examination of individual variables or of pairs of relationships in isolation does not elucidate the behavior of a complex system over time. General planning theory authors, Rittel and Webber, suggested that the search for a scientific basis for “wicked” social policy problems is bound to fail because of their nature.⁸

Tackling a complex problem requires a different approach, one that accepts the problem as complex and seeks solutions appropriate for complex problems. Meadows outlined 12 places or levels of intervention for complex problems.⁹ At one end of the spectrum are “constants, numbers and parameters,” (p. 5) leverage points that are relatively easy to change and by themselves generally only have a small impact. At the other end are the goals of the system and the paradigm under which the system operates, leverage points that are often very difficult to change but if changed can have a large impact. These “places to intervene” arose out of Meadows’ years of experience working with complex systems and out of her frustration for our tendency to seek simple solutions that seem intuitively correct but are often wrong.¹⁰

EXAMINATION OF BACKGROUND PAPERS

We recently adapted Meadows’ 12 “places to intervene” into a 5-level framework (Table 1) that can be used to sort qualitative survey data.¹¹ The 12 levels of Meadows’ framework were collapsed into 5 levels because interrater reliability using all 12 levels was poor. By reducing the framework to 5 levels that were more mutually exclusive, we were able to achieve much higher levels of concordance between raters. The levels of the modified framework were previously used to sort survey data on specific actions needed to address the complex problems of childhood obesity and chronic disease prevention.¹¹ Through sorting these types of data, we have gained insight into the types and distribution of effort needed to address obesity and chronic disease prevention.

Here we present the application of the Intervention Level Framework to the contents of the background papers provided to participants prior to

TABLE 1 Intervention Level Framework

Paradigm ^a	<p>System’s “mindset”</p> <p>Deepest held, often unspoken beliefs about the way the system works</p> <p>Goals, rules, and structures arise out of the paradigm</p> <p>Actions and ideas at this level propose to either shift or reinforce the current paradigm</p> <p>It is very difficult to intervene at this level, but it can be very effective</p>
Goals ^b	<p>Conform to the system’s paradigm</p> <p>Are targets that need to be achieved for the paradigm to shift</p> <p>Actions at this level focus or change the aim of the system</p> <p>The levels below conform to and enable the system’s goals</p>
System structure ^c	<p>All of the elements that make up the system as a whole, including the subsystems, actors, and interconnections between these elements</p> <p>Conforms to the system’s goals and paradigms</p> <p>Actions at this level will change the entire system structure by changing the linkages within the system or incorporating novel types of structural elements</p> <p>System structure gives rise to the dynamic behavior of the system over time</p>
Feedback & delays ^d	<p>Feedback allows the system to regulate itself by providing information about the outcome of different actions back to the source of the actions</p> <p>Feedback occurs when actions by one element of the system in turn affect the flows into or out of that same element</p> <p>Can be simple and direct or involve multiple variables</p> <p>Can be self-regulating/balancing or self-reinforcing</p> <p>Actions at this level attempt to create new, or increase the gain around existing, feedback loops</p> <p>Adding new feedback loops or changing feedback delays has the potential to restructure the system</p>
Structural elements ^e	<p>Subsystems, actors, and the physical elements of the system</p> <p>Connected through feedback loops and information flows</p> <p>Actions at this level affect specific subsystems, actors, or elements of the system</p> <p>Many actions at this level are usually required to create system-wide change</p>

^aCorresponds to Meadows’^{9,10} level 1 (the power to transcend paradigms) and level 2 (the mindset out of which the system arises).

^bCorresponds to Meadows’ level 3 (the goals of the system).

^cCorresponds to Meadows’ level 4 (organize system structure), level 5 (the rules of the system) only if the rules affect multiple subsystems, and level 6 (information flows) only if the flows occur between multiple subsystems.

^dCorresponds to Meadows’ level 7 (positive feedback), level 8 (negative feedback), and level 9 (length of delays).

^eCorresponds to Meadows’ level 5 (the rules of the system) only if the rules affect a particular subsystem or a specific type of actor, level 6 (information flows) only if the flows occur within a specific subsystem, level 10 (physical structure), level 11 (size of system stabilizers), and level 12 (constants and parameters).

the Food Systems and Public Health conference. Five analysts reviewed the contents of the 9 papers. Each of the 4 themes was examined by 2 analysts. The analysts read each of the papers and extracted ideas, statements, or actions that addressed the assigned theme. Each analyst compiled these

statements into a preliminary list in which similar ideas were consolidated to eliminate redundancy. These statements were then sorted according to the Intervention Level Framework parameters (see Table 1). The 2 analysts for each theme compared and consolidated their sorted preliminary lists to gain consensus. This process resulted in a final sorted list of 353 statements addressing the 4 themes (healthy: $n = 122$; green: $n = 87$; fair: $n = 84$; affordable: $n = 60$).

Table 2 illustrates the application of the framework to each of the 4 conference themes. Comparison within levels across themes illustrates the distinctions between the themes. Comparison between levels within each theme illustrates how lower levels (e.g., structure and structural elements) can support change at higher levels (e.g., goals and paradigm).

Figure 1 shows the emphasis of the content on structural elements of food systems when sorted by intervention level. Approximately half of the ideas expressed were at the level of structural elements, with the next largest category being relevant to the system structure. The least number of ideas were relevant to feedback loops and delays.

As illustrated in Table 2, there were significant overlaps in ideas relevant to each of the 4 themes. To understand the pattern of these linkages, statements that linked one theme to another were identified. Examples found include

- Healthy and affordable: “decrease the price of healthy food rather than increasing the price of unhealthy food” and “expand food stamp funds so families can actually purchase healthy food.”
- Healthy and green: “link health more effectively to the sustainability agenda” and “organic production to increase food system resilience and also provide food with increased health values.”
- Healthy and fair: “establish incentives and support for growers to produce healthful products” and “tackle the inequalities of power that characterize the food system and shape food’s impact on public health.”
- Affordable and fair: “we need fair and cooperative trading between producers, retailers and consumers” and “investigate the relationships between crop prices, food prices and food consumption.”
- Affordable and green: “make sustainably produced food accessible and affordable” and “subsidize the costs of healthier and more sustainably produced food for food assistance recipients.”
- Green and fair: “broaden public discussion around health and agricultural policy to include farmers, environmental groups and other public interest organizations” and “support local, sustainable, fair agricultural and dairy production practices.”

Figure 2 illustrates the relative balance of linkages identified. The thickness of the arrows is proportional to the number of statements that connect

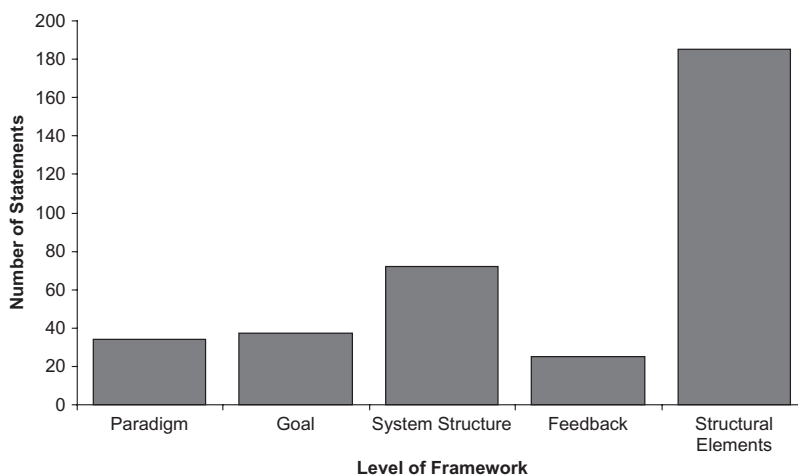
TABLE 2 Intervention Level Analysis of the Themes Healthy, Green, Fair, and Affordable

	Healthy	Green	Fair	Affordable
Paradigm (deepest held beliefs)	A healthy food supply requires consideration of the health impact of agricultural policies	Preservation of our natural resources requires food to be priced according to its full cost of production, including environmental costs	Support for small farms will increase fairness in the food supply	Healthy food needs to be affordable for everyone
Goals (the targets)	Agricultural policy that maximizes positive health outcomes and minimizes negative health impacts	Food prices that reflect the costs of toxic exposure, environmental cleanup, and depletion of natural resources	Farm diversity rather than consolidation. A balance of power across the food supply chain	Food prices that make healthy food more affordable than unhealthy food
Structure (across the system)	Broad public discussion of health and agricultural policy including farmers, environmental groups, and other organizations. Agricultural practices that are ecologically sound, culturally appropriate, and socially responsible	Public education on consumption of an environmentally sustainable diet. Programs, policies, and incentives that promote local food production	Broad public discussion of health and agricultural policy including farmers. Community-based food systems. Policies that decrease market consolidation	Policies and programs that support sustainable food production, distribution, availability, and affordability. Supply management of commodity crops to stabilize markets and consumer prices
Feedback & delays (loop dynamics)	Ensure public access to information on the use of agricultural inputs such as pesticides and fertilizers	Research the links between industrialization of the food system (pesticide use, feedlot operations) and destruction of the environment	Evaluate successful community-based food systems to improve methods and dissemination and to further inform policy and funding decision-making	Research the connections between crop prices, food choices, food availability, and food consumption

(Continued)

TABLE 2 (Continued)

	Healthy	Green	Fair	Affordable
Structural elements (subsystem specific)	Implement food labeling and regulate health claims. Reduce use of pesticides. Establish federal nutrition standards for competitive foods in schools	Encourage strip tillage to save soil. Eliminate routine use of antibiotics in livestock. Reduce use of packaging. Increase pasture-based dairy production	Increase small farms' access to markets. Cap payments to large farms. Increase the number of producers. Increase the viability of polycrop farms rather than monoculture farms	Ensure that low-income families receive sufficient food assistance to afford healthy food. Improve physical access to healthy food in underserved neighborhoods. Improve access through farmer's markets

**FIGURE 1** Distribution of statements according to the Intervention Level Framework ($n = 353$).

the two themes and the thickness of the lines around the nodes is proportional to the number of statements relevant to that theme. Healthy was the dominant theme in this set of preconference papers and healthy was well connected to each of the other 3 themes. Less well connected were the themes of green, fair, and affordable to each other.

Finally, we further sorted the ideas and actions that were identified at the level of structural elements (Figure 3). These statements were sorted

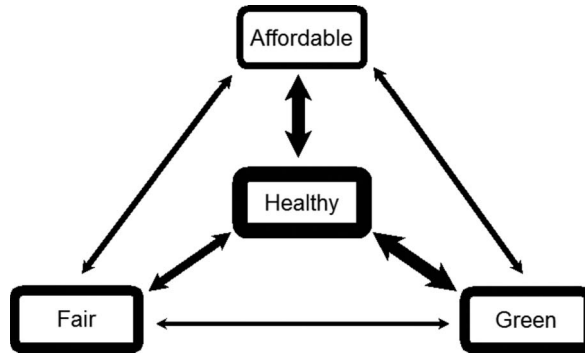


FIGURE 2 Strength of linkages between the 4 themes. Thickness of arrows and borders represent the relative number of statements between and within the themes, respectively.

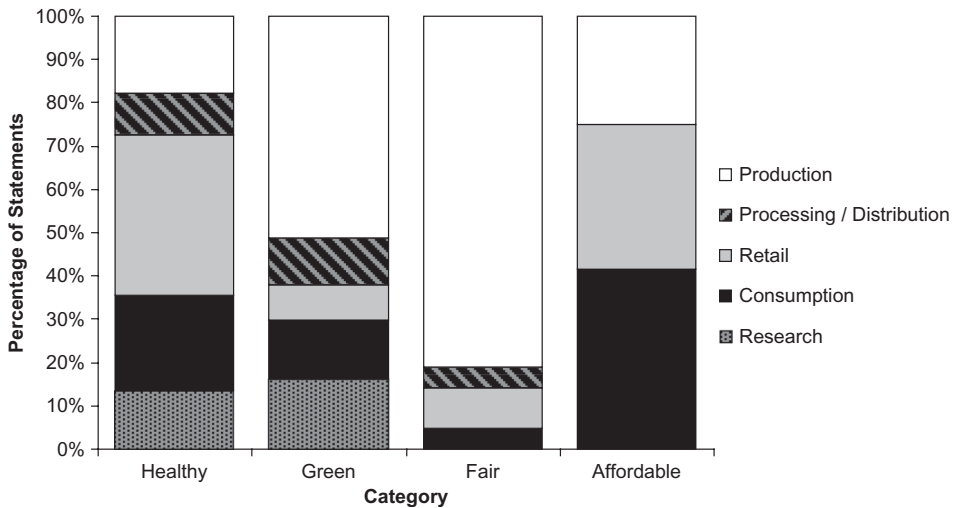


FIGURE 3 Structural elements from the 4 themes sorted by stages of the food supply chain. Research ideas were sorted separately, independent of the parts of the supply chain.

according to their relevance to different parts of the supply chain (production, processing/distribution, retail, and consumption). Because there was considerable effort to identify relevant research questions, statements making reference to research were sorted into a separate category. Ideas relevant to healthy were mostly balanced along the food supply chain, whereas much of the discussion of both green and especially fair was aimed at the production end of the chain. Interestingly, no statements on processing, distribution, or research were identified among the structural elements of the affordable theme.

COMPARABILITY OF HEALTHY, GREEN, FAIR, AND AFFORDABLE

Prior to the Food Systems and Public Health Conference, participants were provided with material that considered each of the 4 conference themes. Healthy was the dominant theme (approximately one third of the ideas) and healthy was clearly well linked to each of the other three themes (Figure 2). The reason for this focus on healthy and the greater detail about linkages between healthy and the other themes are likely a function of the particular authors asked to prepare this premeeting material but may also reflect the progression of ideas in this area to date. Supporting the notion that the discussion around healthy is more advanced and comprehensive is the balanced distribution of the structural elements for healthy across all parts of the food supply chain (Figure 3). In contrast, for the theme fair, more than 80% of the statements found in the preconference material were about the production end of the supply chain and none were about research.

Affordable was the least developed theme, with less than 20% of the statements being relevant to this theme and none were connected to processing, distribution, or research. This seems to be significant because power in the food chain has been concentrated in a smaller numbers of processors and this consolidation has a high potential to affect food prices. The lack of balance of ideas associated with affordable, across the food chain, may reflect the challenge of containing the total content of the background papers to a manageable level.

Whether or not the preconference material was representative of the broader dialogue taking place regarding food systems and public health remains to be determined. Even with this limited sample, the many linkages between the themes suggest considerable terrain for collaboration between and within sectors and movements. The need for collaboration was one of the topics raised during the small group discussions at the conference. Our examination of the linkages between themes and the sorting of ideas into levels could facilitate future dialogues on action. Analysis of key papers on food systems and public health, supported by an expert panel review, would also help to ensure a thorough understanding of the specific issues and the opportunities for intervention and collaboration. A more detailed analysis could also attempt to identify places where the paradigms, goals, and system structures are not compatible between different themes. For example, passing on the full costs of being green to the consumer will not likely make healthy food more affordable for everyone (Table 2).

INTERVENTION LEVELS FOR FOOD SYSTEM CHANGE

Meadows developed her ideas about places to intervene in complex problems to help us understand the possibilities for changing “the structure of

systems to produce more of what we want and less of what is undesirable.” (p. 145)¹⁰ She notes that it is dangerous to generalize about complex systems, but her years of experience supported her idea that the places to intervene could be described within a rough hierarchy generalized in the language of complex systems. She suggests that her list of places to intervene is an invitation to think more broadly about system change.

As illustrated for the 4 conference themes in Table 2, the Intervention Level Framework can help to convert a list of ideas for action into groups of ideas that fit together to support change. In the healthy theme, for example, the belief that a healthy food supply requires consideration of the health impact of agricultural policies naturally gives rise to the goals of maximizing positive health outcomes and minimizing negative health impacts through agricultural policy (Table 2). Broad public discussion of healthy agricultural policy and adoption of ecologically sound agricultural practices will require engagement of actors from across the food supply chain and across many sectors including government, the private sector, and the public. Building connections across ideas and between actors will support the system in moving toward the goal of maximizing health. Many actions within and between different subsystems, such as providing information to support public action or implementing policies that encourage healthy behaviors and healthy agricultural practice, will begin to add up to influence the structure, the goals, and the deepest held beliefs of the system’s actors.

Consistent with our analyses of survey data on actions needed to address childhood obesity and chronic disease prevention,¹¹ the largest proportion of the ideas fit into the structural elements level (Figure 1). System structure as a whole was also high on the authors’ agendas, with an additional 20% of the statements addressing this level of intervention. Also consistent with other analyses using this framework is a low number of statements relevant to creating or affecting feedback loops and delays. Often ideas for academic research are placed in this category because the description of data collection and its possible uses are core activities of research. Evaluation of community-based programs and systems would also support the creation of feedback loops. One author considered the creation of publicly driven feedback loops by calling for public access to information on the use of pesticides and fertilizers. The growing trend toward open access to public and private data encourages the creation of new feedback loops and will shorten delays in the speed of change.¹²

CONCLUSION

In this commentary we have identified many linkages between the themes, including core beliefs, the goals we would like to achieve, and the structures needed to accomplish these goals, but this is far from a comprehensive

analysis of the themes healthy, green, fair, and affordable. This preliminary analysis helps to identify areas of greater and lesser emphasis on the part of the authors of the preconference papers and suggests areas that need further effort and additional sources if a comprehensive picture is to be developed.

It is evident that to effectively create healthy, green, fair, and affordable food systems action is needed throughout the food chain. Systems thinking can support stakeholders in getting a better sense of the big picture, as well as gain insight into the places to intervene to create change within the system. With the Intervention Level Framework, stakeholders can develop a better understanding of how coherent actions among and between subsystems, together with enhanced self-regulating feedback loops and interconnections between subsystems, can create system-wide change that is consistent with goals and paradigms that will help to make our food systems more healthy, green, fair, and affordable.

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