Application of Resilience to Food Systems

Subjects: Public Administration

Contributor: Megan Roosevelt , Eric D. Raile , Jock R. Anderson

The idea of "resilience" increasingly appears in development dialogue and discussion of food systems. While the academic concept of resilience has roots in diverse disciplines, climate change and the coronavirus disease 2019 (COVID-19) pandemic have led to a rapid intensification of interest in the concept as it applies to food systems. The conceptual dimensions of resilient food systems and tools for assessing food system resilience are discussed.

resilience food system sustainability

1. Food System Adaptive Capacities

As it is increasingly used within food systems literature, conceptualizations of resilience echo past definitions from other disciplines, emphasizing "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner by ensuring the preservation, restoration, or improvement of its essential basic structures and functions" [1] , or more specifically, the "capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances" [2]. **Figure 1** presents a conceptual chain linking concepts related to a food system's ability to deal with negative shocks such as those resulting from natural disasters, market volatility, global temperature rise, and increasing climatic variability. Depending on the nature of the shock and the degree of risk to the system, a successful food system may resist or repulse the shock in a way that prevents any impact on function; but a resilient food system recovers or adapts in the wake of a shock as it returns to normal or improved functioning. While the above definitions clearly incorporate recovery and adaptation trajectories following a shock, they also extend into the conceptual space of food security as a desired outcome of resilient and sustainable food systems. At the most fundamental level, resilience is built up through a network of "adaptive capacities", which are commonly grouped into the substantive categories listed in the diagram's bottom left [3].

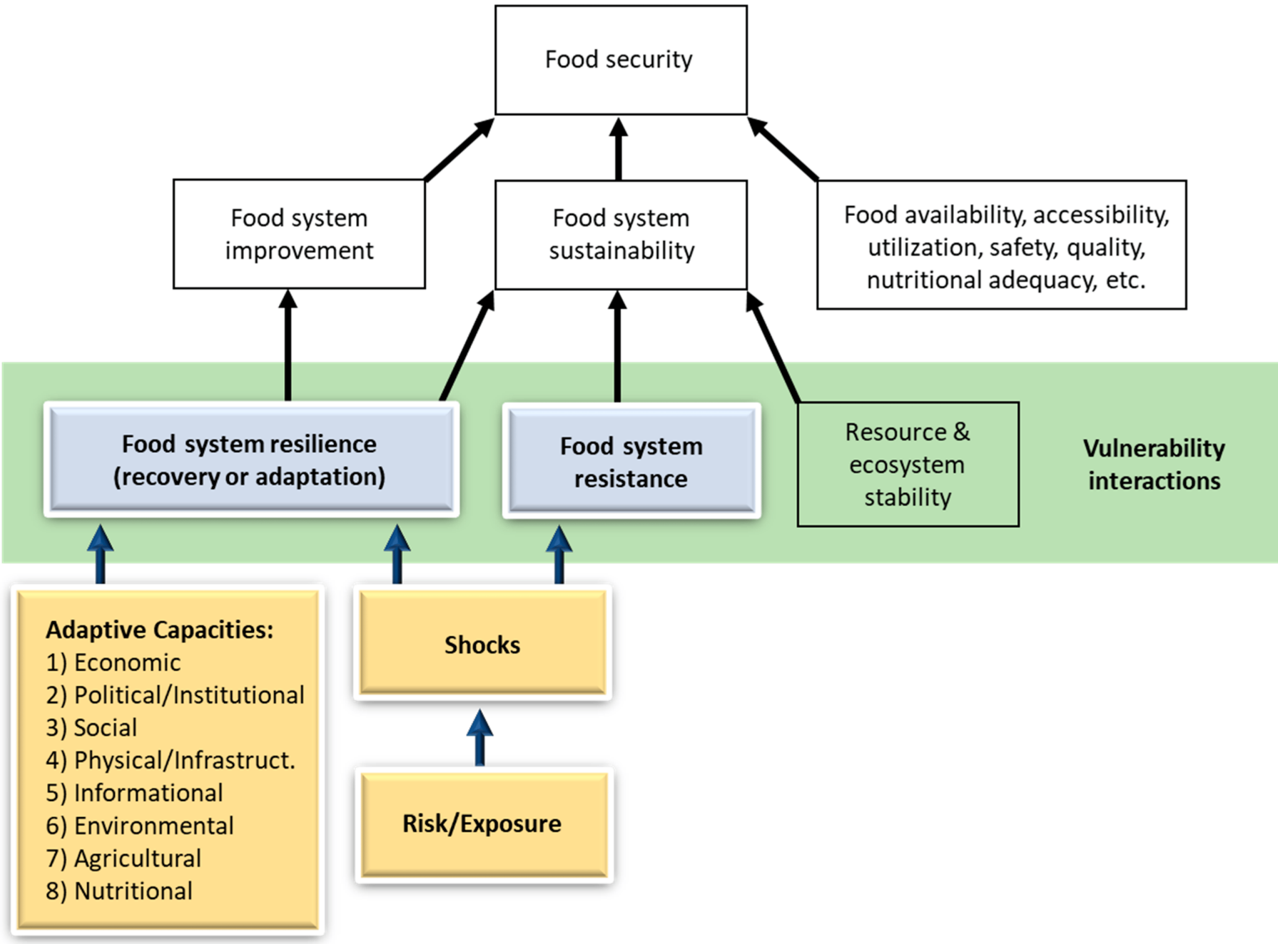

Figure 1. The figure shows relationships among key concepts and food system resilience. Arrows indicate that concepts contribute to or influence other concepts in the diagram.

Economic adaptive capacities (#1 in **Figure 1**) often have the potential to cut both ways in terms of their impact on a system's resilience: for instance, the positive of greater food access from increasingly global food supply chains is accompanied by negative externalities in the form of pollution, food waste, and biodiversity pressure [1]. Similarly, freer global trade can generally address regional shortages of food [4], but increased food supply does not automatically translate to reduced hunger or increased food security due to political and distributional issues [5][6]. And while a general expansion of international trade offers the ability to transport cheap, varied, and high-quality food worldwide, resilient systems should also build in redundancies in the form of having local food resources to fall back on in the event that international supply lines are damaged [7]. Societally and individually, lower levels of poverty and higher income relative to food prices increase food system resilience [6].

Politically (#2), food system researchers have also focused on the organizational structure of different levels of government. Researchers generally recognize the importance of high-quality governance and policy decisions to food system resilience; countries' varied experiences with food supply chain disruptions amid the COVID-19 pandemic underscores the key role of early policy interventions by national governments [8]. National and international agreements regulating subsidies or agricultural policy can stifle local decision-making autonomy, making systems less resilient [9]. Further, the introduction of climate-smart agriculture or other policies designed to make food systems more resilient requires buy-in both from local users and political elites across levels of government, so political institutions--including regime type, electoral rules, and decision-making structures--that influence or facilitate such buy-in are important to resilience [10].

The social (#3) capacity of resilience is echoed in arguments that local farmers should interact with multiple suppliers and retailers, building a large, redundant network that they can draw on to survive shocks. Additional social drivers of resilience tie in to socioeconomic dynamics and demography: food insecurity is significantly more common in both female-headed households and financially insecure households across African countries in the wake of COVID-19′s disruption of food systems [11]. The emphasis on gender as a key factor in food system resilience parallels scholarship examining gendered components of agricultural production [12].

Physical infrastructure (#4) emerges in discussion of food system resilience via the structures in place to produce and distribute food, noting that more resilient food systems develop ways to intensify food output through technological innovation, although these technologies themselves must be resilient and able to maintain or resume function under stress[13]. Resilience also relies on the infrastructure that connects urban and rural areas, shaping the delivery of foods to markets and consumers, and on access to electricity and other infrastructure that shapes production and profit for food producers and enables farms to resist some climate-related shocks [13][14][6].

The increasing digitization of economic transactions and the agricultural sector combine to increase informational (#5) capacities of food systems, building in redundancies for communication and transactions and making food production technologically more robust [14]. Moreover, growing movements to spread food literacy seek to expand knowledge about healthy food choices for consumers, with those informational pathways altering patterns of supply and demand. Further, information transmission by public officials to food producers, retailers, and consumers regarding public health guidelines has consequences for the functioning of food systems [15][16].

Food system resilience is linked to environmental (#6) capacity, in that the biophysical and ecological characteristics of a place are key food system drivers. These characteristics influence the quality, quantity, and diversity of food production possible in an area [17]. Environmental characteristics shape baseline agricultural inputs into food systems and can place constraints on supply chains and market interactions. In line with resilience work focused on the intersection of social factors with built and natural environments, community interactions with the land and the natural resources around them directly influence food system functioning.

Food system resilience by necessity incorporates elements not included in other conceptualizations of resilience. Agricultural (#7) capacities should contribute to robustness, redundancy, rapidity, and adaptability [18]. Food production diversity is an aspect of capacity, as more diverse food systems are viewed as more robust and adaptable in the face of shocks and also supply redundancy to hedge against crop failure. Similarly, diversity of output markets for farmers contributes to resilience, and countries using improved agricultural technologies are better able to respond to shocks quickly and effectively [19][20].

While health capacities appear in a limited way in resilience studies elsewhere, a focus on nutritional (#8) capacities is rather specific to food system resilience. The basic idea is that the current nutritional situation influences the extent to which a food system can handle a shock. For example, per capita food production (often roughly measured in terms of food energy) and storage provide a picture of the nutritional situation, as do food costs and expenditures [6]. Child malnutrition can similarly provide information about the capacity of the society to meet basic needs [20]. Finally, food imports might constitute a vulnerability if they indicate dependency, though imports can also serve as diversified or redundant pathways improving resilience [19].

2. Related Concepts and Complications

This subsection elaborates on the relationships between resilience and similar concepts in the food systems literature, as shown in higher levels of **Figure 1**. The concepts of resistance and recovery appear in food systems research, which emphasizes nonlinear patterns of growth and exploitation, conservation, and reorganization or renewal [9]. Studies incorporate resistance through preparedness for shocks, intensification or diversification of food production processes, or building in redundancies by developing several nonexclusive linkages with suppliers, farmers, retailers, shipping routes, etc.[4][5]. However, studies of food system resilience often focus less on resistance and more on adaptiveness and ability to transform. Such research notes that resistance to change in the face of various food system drivers (e.g., changes in policy, demand, economic or environmental conditions) may actually preclude positive adaptations [2].

Sustainability often appears in tandem with resilience in food system studies. An early definition of agroecosystem sustainability [21] looked much like contemporary resilience definitions. A newer definition of food system sustainability emphasizes protections for producers, retailers, and consumers, meeting current needs for nutritious food supply without compromising the ecosystem’s ability to produce food in the future [22], thereby differentiating itself from resilience. Arguably the biggest distinction in the food system literature is that sustainability is described as a normative concept requiring stakeholders to agree upon subjective goals, whereas resilience and vulnerability are more descriptive system properties[1].

Food system resilience and vulnerability often appear together as well. Some food systems researchers argue that more resilient systems are less vulnerable by definition[1]. A more typical view is that vulnerability is a product of interactions between resilience and risk. **Figure 1** reflects such thinking. While food system resilience is partly a function of risk (as argued earlier), the adaptive capacities of the food system may contribute to high resilience, thereby lessening vulnerability.

A challenge in applying resilience frameworks to food systems is variance in relevant time frames of shocks. Climate change may contribute to near-instantaneous shocks such as floods—a finite event from which a community or system can recover. However, climate change also serves as a chronic stressor to food systems, altering seasonal temperature and precipitation patterns, gradually raising sea levels, or steadily reducing arable land. Many of these shocks occur simultaneously or cumulatively on different time scales, compounding and making it difficult to isolate or identify resilience to a particular external disturbance [13].

Further, the dynamic nature of resilience and the complex interactions among networked adaptive capacities limit ability to disentangle its causes and effects [23]. Food systems are complex social–ecological systems with infrastructures that govern access to water, energy, land, and human labor, and their functioning depends on ecological factors, human behavior, and various other institutions. Failure or vulnerability in any one of these components can have difficult-to-quantify consequences for the functioning of another component, particularly as these consequences may not be immediate or predictable [13]. Both conceptually and empirically, assessments of food system resilience should account for the qualities and behaviors of the constituent parts of food systems and approach them holistically to give a full picture of risk and adaptive capacities.

3. Measurement of Food System Resilience

This subsection examines approaches for measuring food system resilience at different levels and with different degrees of dynamism. Cross-national measurement has tended to focus on broader concepts, such as food security and sustainability, that incorporate resilience as a subconcept. **Table 1** displays how indicators from four cross-national measures map to the eight capacity categories of resilience discussed earlier.

Table 1. Resilience elements in national-level measurement approaches.

	Chaudhary et al. [24]	Seekell et al. [6]	EIU's GFSI [25]	FAO [19]
(1) Economic				
Wealth distribution		X	X	
Economic readiness	X			
Dependence on natural capital	X			
(2) Political/institutional				
Political commitment to adaptation			X	
Governance readiness/risk management	X		X	
(3) Social				
Demographic stress	X			
Social readiness	X			
Sociocultural wellbeing	X		X	
(4) Physical/infrastructural				
Energy infrastructure	X			

	Chaudhary et al. [24]	Seekell et al. [6]	EIU's GFSI [25]	FAO [19]
Transport infrastructure	X			X
(5) Informational				
Information and communication technology	X			
(6) Environmental				
Exposure to climate change impacts	X		X	
Freshwater resources	X	X	X	
Land health			X	
Marine health			X	
Arable land resources		X		
Ecosystem stability	X			
(7) Agricultural				
Food production diversity	X	X		X
Output market diversity				X
Yield gap/projected change	X	X		
Agriculture capacity	X			
Agricultural water risk			X	
(8) Nutritional				
Food imports	X			X
Stored food				X
Malnutrition	X			
Waste and loss reduction	X			
Cost of food				X
Per capita food expenditures		X		
Caloric production per capita		X		X

Diversity [26] [20] ite index characterizing resilience in its own right, though it assesses the two components of readiness and vulnerability. Gustafson et al. introduced this two-component (i.e., Food Production Diversity and ND-GAIN) measure of resilience in food systems and applied it to nine countries [27], while Chaudhary et al. extended to 156 countries [24]. However, this measure produces relatively low cross-national variance.

Notes: Chaudhary et al. measure food system sustainability, so some indicators capture components of sustainability other than food access [24]. The authors use ND-GAIN to measure resilience, but shaded cells do not appear in ND-GAIN.

Another cross-national index of food system resilience, produced by Seekell et al., scores up to 96 countries from 1992–2011 on metrics of resilience (via income distribution and purchasing power), biophysical capacity, and production diversity [6]. Data availability might now allow for greater coverage, particularly with socioeconomic indicators. Several of their indicators are related to earlier measures by the Food and Agriculture Organization of the United Nations (FAO) and other agricultural development practitioners.

The Economist Intelligence Unit’s (EIU’s) Global Food Security Index (GFSI) incorporates a category on “Sustainability and Adaptation” as a main pillar [25]. Within this pillar, indicators mark countries’ exposure to climate-related shocks; the quality and quantity of land, water, and biodiversity; political measures showing commitment to adaptive strategies; and disaster risk management. Covering 113 countries, the GFSI pillar is the most comprehensive cross-national measure of food system resilience. Worth noting is that some of the categories indicated in **Table 1** for the EIU’s GFSI are indicators in pillars other than the Sustainability and Adaptation pillar.

The final column in **Table 1** captures a recent cross-national measurement approach for agrifood systems’ resilience from FAO. The approach utilizes various indicators in assessing four areas of food system resilience: the domestic agricultural production system, availability of food for consumers, food transportation infrastructure, and economic access to food [19]. Redundant pathways and diversity of food sources are important elements of the approach.

Researchers have also measured food system resilience at levels more granular than the country level. **Table 2** summarizes six different approaches for such measurement. These measures typically operate at the household, community, or regional levels. The measures have different purposes and emphases but typically incorporate adaptive capacities.

Table 2. Subnational resilience measures.

Measure/Approach	Description	Source(s)
Self-Evaluation and Holistic Assessment of climate Resilience of farmers and Pastoralists (SHARP)	Small-group interview data collected by tablet with quick data visualization tools, indicating smallholder, farmer, and household perceptions; refined version is SHARP+	[28]
Resilience Index Measurement and Analysis (RIMA) I and II	Assessment of household-level adaptive capacity, social safety nets, assets, and access to basic services as four core pillars of resilience; measures direct and indirect resilience	[29]
International Development Enterprise (iDE)’s Market System Resilience Index (MRSI)	Assessment of resilience in market system, especially in rural areas; combines market structure, connectivity, and support, as well as dynamic functioning and redundancy	[30]
Resilience and resilience capacity measurement options (produced for the	Light, intermediate, and full approaches for measuring resilience at the household and	[31]

Measure/Approach	Description	Source(s)
United States Agency for International Development)	community levels, along with specific measures for absorptive capacity, adaptive capacity, and transformative capacity	
World Bank Group rating system	Assessment of exposure and adaptive capacity in individual development projects	[32]
Operationalizing food system resilience in three dimensions	Assessment of resilience dimensions of “buffer capacity, self-organization, and capacity for learning and adaptation” at subnational level	[33] p. 434 [9]

s farming [34]. Some ners have argued for standardized metrics that convey approximate measures of resilience across agroecosystems, countries, or regional contexts [6][24]. Researchers will have to determine acceptable trade-offs between specificity and generalizability. A related concern is that tools useful for generalizing across spatial and temporal contexts cannot really capture multiscale feedback loops or variables having different impacts in different time periods[34]. Researchers have aimed to capture such dynamism by employing methods such as scenario diagramming [13], social foresight modeling [14], and discrete choice models to draw inferences about resilience under varying climate forecasts [35].

The concept of resilience is likely to become an integral part of food system research and practice moving forward. Conceptualization and measurement of food system research have important implications both for scientific advancement and for policymaking and evaluation; clarity along both theoretical and methodological dimensions is necessary for establishing policy priorities, making projections, and evaluating subsequent performance.

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