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Food system resilience: Defining the concept

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ABSTRACT

In a world of growing complexity and uncertainty, the security of food supplies is threatened by many factors. These include multiple processes of global change (e.g. climate change, rapid urbanization, population ageing), unexpected shocks (e.g. natural disasters, financial and political crises), and unexpected responses of food systems themselves to these processes and events. In this paper, we develop a conceptual framework for food system resilience, and consider how this could be implemented through stakeholder participation to ensure food security for everyone. Resilience is conceptualized from a holistic perspective, as encompassing the complexity of whole food systems, including social, economic and biophysical processes operating at many scales. It presents the opportunity to eradicate weaknesses and build capacities in the food system while dealing with future uncertainty.

1. The need for resilience in food systems

Today, almost 1 billion people in the world are hungry or undernourished, while a growing 1.5 billion are overweight or obese (FAO, 2012). In developing countries, often more than half of the household income is spent on food, making poor people highly vulnerable to sudden price fluctuations (Cranfield et al., 2007; Ivanic and Martin, 2008) which may drive people into poverty and/or impede efforts of poverty alleviation. Food systems are increasingly exposed to multiple internal and external drivers of change, ranging from sudden shocks to long-term stressors, that in turn increase the systems' vulnerability to shocks (Wisner et al., 2003). Various slow but major shifts such as climate change, soil degradation, pest outbreaks, economic and political crises, and population growth are adding pressure to the global food system (Rockström et al., 2009; Godfray et al., 2010; Pretty et al., 2010). Changes in food consumption patterns, such as rising demand for meat in emerging countries (FAO, 2009) and for organic food (Falguera et al., 2012) pose further challenges. Food systems are also intrinsically complex: they comprise many different processes, value chains, actors and interactions; their outcomes affect multiple stakeholders and sectors in diverse and sometimes conflicting ways. With so much uncertainty and complexity, food systems must be able to fulfill their goals, even in the face of multiple, unpredictable drivers of change.

The concept of resilience is increasingly used to address the above challenges. For example, the Food and Agriculture Organization (FAO) of the United Nations has recently advocated building resilient food systems in various contexts (FAO, 2013; Choptiany et al., 2014); the International Food and Policy Research Institute (IFPRI) dedicated a conference to "building resilience for food and nutrition security", which focused on the links between resilience, food security, humanitarian aid and development aid (Fan et al., 2014). This paper discusses and clarifies the role resilience can play in addressing food system challenges today, and sets the foundations for applying it for this purpose.

2. Food system approaches

In order to explore the role of resilience in food systems, we start by clarifying what food systems and food system approaches are. Food system approaches are increasingly seen as a way to improve food systems' outcomes and sustainability, in order to deal with competing priorities, and address the complex relationships that exist between components of food systems (Ericksen et al., 2010; Ingram et al., 2010; Garnett et al., 2013).

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Food systems are social–ecological systems, formed of biophysical and social factors linked through feedback mechanisms (Berkes et al., 2003; Ericksen, 2008b). They comprise, at a minimum, the activities involved in food production, processing and packaging, distribution and retail, and consumption (Ericksen, 2008a). These activities encompass social, economic, political, institutional and environmental processes and dimensions, referred to as scales. The processes play out at different levels, that is, at different positions on a scale (Cash et al., 2006). To analyze the interactions of food system activities across scales and levels, a food system can be more broadly conceived as including the determinants and outcomes of its activities. The determinants describe the biogeophysical as well as the social, economic and political environments that determine how food system activities are performed (food system drivers). These activities lead to a number of social and environmental outcomes, as well as a certain level of food security: "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life" according to the World Food Summit 1996 (Pinstrup-Andersen ,2009). Food system activities and outcomes eventually result in processes that feed back to environmental and socioeconomic drivers (Ericksen, 2008a; FAO, 2008a): this may lead to unintended consequences (Ingram et al., 2010). These complex interactions and their implications need to be accounted for in the design and implementation of effective policy and management interventions. Such interventions thus cannot be treated as isolated changes in one part of the food system (Pinstrup-Andersen and Watson, 2011). However, efforts have often focused on only a part of the system (most often agricultural production), while neglecting effects on other parts: a holistic approach would account for the whole system and its internal interactions between components.

3. Resilience

Resilience thinking has its origins in ecology (Holling, 1973), but has been increasingly adopted as a generic approach to understanding social–ecological systems (Adger, 2000; Carpenter et al., 2001; Adger et al., 2005; Folke, 2006; Folke et al., 2010). It is important to emphasize that resilience thinking represents a paradigm rather than a testable body of theory (Anderies et al., 2006; Brand and Jax, 2007; Kinzig, 2012; Anderies et al., 2013), and has been variously characterized as a "loosely organized cluster of concepts" (Carpenter and Brock, 2008), a collection of ideas (Anderies et al., 2006), and a way of enabling exchanges across disciplines (Brand and Jax, 2007; Hoddinott, 2014). Many definitions of resilience exist, according to the discipline for which they have been developed (Brand and Jax, 2007; Barrett and Constas, 2014; Speranza et al., 2014). Many of these definitions relate system resilience in some way to the capacity of the system to withstand and/or adapt to disturbances over time (Hoddinott, 2014), even those which are unpredictable and thus not accounted for in risk or robustness analysis (Anderies et al., 2013; Jones, 2013), in order to continue fulfilling its functions and providing its services or desirable outcomes (Walker et al., 2006).

In relation to sustainability, which has been broadly defined as the capacity to achieve today's goals without compromising the future capacity to achieve them (Brown et al., 1987; UN, 1987; Heller and Keoleian, 2003; Maleksaedi and Karami, 2013), resilience can be broadly defined as the dynamic capacity to continue to achieve goals despite disturbances and shocks. As shown in Fig. 1, we can thus see resilience and sustainability as being complementary concepts (Maleksaedi and Karami, 2013): sustainability implies preserving the capacity of a system to function in the future, which is also one of the conditions of maintaining resilience. However, resilience implies the capacity to continue providing a function over time despite disturbances, and thus forms an essential part of what enables sustainability (Rees, 2010; Maleksaedi and Karami, 2013): sustainability is the measure of system performance, whereas resilience can be seen as a means to achieve it (Brand and Jax, 2007; Anderies et al., 2013) during times of disturbance.

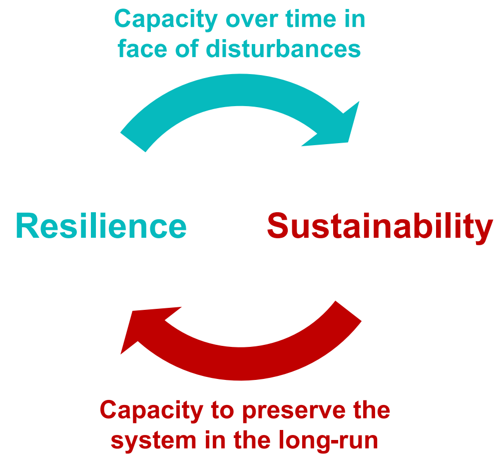

Fig. 1. Resilience and sustainability as complementary concepts.

4. Bringing resilience into food systems

Resilience thinking has a high potential to contribute to food security and sustainable food systems (Naylor, 2009; Prosperi et al., 2014) and a number of studies have looked at food systems or their components from a resilience perspective. Most focus on agricultural production or other specific stages in the food value chain (Darnhofer et al., 2010b; Milestad et al., 2010; Van Apeldoorn et al., 2011; Soane et al., 2012) but others focus on particular components of resilience, e.g. adaptability and transformability (Walker et al., 2009), cascading effects in regime shifts (Kinzig et al., 2006), or on particular outcomes and contexts, e.g. food security in emergency situations (Pingali et al. ,2005). These studies thus focus on selected components of food systems, and do not tend to account for complex cross-scale and cross-level interactions. However, the design and implementation of effective policy and management interventions require an understanding of these complex interactions and their implications. Such interventions thus cannot be treated as isolated changes in one part of the food system (Pinstrup-Andersen and Watson, 2011), therefore a whole system perspective is required. Furthermore, specifically in the context of *entire* food systems, we still lack a reflection on what resilience means conceptually and can contribute to operationally (Hoddinott, 2014). The very vagueness of the term resilience has promoted its popularity across disciplines, as a boundary object enabling cross-discipline and science-practice communication (Brand and Jax, 2007). This same vagueness, however, poses the risk of using the concept of resilience subjectively, for example as an argument for supporting the *status quo* (Kirchhoff et al., 2010, 2012). Thus, a conceptual definition of resilience in the context of food systems will help avoid the ambiguity caused by the multitude of resilience definitions used in other disciplines and contexts by setting boundaries, and thus providing the basis for operationalization and application of resilience thinking (Brand and Jax, 2007) in food systems.

5. Food system resilience

We thus propose the following definition of food system resilience:

This definition recognizes the importance of the time dimension in resilience. It emphasizes that resilience occurs at the multiple levels of the food system, from individuals to national food systems to global webs of value chains, thus signaling that resilience will imply more participatory food systems, and explicitly adopting a whole systems perspective. It explicitly ties resilience to a functional goal, as suggested by Barrett and Constas (2014), and FSIN (2014). Importantly, this normative definition of resilience thus excludes the danger of enhancing the resilience of systems that produce undesirable outcomes, such as food and nutrition insecurity or environmental degradation. Other social and environmental outcomes of a food system must implicitly also be favorable, as these contribute in turn to the system's resilience. Hence, we ensure that resilience is complementary to sustainability (see Fig. 1). The specific functional goal of food systems that we prioritize here is ensuring sufficient, appropriate and accessible food to all. By sufficient, we understand sufficient quantity and nutritional quality of food; by appropriate, we include the notions of culturally, technically and nutritionally appropriate food; by accessible, we mean physically and economically accessible. These components represent the three first dimensions of food security: availability, access and utilisation (FAO, 2008b). Providing this functional goal during times of disturbance can thus be related to the fourth dimension of food security: stability. We thus understand food system resilience to be specific to the function of food security, reflecting the importance of resilience for food security illustrated by Alinovi et al. (2008). However by explicitly considering various disturbances, our definition implies that food system resilience is not limited to the capacity of the system to cope with a specific driver of change. Indeed, disturbances in food systems can be internal or external, cyclical or structural, sudden or gradual; they can consist of natural, political, social, or economic shocks. It is important to consider this variety of possible disturbances when using a food system resilience perspective, as disturbances may also interact and have cumulative impacts. We specify the case of *unforeseen* disturbances, as resilience extends beyond conventional risk management, which typically deals with identifiable risks to which a probability of occurrence can be attributed, and thus for which a set response plan can be identified. Food system resilience is not an either-or attribute: a food system can be more or less resilient to disturbances; the question is less whether a food system is or is not resilient, but rather how resilient it is (Fig. 2).

A food system's resilience can be broken down into various components (Fig. 2) affecting the behavior of the food system

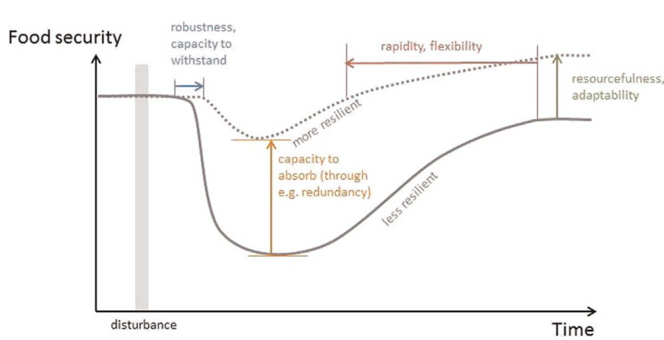

Fig. 2. Food system resilience, as the capacity to provide food security over time and despite disturbances, can be broken down into various components.

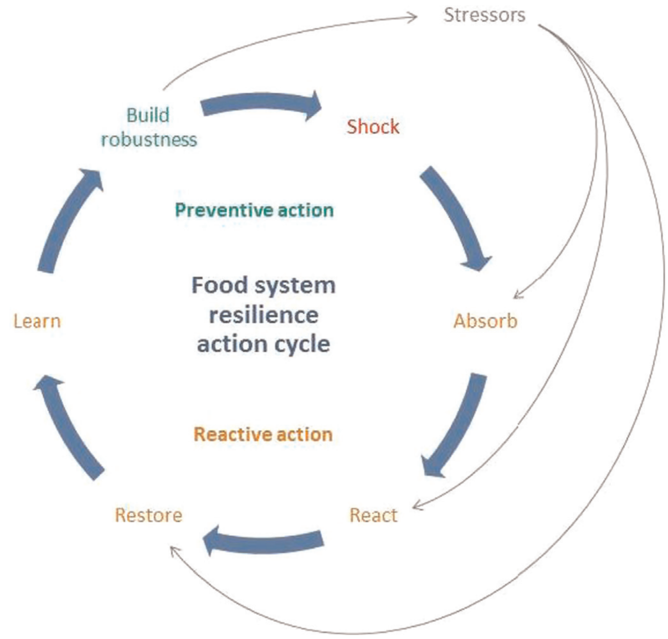

Fig. 3. The food system resilience action cycle consists not only of reactive actions (absorb, react, restore, learn) but also of preventive actions (build robustness). Preventive actions can also address stressors, which affect the reactive capacities of the food system in response to a shock. Each action is enabled by a capacity of the food system (i.e. capacity to absorb, flexibility and rapidity, resourcefulness and adaptability, learning capacity, capacity to withstand).

over time (Simonovic and Peck, 2013): (1) robustness, or the capacity to withstand the disturbance in the first place before any food security is lost (Anderies et al., 2013); (2) redundancy, or the extent to which elements of the system are replaceable, affecting the capacity to absorb the perturbing effect of the disturbance and avoid as much food insecurity as possible; (3) the flexibility and thus rapidity (or food system reactivity) with which the food system is able to recover any lost food security; (4) resourcefulness and adaptability, which determines just how much of the lost food security is recovered. Together, these capacities form the basis of the food system resilience action cycle (Fig. 3).

This food system resilience action cycle includes the learning and preventive action components possible in food systems. The notion of a cycle also underlines that food system resilience is not a one-time trick to deal with a one-time disturbance in the food system. It does not target the idea of achieving a stable and optimized state of a food system: rather, it is a built-in, continuously developing capacity, which allows a food system to minimize food insecurity in a changing environment with recurring disturbances (Fig. 4).

Drivers of change affecting food systems are often emphasized as negatively affecting the food system, but some (e.g. adequate interventions or policies) can also have beneficial effects on food system functions, outcomes and resilience. Even negative drivers of change provide an opportunity for change (Scheffer et al., 2012). Indeed it would be inconsistent with the normative goal of food security if a food system were resistant to any form of change, in particular positive forms of change: this would mean staticity and rigidity, rather than the adaptiveness and flexibility required in a resilient food system. Thus a resilient food system is more of a safe-fail food system than a fail-safe food system (cf. Anderies et al., 2013).

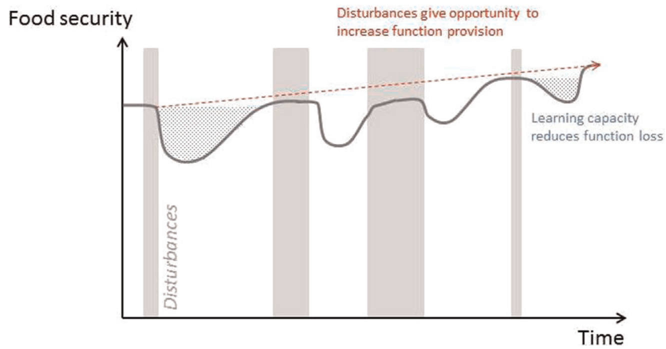

Fig. 4. The food system resilience concept acknowledges the dynamic nature of food systems: it aims to maximize the functional goal of food security over time, despite disturbances, but does not require the assumption of a single optimal, indefinitely sustainable, steady state. Rather, it entails a long-term, continuous action and learning cycle that iteratively builds resilience over time, and enhances performance of the food system. Disturbances are seen as an opportunity for change and improvement, with learning occurring after each successive shock.

6. Outlooks

6.1. Making food system resilience tangible

The next step toward building food system resilience is to transpose the concept as defined here into a tangible framework to assess the resilience of a food system, identify its strengths and weaknesses, and identify leverage points and interventions to improve food system resilience. This requires the development of measures of food system resilience (FSIN, 2014) in the form of indicators (Hoddinott, 2014). Systems resilience is assumed to be enhanced by system attributes such as diversity, redundancy, buffering capacity, modularity, capital (economic, financial, environmental, social, physical), exposure to disturbances, profitability, self-organization capacity, governance capacity, transformability, transparency, learning capacity (Darnhofer et al., 2010a; Darnhofer et al., 2010b; Cabell and Oelofse, 2012; Scheffer et al., 2012; Engle et al., 2013), as well as the existence of an appropriate institutional framework with equitable rights, entitlements and decision-making processes (Tyler and Moench, 2012; IISD, 2013). Multiple indicators have been proposed to evaluate these resilience attributes in various systems and contexts: livelihoods (Speranza et al., 2014); household food security and climate change (IISD, 2013); freshwater distribution systems (Milman and Short, 2008); smallholder farmers (Choptiany et al., 2014); community and natural disasters (Cutter et al. 2010); individuals' psychological resilience (Lamond et al., 2009); landscapes (Oudenhoven et al., 2010); urban communities and climate disasters (Joerin et al., 2014); adaptive capacity of institutions (Gupta et al., 2010); and agroecosystems (Cabell and Oelofse, 2012). However, to what extent are these indicators valid and adaptable for food system resilience? So far, there is a wide gap in the knowledge of how such attributes affect food system resilience, whether the relationship between the attributes and resilience is necessarily linear and always positive, what levels of

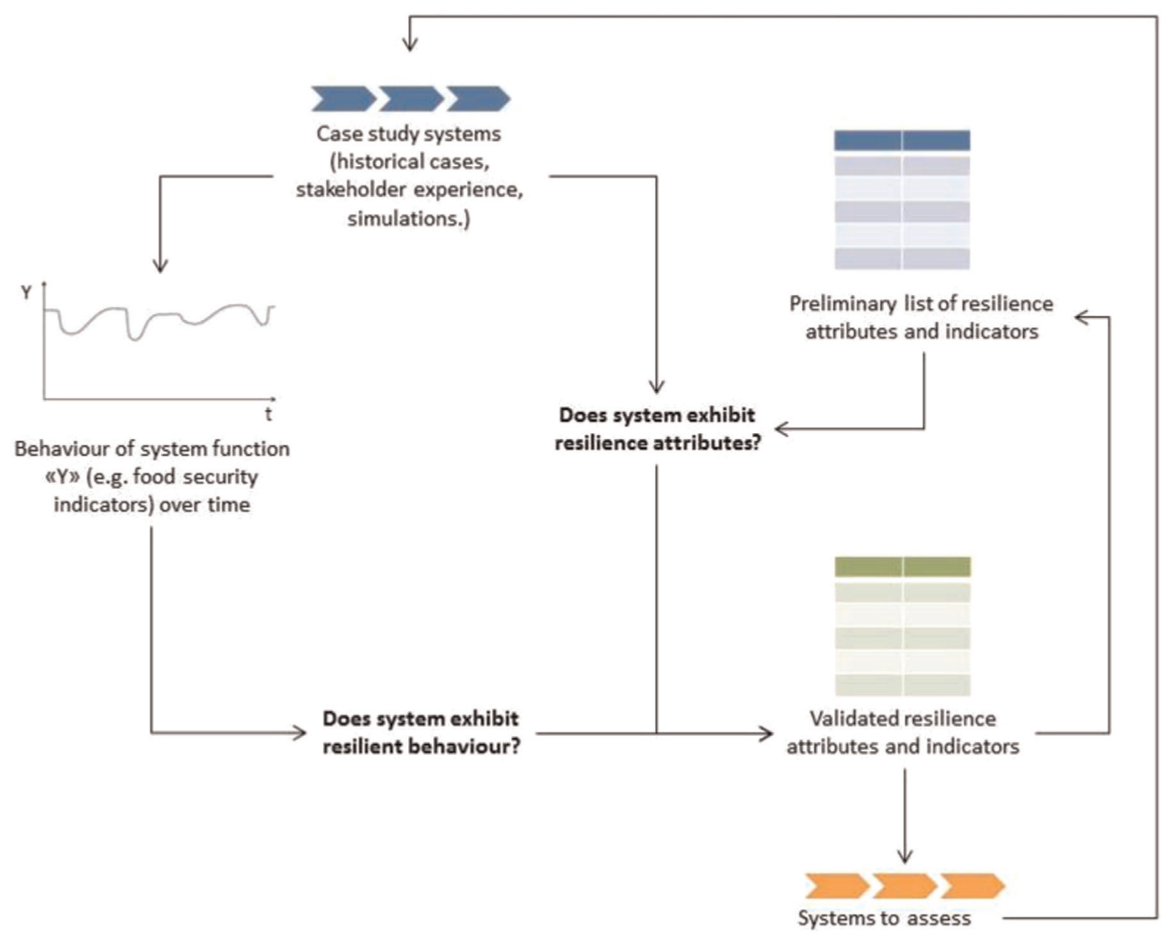

Fig. 5. Resilience indicators are useful to assess the resilience of food systems with limited effort, and to identify operational intervention points to improve it. However, current assumptions of food system resilience attributes and indicators have been drawn from literature from other disciplines, or only parts of food systems: they therefore need validation for whole food systems. This can be achieved by comparing the behavior of case study systems (obtained through historical analysis, stakeholder expertize, or simulation models) with the system's resilience attributes. The indicators can thus be iteratively improved through the experience gained over many case studies.

these attributes are desirable, and how different attributes may interact to reinforce or degrade resilience. Improving resilience in food systems in practice therefore first requires the identification, validation and measurement of food system resilience attributes and indicators. This can be iteratively achieved based on empirical data collected from case studies, historical analysis, simulations, and expert and stakeholder experience (Fig. 5).

These indicators can be compared with measures of food system performance (e.g. food security, the normative goal of food systems as defined in this paper) over time, before and after shocks, to determine whether (a) the food system is behaving resiliently, and (b) where resilience can be improved in the food system. The cycle between evaluating case studies using indicators, improving indicators, and improving resilience of those case studies (Fig. 5) provides a concrete example of the food system resilience action cycle conceptualized in Fig. 3.

To strengthen our understanding of resilience in food systems, much more empirical data, both quantitative and qualitative, are needed (FSIN, 2014). Assembling these data, however, is no simple academic task, but must be conducted within a transdisciplinary framework with stakeholder involvement, to ensure that the food system is adequately characterised: important structures, links, mechanisms, drivers, outcomes and stakeholders are considered. In the long-term, such studies should enable a more concrete formulation of what contributes to food system resilience. However, we doubt that it is meaningful to hope for a precise and common benchmark, beyond which any food system can be confidently presumed to be sufficiently resilient and able to cope with disturbances. Rather, the building of food system resilience will lie as much in the resilience assessment process as in the quantitative or qualitative results themselves, as described in the next section.

6.2. Building food system resilience

We believe improving food security requires improving resilience from a whole food systems perspective: food systems have multiple components and outcomes, ranging across multiple scales and levels; they are also closely linked to other sectors such as the energy, fiber, and tourism sectors (Fig. 6). This cross-scale, whole system approach needs to be included in any resilience building effort, capturing the concept of panarchy in resilience theory (Holling, 2001; Jones, 2013).

We see three accessible entry points for such a whole food system resilience building process (Fig. 6):

1. National or regional food systems, which comprise multiple value chains contributing to food security and other outcomes of importance in the region. This perspective is of particular interest to national policy-makers and governments, concerned about the food security of their citizens.
2. Individual food value chains ranging from local to global levels, which form the national and regional food systems, and together lead to the diverse outcomes of food systems. For example, looking at individual value chains of agricultural commodities. This perspective is of particular interest to individual value chain actors such as industries and retailers, for whom the value chain is generally a well-known management level.
3. Individual's perspective in the value chain, and the specific outcomes that concern them: this includes smallholder livelihoods, household food security, consumers' health etc. This entry point to resilience assessments has most often been used in existing studies of resilience of components within food systems.

The selection of one of these three entry points can be adapted according to the context within the resilience building process: who is initiating, leading and supporting the process; who is involved; what are the goals of the process; what are the major issues in the food system of interest. No matter which entry point is selected, it is essential that the process then integrates the two other levels in further steps, in order to capture the cross-scale interactions in food systems (both the effect of actions in the entry point level on the rest of the system, and the effect of other issues at other levels on the entry point level component). Without this, there is a high risk of making decisions that do not account for effects at other levels, which may ultimately lead to failure of the desired change.

Any approach seeking to assess and build resilience in food systems needs to include a wide range of stakeholders and interest groups in some form of participatory and collaborative process, as has already been recognized by the Food and Agriculture Organization of the United Nations for example (FAO) (FAO, 2013). Stakeholder knowledge is also very important because of the current lack of data and understanding of resilience in food systems. This lack of data and understanding also means that any efforts to build food system resilience must be conceived as a learning-by-doing,

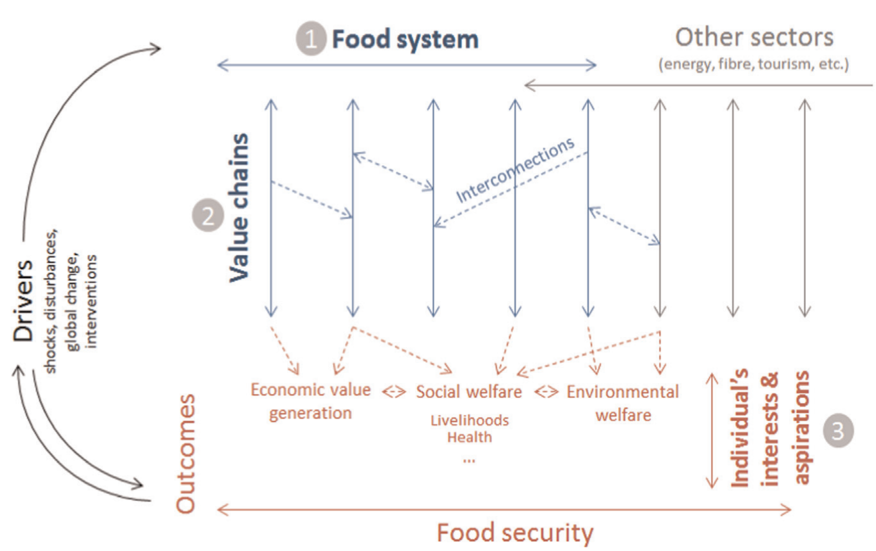

Fig. 6. food systems across multiple levels: national or regional food systems (1) are composed of value chains ranging from the local to the global spatial scale (2); these lead to outcomes affecting various stakeholders at the scales of businesses, communities, households and individuals for example (3).

trial-and-error process: uncertainty must be accepted, allowing action even without a guarantee of immediate success, and iterative improvements continuously made based on lessons learned, since food systems themselves will change over time.

7. Conclusion

Our definition and conceptualization of food system resilience sets a foundation for understanding how we can deal with food system challenges from a holistic, long-term perspective, by narrowing down the diverse disciplinary and general concepts of resilience available, and concretely linking it with state-of-the-art understanding of food systems, their goals and their challenges. The food system resilience approach has a high potential to help cope with the shocks, complexity and uncertainty facing food systems today, by using the concepts of continuous learning, flexibility and "back-up" capacity. However, much has still to be learned in order to validate food system resilience from an analytical perspective. Our contribution is, thus, a critical first step before we can arrive at more quantitative formulations of food system resilience with adequate metrics and measurements, and extend assessments of food system resilience from driver-specific resilience to general resilience accounting for multiple disturbances.

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