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Operationalizing food system resilience: An indicator-based assessment in agroindustrial, smallholder farming, and agroecological contexts in Bolivia and Kenya

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ABSTRACT

Resilience is often considered a precondition for sustainable social-ecological systems. But how can this understanding of resilience be applied to food systems? We operationalized the concept by subdividing it into different resilience dimensions, namely: buffer capacity, self-organization, and capacity for learning and adaptation. Specific indicators were defined for each dimension: (1) agrobiodiversity and livelihood assets for buffer capacity; (2) decentralization and independence, local consumption of production, interest groups, ecological self-regulation, and connectivity for self-organization; and (3) knowledge of threats and opportunities, reflective and shared learning, feedback mechanisms, existence and use of local-traditional knowledge, and a shared food system vision for capacity for learning and adaptation. Next, we applied the resilience indicators to different food systems (agroindustrial, local, and agroecological) in Kenya and Bolivia, including assessment of the interaction and coexistence of food systems. While the contexts in the two countries differ greatly, we identified several common trends that appear to be undermining food system resilience in both settings. These trends include low ecological buffer capacity and self-regulation in agroindustrial food systems; strong disparities in income and access to productive resources; competition for water, land, and labor; exclusion from markets; and low human capital and feedback mechanisms in locally based, traditional food systems. Taken together, these trends cast doubt on food system coexistence narratives. Finally, the results enable us to identify leverage points in the food systems – e.g., regarding learning and feedback mechanisms – that could be used to foster food system transformations linked to goals of sustainability and justice.

1. Introduction

Food systems illustratively link society and nature (Blesh and Wittman, 2015): They are social-ecological systems (Berkes and Folke, 1998; Ericksen, 2008a; Ostrom, 2009) comprising actors – their needs, interests, knowledge, and institutions – determining how to produce, distribute, and consume food, correspondingly giving rise to different impacts on ecosystems. While agricultural yields have increased when measured globally, poor distribution and poor food quality have meant rising numbers of both hungry people and obese people (FAO, 2017), pointing to serious flaws in our food systems inherited from the last century (De Schutter, 2014). Other signs of food system weakness include the erosion of local and national food security in various areas due to the problematic convergence of import/export dependencies, dietary reliance on a narrow range of crops, and climate change impacts, especially in the global South (Bren d'Amour et al., 2016).

Properly addressing the manifold trade-offs between global food production/consumption and environmental, social/cultural, and economic dimensions requires going beyond the common focus on maximizing yields, and instead focusing on optimizing the complex

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interactions of food production, environmental impacts, and social justice outcomes (Godfray et al., 2010). It is necessary to better understand – and eventually act upon – the dynamic interplay of different food systems and their social, economic, political, and ecological effects, thereby situating food security within the wider concept of *food sustainability* (Lang and Barling, 2012).

Rist et al. (2016) developed an operational concept of food sustainability. It classifies food systems as sustainable if they are able to strike a positive balance between five fundamental aspects: (1) the capacity to ensure food security; (2) to fulfil people's right to food; (3) to reduce poverty and inequality; (4) to exhibit a high environmental performance; and (5) to exhibit high levels of social-ecological resilience. From this concept of food sustainability, we thus derive the need for improving food systems' resilience and, by extension, their sustainability so as to ensure human well-being and ecological functioning. Resilience refers not only to the capacity to absorb stress and shocks as a system, but also to the capacity for self-organization and learning among system actors. In this way, resilience is a dynamic concept (Ericksen et al., 2010), accounting for fast and slow changes that must be addressed at multiple interaction scales (Anderies et al., 2006). Overall, resilience may be considered a system property that plays a critical role in the sustainability of food systems.

Resilience is not intrinsically positive, however, and must therefore be embedded in a broader normative framework (see Hodbod and Eakin, 2015). For example, a food system that produces negative environmental or health impacts may be resilient in the short term, but not sustainable or desirable. To identify steps towards increasing long-term food system resilience, the actors involved must co-develop a vision and related values regarding the desired direction of development. Further, Toth et al. (2015) make an important distinction between the concepts of food security and food resilience: While *food security* is an *outcome* of food systems – in terms of the availability, accessibility, and utilization of food (Ericksen, 2008b) – *resilience* corresponds to the ability of food systems to withstand shocks as well as to learn and adapt to changes in external and internal conditions. In this way, resilience represents a broader concept than mitigation of vulnerability. Resilience refers more expansively to the ability of a food system to produce and distribute food under changing conditions, and, if linked to a normative framework such as the concept of food sustainability, to do so in a way that is equitable and sustainable in both the short term and the long term (see Toth et al., 2015). Additionally, Smit and Wandel (2006) state that vulnerability reduction appears most effective when undertaken in combination with strategies and plans at various levels, pointing to an added value compared to regarding resilience simply as the opposite of vulnerability. While vulnerability describes a set of conditions that prevent people from overcoming adverse events, resilience comprises a set of responses where one response may address various vulnerability factors (FSIN, 2010). Sage (2014:255) conceptualizes resilience as a "*desired state to which communities aspire, representing the capacity to absorb disturbance while undergoing changes to retain essentially the same functionality, structure, and identity*", and links the concept to food system transformation. Jones and Tanner (2016) have sought to shift the theory of resilience away from conceptualizing the return of a given system to its "original" state and towards conceptualizing the root causes of vulnerability and loss of resilience. Together with other previous work – e.g., that of Ericksen et al. (2010) who state that resilient food systems should have the potential to create opportunities for innovation and development – the relevance of the concept of resilience to transformation becomes evident.

To date, few research studies have applied resilience thinking to sustainability assessments of food systems. Food-related resilience studies have analysed specific components of food systems (Tendall et al., 2015), including: the resilience of agroecosystems and pastoral systems to climate change (Choptiany et al., 2017; Molina-Murillo, 2017; Heckelman et al., 2018); the role of different forms of knowledge (Anderson, 2015); functional and response diversity (Hodbod and Eakin, 2015); as well as global comparisons of national income levels, yield gaps, and food calories produced (Seekell et al., 2016). Ifejika Speranza et al. (2014) applied resilience thinking to livelihoods, conceptualizing resilience as a system property and component of sustainability corresponding to the ability to adapt to or handle social-ecological change, thereby providing an example of operationalization. Our research builds on the theories of Tendall et al. (2015) and on the conceptual-empirical work of Ifejika Speranza (2013) and Ifejika Speranza et al. (2014)), applying a resilience assessment to food systems as part of their sustainability performance. The present study was part of a larger research project on food system sustainability in South America and Africa (Rist et al., 2016). The project study areas were in Kenya and in Bolivia, with each study area featuring different types of food systems and figuring prominently in the respective national food supply. Both Bolivia and Kenya have the human right to food enshrined in their constitution (Kenya in 2010; Bolivia in 2009) and may be considered innovative in this respect. With the aim of contributing to the operationalization of resilience thinking in research on food systems, we conducted a parallel assessment in Kenya and Bolivia based on the following research questions:

(1) What is the state of social-ecological resilience in different, coexisting food systems in Kenya and Bolivia?
(2) What are the key differences or similarities that reduce resilience in the selected food systems?
(3) What are the main identifiable leverage points or potentials for increasing resilience in the different food systems?

2. Materials and methods

2.1. Operationalizing resilience in three dimensions

To apply the concept of resilience to food systems, we used the three core dimensions of resilience proposed by Carpenter et al. (2001). Application of these three resilience dimensions – i.e. buffer capacity, self-organization, and the capacity for learning and adaptation – makes it possible to join biophysical and social aspects of "resistance", and include the dynamic component of organization and adaptation. In this way, the rather abstract overarching concept of "resilience" may be made operational and indicators can be identified. Further, we primarily used Cabell and Oelofse's (2012) indicator framework for agroecosystem resilience to assess these three core dimensions, adapting the framework to food systems by drawing on additional literature as outlined below.

(1) *Buffer capacity*: referring to the capacity of a system and its properties to cushion against stresses and shocks. The state of and access to livelihood assets – i.e., natural, human, financial, social, and physical capital (DFID, 1999) – indicate the resilience of the actors in a food system (Alinovi et al., 2010; Ifejika Speranza et al., 2014; Lisa et al., 2015). We considered whether food system activities generate a livable wage/income when assessing financial capital (Cabell and Oelofse, 2012), and considered people's autonomy in decision-making when assessing social capital (Rotz and Fraser, 2015). Further, the diversity of system components is key to resilience (ibid.). To assess this indicator, we considered the diversity of crops and breeds (variety level) on farms. Many connections among a diversity of system components ensure a wide range of possible responses to external or internal challenges and enable redundancy (Altieri, 2013), permitting the food system to adjust to losses and to buffer against shocks.
(2) *Self-organization*: referring to the degree to which actors in a food system are capable of controlling system processes as well as to self-regulation, or the extent to which food system processes interact to keep the system functioning. Following Anderson (2015) and Carpenter et al. (2001), resilience is related to the degree of