USING MICROWORLDS FOR RESILIENCE MANAGEMENT OF FOOD SYSTEMS

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EXTENDED ABSTRACT

Food systems are socio-ecological systems in which a variety of stakeholders interact through a wide range of activities such as production, packaging, selling and consumption of food (Ericksen, 2008). The objectives for food systems include long-term sustainability of food security and social and environmental outcomes (Ericksen, 2008). A prerequisite for long-term sustainability is the capacity of a system to maintain its functionality without compromising its ability to do so in the future. There is an increased awareness of the vulnerabilities of food systems to changes in the environment like those introduced by climate change (e.g. water scarcity, weather variability) (Campbell et al, 2016; Tendall et al, 2015).

Socio-ecological resilience is essentially understood as a system ability to maintain its functionality even when it is being affected by a disturbance (Folke et al, 2010; Holling, 1996). While sustainability provides a framework for long-term planning, resilience focuses on adaptive mechanisms that will support a system's functionality in the medium and long-term future. The emphasis on adaptive mechanisms to unpredictable changes has made resilience a compelling forward-looking approach to adaptation (Berkes and Jolly, 2001; Pizzo, 2015).

While resilience is a characteristic of the system, resilience management is the active modification of a system with the explicit aim to improve its capacity to absorb and adapt to change (Nettier et al, 2017; Fath et al, 2015; Walker et al, 2002). These capacities depend on the way the system has been organised and, therefore, resilience management is interested in understanding such organisation and identifying more effective ways for structuring the system.

According to Walker et al. (2002: 14), the aims of resilience management are a) to prevent a system from transitioning into undesirable configurations in the face of external shocks and b) to develop the conditions that facilitate system adaptability. While the first aim of resilience management requires that system resilience is operationalised, its second aim implies that resilience management process is not a normative process. Instead, resilience management needs to be approached as a structured and systematic framework that allows stakeholders to adapt to challenges in the environment (Nettier et al, 2017; Holling & Gunderson, 2002).

In the past, system dynamics model had been used to operationalise and assess resilience (e.g. Herrera, 2018; Brzezina,2016). However, there is little research about how to use these models to facilitate adaptability. Herrera and Kopainsky (2020) make a first step in this direction by recommending to use system dynamics in participatory setting. Following the advice of other authors (e.g. Walker et al. 2002; Resilience Alliance, 2010), Herrera and Kopainsky recommend to use stakeholder engagement to help stakeholders to understand important adaptive mechanisms driving system's resilience.

In participatory settings, like group model building, system dynamics models are used as boundary objects. These boundary objects are not only helpful tools for conducting analysis but a joint representation of stakeholders views that is used in the group model building process to mediate between conflicting stakeholder views and to build consensus about the system challenges and potential solutions. As Herrera and Kopainsky (2020, p12) concluded, used in participatory settings system dynamics models help "to make

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sense of some assumptions, allow testing hypotheses and supports learning about the system".

In this paper we keep exploring how system dynamics models can simultaneously support learning and policy making by reflecting on the model itself, as a boundary object, rather than the participatory process that could be used to develop it. We do so by borrowing the concept of 'microworlds for policymaking debate' introduced by Morecroft (1998).

Microworlds are system dynamics models that are simple enough to act as boundary objects and be easily grasped by stakeholders but realistic enough to offer relevant insights about scenarios and to support the policy debate. Microworlds help to foster understanding among stakeholders by capturing stakeholders knowledge into diagrams and enriching that knowledge with the insights from computer simulations (Morecroft, 1998).

In this paper we show how relatively simple and small models can be used as microworlds for resilience management. Resilience management requires understanding social, economic and environmental aspects of food systems (De Bruijn et al, 2014; Berkes, 2009). Therefore, food systems need to be studied as a whole and the processes and subsystems within the system viewed as interdependent (Biesbroek et al, 2017; Bruijn et al, 2017; Walker et al, 2002). Elements of the system traditionally considered in isolation are often part of complex structures linking them and conditioning the system outcomes (Spielman et al., 2009). This complexity is challenging if modellers want to keep the model accessible and transparent to the stakeholders.

The results presented in this paper show that there are at least three clear benefits from using small microworlds. First, small models allow us to aggregate complex systems into their main dynamics helps to understand what are the underlying mechanisms driving systems responses. The diagrams and simulation results presented in this paper illustrate how theoretical and empirical knowledge can be translated into mathematical tools that facilitate a discussion about resilience and its drivers. By keeping the model small and simple, the model structure itself can be used to understand and to communicate complex dynamics in a concise and comprehensive manner.

Second, the simplicity and transparency of the models used also ease the analysis and discussion of potential points for intervention and strategies that can enhance resilience. Whereas the simulation results produced by the model are not meant to offer an accurate prediction of future developments, the analysis we present in this study shows how simulation results can be used to explore the complex mechanisms fostering resilience. Understanding these mechanisms and basic dynamics will help researchers and policymakers to identify areas where further research and more detailed examination is needed. For instance, stakeholders might decide to explore in more detail, and consider a wider political and economic agendas, the benefits and challenges of focusing on local production against opening local markets to foreign crops.

Third, having models with wide breath allows stakeholders to experiment with different strategies and to investigate trade-offs between different types of resilience. Looking at the simulation results and model structures it becomes evident that there are some trade-offs between resilience to different disturbances (e.g. environmental vs. economic disturbances).

References:

Berkes F (2009). Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of environmental management* 90(*5*): 1692-1702.

Biesbroek GR, Termeer CJ, Klostermann JE and Kabat P (2014). Rethinking barriers to adaptation: Mechanism-based explanation of impasses in the governance of an innovative adaptation measure. *Global Environmental Change* 26: 108-118.

Biesbroek R, Dupuis J, & Wellstead A. (2017). Explaining through causal mechanisms: resilience and governance of social–ecological systems. *Current Opinion in Environmental Sustainability* 28, 64-70.

Brzezina N, Kopainsky B, Mathijs E (2016) Can organic farming reduce vulnerabilities and enhance the resilience of the European food system? A critical assessment using system dynamics structural thinking tools. *Sustainability* 8(*10*):971

Campbell BM, Vermeulen SJ, Aggarwal PK, Corner-Dolloff C, Girvet, E, Loboguerrero AM, … Wollenberg E. (2016). Reducing risks to food security from climate change. *Global Food Security* 11, 34–43.

De Bruijn KM, Diermanse FLM and Beckers, JVL (2014). An advanced method for flood risk analysis in river deltas, applied to societal flood fatality risk in the Netherlands. *Natural*

Hazards and Earth System Sciences 14(*10*): 2767-2781.

Ericksen, P. (2008). Conceptualizing food systems for global environmental change research. *Global Environmental Change*, 18(*1*), 234–245.

Fath BD, Dean C and Katzmair H (2015). Navigating the adaptive cycle: an approach to managing the resilience of social systems. *Ecology and Society* 20(*2*).

Folke C, Carpenter SR, Walker B, Scheffer M and Chapin T (2010). Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society* 15(*4*).

Herrera, H. (2017). From Metaphor to Practice: Operationalizing the Analysis of Resilience Using System Dynamics Modelling. *Systems Research and Behavioral Science* 34(*4*), 444–462.

Herrera H. (2018) Public Policy Design for Climate Change Adaptation: A Dynamic Performance Management Approach to Enhance Resilience. In: Borgonovi E., Anessi-Pessina E., Bianchi C. (eds) Outcome-Based Performance Management in the Public Sector. *System Dynamics for Performance Management*, (pp. 425-445). Springer, Cham.

Herrera H, Kopainsky B. (2020). Using system dynamics to support a participatory assessment of resilience. *Environment Systems and Decisions*, 1-14.

Holling CS. (1996). Engineering resilience versus ecological resilience. *Engineering within ecological constraints*, 31-32.

Holling CS, Gunderson LH (2002). Panarchy: Understanding transformations in human and natural systems. Washington, DC: Island Press.

Morecroft JD. (1988). System dynamics and microworlds for policymakers. *European journal of operational research* 35(*3*), 301-32

Nettier B, Dobremez L, Lavorel S and Brunschwig G. (2017). Resilience as a framework for analyzing the adaptation of mountain summer pasture systems to climate change. *Ecology and Socie*ty 22(*4*).

Pizzo, B. (2015). Problematizing resilience : Implications for planning theory and practice. Cities, 43, 133–140.

Resilience Alliance (2010). Assessing resilience in social-ecological systems: Workbook for practitioners. Version 2.0. http://www.resalliance.org/3871.php

Tendall, D.M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q. B., … Six, J. (2015). Food system resilience : Defining the concept Resilience Sustainability. *Global Food Security* 6, 17–23.

Walker, B., Carpenter, S., Anderies, J., Abel, N., Cumming, G., Janssen, M., … Pritchard, R. (2002). Resilience Management in Social-ecological Systems : a Working Hypothesis for a Participatory Approach. *Conservation Ecology*, 6(*1*), 14.