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Research paper

Transforming food systems at local levels: Using participatory system dynamics in an interactive manner to refine small-scale farmers' mental models

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ABSTRACT

Food systems will need to undergo considerable transformation. To be better prepared for and resilient to uncertainty and disturbances in the future, resource users and managers need to further develop knowledge about the food and farming system, with its dominating feedback structures and complexities, and to test robust and integrated system-based solutions. This paper investigates how participatory system dynamics modeling can be adapted to groups at the community level with low or no formal educational background. The paper also analyses the refinement of workshop participants' mental models as a consequence of a participatory system dynamics intervention. For this purpose, we ran two workshops with small-scale farmers in Zambia. Analysis of workshop data and post-workshop interviews shows that participatory system dynamics is well adaptable to support an audience-specific learning-by-doing approach. The use of pictures, objects and water glasses in combination with the basic aspects of causal loop diagramming makes for a well-balanced toolbox. Participants acquire understanding that is also relevant beyond systems thinking in that it offers a range of practical insights such as a critical evaluation of common food security strategies.

1. Introduction

Food systems will need to undergo significant transformation and adaptation in order to meet future challenges of achieving food security for all, decreasing environmental impacts and adapting to climate change (Foley et al., 2005; Godfray et al., 2010; Godfray et al., 2011). Food systems are social-ecological systems (SES) that consist of biophysical and social factors linked through feedback mechanisms (Berkes et al., 2003). These mechanisms determine the outcome of food systems over time. A wide range of policy and management actions is available to create positive outcomes at the micro-level in the face of the above-mentioned challenges. For the case of small-scale farmers in sub Saharan Africa, these actions include direct interventions in farm management practices, adoption of new technologies and knowledge management, incl. strengthening networks and local governance (Below et al., 2010). As SES are both complex and adaptive, they require resource users and mangers to continuously test and develop new knowledge and understanding in order to cope with change and uncertainty (e.g., Carpenter and Gunderson 2001; Thompson and Scoones, 2009; Darnhofer et al., 2010). This reinforces the need for effective knowledge management.

Participatory modeling (e.g., Voinov and Gaddis, 2008; Voinov and Bousquet, 2010) is often used in the context of knowledge management because it facilitates inclusion of diverse knowledge sets and at the same time enables explicit examination of the trade-offs and synergies in different food system outcomes under alternative management scenarios. Davies et al. (2015) explored the efficacy of different participatory modeling approaches with respect to their ability to contribute to knowledge management, that is, to generate four important elements of social capital needed to address wicked or complex dynamic problems: enhancing social learning and capacity building; increasing transparency; mediating power; and building trust. Their study found that mediated modeling or participatory system dynamics, group mapping, and mental/conceptual modeling are all likely to generate elements

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of social capital that can improve ecosystem services or social-ecological systems frameworks.

The field of System Dynamics (SD) has a long tradition of facilitating learning about complex systems through the use of system diagrams and computer simulation models (Lane, 1992; Vennix, 1996; Sterman, 2000), also in the context of agricultural production and development (e.g., Matinzadeh et al., 2017; Walters et al., 2016). It utilizes those tools to develop an understanding of the interdependent structures of dynamic systems, that is, the ability to: understand how the behavior of a system arises from the interaction of its agents over time (i.e., dynamic complexity); discover and represent feedback processes (both reinforcing and balancing) hypothesized to underlie observed patterns of system behavior; identify stock and flow relationships; recognize delays and understand their impact; identify nonlinearities; and recognize and challenge the boundaries of mental (and formal) models (Booth Sweeney and Sterman, 2000).

Participatory system dynamics employs the use of system diagrams (Videira et al., 2014) and computer simulation models (Andersen et al., 2007) in group-settings. While the purpose of participatory SD is often the construction of a running simulation model, the process accommodates a range of additional goals: mental model refinement, commitment, the creation of a shared language, consensus and alignment (Rouwette and Vennix, 2006). The effectiveness of participatory SD, however, might be restricted in contexts in which computer simulation is not possible or not fit for purpose. Hence, a different approach might be required.

In this paper we report on a participatory SD modeling process tailored to groups at the community level with very basic or no formal educational background using an interactive learning-by-doing approach. This approach unlocks participatory SD and its ability to explicitly examine the direct and indirect consequences of proposed management options to a relatively new audience. Our approach thus acts as a knowledge management strategy that strengthens local communities through shared systems learning, networking and an increased focus on local governance and empowerment.

There is no single classification of knowledge management strategies, but rather a series of theories about how knowledge is created and shared by individuals in the same network (e.g. Berkes, 2008; Maier and Remus, 2003). The term knowledge management strategy is usually used to describe approaches for managing knowledge-related activities such as knowledge elicitation, information dissemination, and learning (Bhatt, 2002). In this paper, we focus on learning, that is, the process of building a common understanding of the main dynamics of a system.

Learning in the context of participatory modeling processes results from participants sharing their own mental-models (tacit knowledge) with the rest of the group (Tavella and Franco, 2015; Choi and Lee, 2002). During this process, mental models are captured in system maps or formal simulation models and thus transformed into explicit knowledge that can be accessed by others (e.g., Sims and Sinclair, 2008). Moreover, knowledge captured in a model in the form of data and causal relationships is used to produce new knowledge about effects and consequences of interventions on the system. Hence, participants not only learn from each other but also from the model itself (Tavella and Franco, 2015) and this new knowledge can then be used to tackle other problems or to broaden the range of options explored to tackle to problem at hand (Berkes, 2008).

The objective of this paper is twofold:

1. It reports on the modification of the participatory SD modeling method so that it can be used as a knowledge management strategy at the community level adaptable to contextual factors, incl. the educational background of the participants.
2. It explores how this adapted design for participatory SD can facilitate participant learning and mental model refinement about food systems and with that support decision making at the local level.

For this purpose, we designed and ran two participatory SD workshops with small-scale farmers in Zambia. Those small-scale farmers face recurrent food insecurity as well as rapidly changing and increasingly volatile framework conditions, which calls for considerably strengthening their adaptive capacities. Video material from the workshops as well as interviews at two different times after the workshops allowed us to track changes in participants' systemic understanding of their food security and livelihood situation and options they considered for improving it. This data provides clear evidence that the participatory SD intervention effectively helped participants to improve their understanding of the archetype structures that lock them in a vicious circle of food insecurity and poverty. Additionally, the intervention provided participants with tools to evaluate not only the direct and short-term but also the indirect and long-term consequences of different coping and adaptation options.

2. Methods

A participatory SD process is generally broken down into three distinct stages: (1) problem scoping, (2) workshop planning, and (3) the actual participatory modeling workshops (Hovmand, 2014). The problem-scoping phase involves interviews and discussions to identify the problem of interest. The workshop planning phase designs the participatory modeling workshops by developing a series of activities or exercises and facilitated discussions that are eventually implemented in the workshops and evaluated afterwards. This section describes the participatory SD process in two case study villages in Zambia and the subsequent analysis of video and audio data.

2.1. Participatory system dynamics workshops

2.1.1. Site description

According to the Food Security Index (The Economist, 2013), Zambia is one of the ten most food insecure countries in the world. Agricultural productivity in the country is held back by a lack of access to inputs and services, as well as to transport, markets and other social infrastructure. At present, small-scale farmers do not have access to financial services, and even larger enterprises lack access to long-term finance. Soil fertility is decreasing, and agricultural farming systems are one sided. This is particularly the case for small-scale farmers and staple crops, mainly maize production (Neubert et al., 2011). External drivers, such as climate change and economic shocks, are posing increasingly significant challenges to the agricultural sector. Rainfall patterns have changed significantly since the late 1980s and, on average, delayed the onset of the rainy season by one to two months (Neubert et al., 2011; Nyanga et al., 2011).

This study was conducted in Chibombo district. Chibombo district is located in the Central Province, about 90 km to the north of Lusaka. It is a farming district where about 90% of the district population depends on agriculture for their livelihoods. The district lies within the Agro-Ecological Region II, spanning from east to west covering the central part of Zambia. It receives rainfall between 800 and 1200 mm per year and is characterized by relatively good soil fertility with limitations due to low nutrient retention and water holding capacity (FAO, 1998). Climatic conditions make it suit-