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Towards a complexity-aware theory of change for participatory research programs working within agricultural innovation systems

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ABSTRACT

Agricultural innovation systems (AIS) are increasingly recognized as complex adaptive systems in which interventions cannot be expected to create predictable, linear impacts. Nevertheless, the logic models and theory of change (ToC) used by standard-setting international agricultural research agencies and donors assume that agricultural research will create impact through a predictable linear adoption pathway which largely ignores the complexity dynamics of AIS, and which misses important alternate pathways through which agricultural research can improve system performance and generate sustainable development impact. Despite a growing body of literature calling for more dynamic, flexible and "complexity-aware" approaches to monitoring and evaluation, few concrete examples exist of ToC that takes complexity dynamics within AIS into account, or provide guidance on how such theories could be developed. This paper addresses this gap by presenting an example of how an empirically-grounded, complexity-aware ToC can be developed and what such a model might look like in the context of a particular type of program intervention. Two detailed case studies are presented from an agricultural research program which was explicitly seeking to work in a "complexity-aware" way within aquatic agricultural systems in Zambia and the Philippines. Through an analysis of the outcomes of these interventions, the pathways through which they began to produce impacts, and the causal factors at play, we derive a "complexity-aware" ToC to model how the cases worked. This middle-range model, as well as an overarching model that we derive from it, offer an alternate narrative of how development change can be produced in agricultural systems, one which aligns with insights from complexity science and which, we argue, more closely represents the ways in which many research for development interventions work in practice. The nested ToC offers a starting point for asking a different set of evaluation and research questions which may be more relevant to participatory research efforts working from within a complexity-aware, agricultural innovation systems perspective.

1. Introduction

Agricultural innovation systems are increasingly understood to be complex adaptive systems, a type of complex system with specific characteristics that hold significant implications for interventions seeking to create "impact" within these systems. In complex adaptive systems (CAS), a wide array of heterogeneous actors adapt their strategies and actions based on the actions of others and on changing system conditions, while contributing to these changing conditions through their evolving responses to them (Spielman et al., 2009; Klerkx et al., 2010). As a result of the dynamic nature of these inter-connected changes, CAS produce unpredictable yet recognizable patterns, such as co-evolution, path dependency and emergent properties, which cannot be predicted by understanding the behavior of discreet actors within the system (Axelrod and Cohen, 2000; Axelrod and Cohen, 2000). In CAS, small initial changes in system conditions can create large and unanticipated impacts throughout the system, even when system components are connected in ways that are causally deterministic (Miller and Page, 2007).

While complex adaptive systems do not readily lend themselves to control or management due to their unpredictable nature (Spielman et al., 2009; Arkesteijn et al., 2015), they can be successfully intervened into if the intervener has an understanding of the dynamics of CAS and how to harness these (Williams, 2011). Snowden (2010) proposes a strategy of seeing program intervention as catalytic probes that stimulate patterns of activity. Program staff then stabilize and amplify

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Table 1
Comparison of the traditional approach to agricultural research for development with a recent complexity-aware one.
(Adapted from Klerkx et al. (2012) and Douthwaite (2016).)

Characteristics	Linear approach to AR4D	Complexity-aware approach to AR4D
Name	"Transfer of technology" or "pipeline"	"Agricultural innovation systems"
Era	Central since 1960s to present	From 2000s to present
Mental model and activities	Supply technology to next user	Co-develop innovation involving multi-actor processes and partnerships
Knowledge and disciplines	Single discipline driven (mainly plant breeding)	Transdisciplinary, holistic systems perspective
Drivers	Supply-push from research	Responsiveness to changing contexts, patterns of interaction
Source of innovation	Scientists	Multiple actors, innovation platforms
Role of farmers	Adopters or laggards	Partners, entrepreneurs, innovators exerting demands
Role of scientists	Innovators	Partners, one of many responding to demands
Key changes sought	Benefits accruing from technology adoption	Institutional change, increase in system capacity to innovate
Dynamic	Research begins quickly according to a pre-defined agenda	Intervention begins by building relationships and trust through an open research agenda

beneficial patterns and dampen down and kill off negative ones. This is similar to the improvisational model of change management proposed by Orlikowski and Hoffman (1997) in which planned change gives rise to emergent change that then provides opportunity for further planned change.

A sub-set of agricultural research interventions over the past twenty years have been designed by actors who are aware of the complex nature of agricultural innovation systems (AIS). These interventions have sought to harness the dynamics of complexity to catalyze system learning, innovation, and adaptive change within AIS. Examples of these "complexity-aware" approaches to agricultural research include Integrated Natural Resource Management in the 1990s (Campbell and Sayer, 2003), Learning and Action Research in the 2000s (Probst and Hagmann, 2003), and Adaptive Collaborative Approaches (Ojha and Hall, 2013). Such approaches cast extension agents and researchers in the role of "innovation brokers" (Klerkx et al., 2012), and facilitators of multi-stakeholder innovation processes (Dugan et al., 2013; Kraaijvanger et al., 2016). Klerkx et al. (2012) provides a summary of the evolution of systems and complexity-aware approaches based on a literature review. Table 1, adapted from that paper, compares the traditional linear approach to technology development and transfer with a complexity-aware one to illustrate the dimensions of difference between the two approaches.

While much has been written on the need for systems approaches when intervening into complex natural, social, and/or economic systems, less has been said about the outcomes that result from using these approaches. There is, however, a small body of empirical work which is starting to show that these approaches generate benefits that contribute to the ability of local systems to evolve in ways that contribute to inclusive and sustainable development. Complexity-aware research interventions into AIS can build multiple types of social capital (Uphoff and Wijayaratna, 2000), increase system actors' skills and confidence in systematic experimentation, and lead to the development of new practices and technologies as well as the application of existing agricultural knowledge and technology to new local contexts (Ayele et al., 2012; Sterk et al., 2013; Hounkonnou et al., 2016; Kraaijvanger et al., 2016). There is also evidence that these approaches improve the functioning of local and regional institutions (Hounkonnou et al., 2016) as well as the linkages and relationships between key system actors (Douthwaite et al., 2015). The benefits of these outcomes can be significant for rural smallholders and other system stakeholders: Uphoff and Wijayaratna (2000) found that investment in farmer-led irrigation groups built specific forms of cognitive and structural social capital that allowed farmers to significantly increased agricultural productivity in the face of sudden and severe water scarcity over thousands of hectares in the Gal Oya area of Sri Lanka.

Despite evidence that complexity-aware approaches can produce valuable results, the dominant narrative about how agricultural research creates impact, particularly in the context of developing economies, remains complexity-blind (Ekboir, 2003; Klerkx et al., 2012; Schut et al., 2016). This narrative holds that agricultural researchers develop knowledge, technology, and processes to address the problems of farmers and other agricultural system actors. These innovations are passed on to other organizations who are tasked with promoting their adoption and use (Hellin et al., 2008). Impact for end-users and for the system derives from the adoption, use, and scaling of these improved technologies and ways of doing things, which can include new or improved methods (Ayele et al., 2012; Schut et al., 2016; Gaunand et al., 2015; Joly et al. 2015; Wigboldus et al. 2016). This model has several names in agriculture including the "pipeline" approach to innovation (Sumberg et al., 2003), the "central source of innovation" model (Biggs, 1990) and the "transfer of technology" or "diffusion of innovation" approach (Klerkx et al., 2012). In industry, the model is called the "delivery" mode or "over-the-wall" approach (Leonard-Barton, 1995). We call this conventional model the "adoption impact pathway" where "impact pathway" refers to a causal chain of inputs, processes and outcomes that lead to impact.[2]

In the past five years, several studies have sought to better understand and describe how agricultural research efforts create societal impact, focusing on uncovering diverse impact pathways and on understanding aspects of the research process which themselves contribute to producing and sustaining impact over time (Gaunand et al., 2015; Schut et al., 2014). These studies have highlighted the importance of process-related factors, such as the quality and duration of research partnerships, the nature of roles and relationships between researchers and stakeholders, and the type of research strategies used in particular contexts as important determinants of impact (Joly, et al. 2015; Schut et al., 2016). However, the insights and findings emerging from this work have not yet been incorporated into usable, alternative theories of change (ToC) which could guide the program planning and evaluation work of major actors in international agricultural research.

Despite significant criticism from within the literature, the long-established adoption impact pathway therefore remains the dominant overarching change narrative for major international funders of research and innovation related to global development (Dalrymple 2008; Renkow & Byerlee, 2010). It is also the dominant change narrative for agenda-setting institutions for international agricultural research such as the Food and Agriculture Organization (FAO) and the CGIAR[3]

[2] An impact pathway is a more descriptive synonym for "theory of change" (ToCo) (Douthwaite et al., 2003), which describes how and why a program works (Weiss, 1995). ToC is useful to guide implementation and as the basis of theory-driven evaluations (Douthwaite et al., 2003; Stame, 2004).

[3] The CGIAR is a worldwide partnership addressing agricultural research for development carried out by 15 research centers. The CGIAR's vision is a world free of poverty, hunger and environmental degradation (CGIAR, 2016). As of 2014, the CGIAR employed more than 8500 researchers and support staff worldwide, with an annual budget of US $800 million (Agropolis International, 2015). While CGIAR funds represent a small proportion of the total global funds invested in agricultural research in developing countries, the CGIAR influences how this investment is conceptualized, implemented and evaluated