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A conceptual framework to support adaptation of farming systems – Development and application with Forage Rummy

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ABSTRACT

The context of agricultural production, climate change in particular, increasingly requires adaptations to the structure and management of farming systems. As a result, farmers need to develop their adaptive capacity. To support this process, agricultural research has developed two main approaches: hard approaches that are mainly science-driven and rely on simulation models, and soft approaches that rely fully on stakeholders' knowledge. Both approaches present several drawbacks to achieve relevance to real-world decision-making and management. In this article, I elaborate a conceptual framework hybridizing hard and soft approaches to develop farmers' adaptive capacity. First, based on the literature, I define the requirements (systemic, situated, integrating multiple perspectives, etc.) for research approaches aimed at developing farmers' adaptive capacity. According to these requirements, I clarify the scope for hybridization of hard and soft approaches. For instance, hard approaches enable integration of up-to-date scientific knowledge while soft approaches ensure local relevance, thanks to stakeholders' knowledge. However neither approach is able to synergize the two knowledge types (scientific and empirical). Building on this analysis, the proposed conceptual framework relies on participatory group (researchers and stakeholders) modeling workshops. During these workshops, stakeholders are involved in an iterative process consisting of designing and evaluating candidate adaptation solutions using boundary objects encapsulating scientific and empirical knowledge. An application example of the conceptual framework is presented with Forage Rummy. Playing this board game, farmers' groups use their empirical knowledge to select and combine sticks and cards representing forage crop and grassland production and animal feeding, production and reproduction from a range of possibilities to design a livestock system. The system designed is instantaneously evaluated using a spreadsheet informing among other things about the matching of forage production and animal feeding requirements. Past workshops show that Forage Rummy stimulates farmers' discussions and knowledge exchange about farming practices. By supporting collective thinking about adaptation of livestock systems to changes in the production context e.g. climate change, it develops farmers' adaptive capacity.

1. Introduction

Under the influence of various factors (climatic, economic, social, etc.), the context of agricultural production is increasingly changing and erratic (Gilbert and Morgan, 2010; IPCC, 2007). With the support of agricultural consultants, farmers keep trying to adapt their farming systems to this context in order to preserve the sustainability, in particular the production ability, of such systems (Darnhofer et al., 2010; Fleming and Vanclay, 2009; Reidsma et al., 2009). Adaptation refers to a process, action or outcome in a system in order for the system to better cope with, manage or adjust to experienced or expected events e.g. climatic (Smit and Wandel, 2006). The pace, scale and even the direction of contextual changes being plagued with uncertainties (Thompson and Scoones, 2009), it is particularly difficult for farmers to make decisions about adaptation measures.

To address this adaptation challenge, technology transfer has long been dominant in agricultural research and development. It consisted of the development and promotion of ready-to-use technical adaptation packages with limited consideration for the peculiarities of farming systems and contexts (Darnhofer et al., 2010). Nowadays, these approaches are no longer of interest to effectively manage potential contextual changes such as climatic risks (Howden et al., 2007). Indeed, the occurrence and impacts of contextual changes are increasingly variable between farms within a single region (Reidsma et al., 2007). Hence the effectiveness of farming system adaptation and the connected preservation of the sustainability of farming systems require flexibility, since there are

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no single problems and no single adaptation solutions (Magne and Ingrand, 2004; Vanclay, 2004).

Over recent years, along with the development of adaptation science (Meinke et al., 2009) and unlike the technology transfer approach, approaches seeking to develop farmers' adaptive capacity have increasingly been developed (Darnhofer et al., 2012; Klerkx et al., 2012b; Speelman et al., 2014). Adaptive capacity refers to farmers' "ability to design and implement effective adaptation strategies, or to react to evolving hazards and stresses so as to reduce the likelihood of the occurrence and/or the magnitude of harmful outcomes resulting from climate-related hazards" (Brooks et al., 2005). Adaptive capacity and the corollary concept of adaptive management (Pahl-Wostl et al., 2007) build upon farmers' local knowledge as well as farmers' learning about oneself, the farming system and its environment (Newsham and Thomas, 2011). It consists of continually improving management strategies and practices by learning from the outcomes of implemented strategies and practices.

As elaborated by Darnhofer et al. (2012), agricultural research accommodates two approaches to promote learning and, as a result, adaptive capacity of farmers. (i) The hard approach (e.g. Hansen, 2005) views farming systems as real entities existing as such with defined boundaries and goals. It relies on analysis and modeling of data from physical, chemical, physiological and ecological processes. Farmers are seen as optimizers seeking for combinations of best technical means to manage their farming systems. (ii) The soft approach (e.g. Ison et al., 2007) views farming systems as social constructs with negotiated boundaries and goals. The core concern is farmers' perceptions of their environment and their adaptation options. Farmers' strategies are seen as the product of human interaction, learning, conflict resolution and collective action.

As stated by several authors (Darnhofer et al., 2012; Martin et al., 2011c), both hard and soft approaches have drawbacks. For instance, due to mathematical complexity and inflexibility (Jones et al. 1997), the hard approach is criticized for being unable to cope with different production and management contexts and for relying on 'black box' models lacking transparency (Leeuwis, 2004; McCown et al., 2009). The consequence is that applications of the hard approach are regarded as unintelligible and as a result neither salient nor legitimate by most farmers. On the other hand, quantitative analysis and up-to-date scientific advances are neglected by the soft approach (Sellamna, 1999). Moreover, the soft approach hardly enables exhaustive exploration of the whole space of adaptation options. Applications of the soft approach may thus lack scientific credibility.

So far, in agricultural science, despite practical examples (e.g. Van Paassen et al., 2007) no third way has emerged that combines the merits of the hard and soft approaches to compensate for their drawbacks, with the aim of promoting learning and hence the adaptive capacity of farmers. In this article, I elaborate the conceptual foundations of such a third way, located at the interface between the hard and soft approaches. In Section 2, based on the scientific literature, I define a set of requirements for approaches aimed at developing the adaptive capacity of farmers. In Section 3, based on these requirements, I evaluate the benefits and drawbacks of the hard and soft approaches, and point out opportunities for hybridizing the two approaches. In Section 4, I present the conceptual foundations of such a hybridization and an application example, i.e. Forage Rummy (Martin et al., 2011a). The whole work is discussed in Section 5.

2. Requirements for research approaches aimed at developing farmers' adaptive capacity

As stated by Cash et al. (2003), effectiveness of scientific information and intervention in influencing societal learning and action and hence farmers' adaptive capacity and adaptations of farming systems depends on three main features: credibility, salience and legitimacy. "Credibility involves the scientific adequacy of the technical evidence and arguments. Salience deals with the relevance of the assessment to the needs of decision makers. Legitimacy reflects the perception that the production of information and technology has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of opposing views and interests" (Cash et al., 2003).

Table 1
Determinants of salience, credibility and legitimacy for research approaches aimed at developing farmers' adaptive capacity.

	Problem reframing stage
Salience	Situated approach
	Systemic approach
Credibility	Up-to-date and multidisciplinary scientific knowledge
	Scientific methods for design and evaluation of candidate solutions
Legitimacy	Transparency
	Multiple perspectives

Based on the scientific literature, a number of determinants can be identified for salience, credibility and legitimacy respectively (Table 1). Applied to the enhancement of farmers' adaptive capacity, I consider that salience is conditioned by three features of the research approach: it has to include a (i) problem reframing stage, and has to be (ii) situated and (iii) systemic. In order to be credible, the research approach has to use (iv) up-to-date and multidisciplinary scientific knowledge and (v) scientific methods for design and evaluation of candidate solutions for adaptation of farming systems. Finally, legitimacy is a function of (vi) the transparency of the research approach for stakeholders and the extent to which it (vii) integrates the multiple perspectives of researchers and stakeholders such as farmers.

(i) As stated by Pretty (1995), there is no single correct understanding of problem situations. These understandings are framed by individual interpretations that themselves depend on knowledge and beliefs acquired during life. A typical pitfall for research approaches aimed at enhancing farmers' adaptive capacity is to take definitions of problem situations for granted, i.e. without questioning the problems farmers face and how they are handling them now (Cox, 1996). This may lead to lack of structure in problem situation definitions because farmers' goals and constraints, knowledge underpinning decisions as well as farming system states are uncertain, contested or even unknown (Groot and Rossing, 2011; McCown, 2002). Ill-structured problems are critical in that they affect how the solution space is defined (White et al., 2010). At a very early stage of a project, problem reframing is thus essential to ensure that researchers and farmers share the same definition of the problem situation (Pahl-Wostl and Hare, 2004).

(ii) Farming is definitely a "situated" activity – characterized by a diversity of climatic, spatial, social, institutional and economic conditions defining constraints at different levels (Giller et al., 2008). As a result, farmers have situated management practices and situated management problems (McCown et al., 2009). For this reason, research approaches aimed at enhancing farmers' adaptive capacity have to be social and locally-specific, that is flexible enough to accommodate simultaneously the conditions of any farming context (Pretty, 1995; Sellamna, 1999).

(iii) While research and scientific information generally rely on reductionist approaches, farmers have no alternative to a holistic management approach (Meinke et al., 2006). Indeed, their decisions are influenced by on-farm observations and information as well as by factors such as policy, legislation, knowledge availability, infrastructure, funding, and markets. Adapting a farming system