Journal of Environmental Management 193 (2017) 541–550

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Exploring adaptations to climate change with stakeholders: A participatory method to design grassland-based farming systems

Marion Sautier [a,*], Mathilde Piquet [a,1], Michel Duru [a], Roger Martin-Clouaire [b]

[a] AGIR, Université de Toulouse, INRA, INPT, INP- EI PURPAN, 31320, Auzeville, France
[b] MIAT, INRA, Université de Toulouse, Auzeville CS 52627, 31326, Castanet Tolosan, France

ARTICLE INFO

Article history:
Received 4 October 2016
Received in revised form
21 December 2016
Accepted 19 February 2017
Available online 3 March 2017

Keywords:
Climate variability
Dairy cow
Grassland
Intermediary object
Farm management
Participatory

ABSTRACT

Research is expected to produce knowledge, methods and tools to enhance stakeholders' adaptive capacity by helping them to anticipate and cope with the effects of climate change at their own level. Farmers face substantial challenges from climate change, from changes in the average temperatures and the precipitation regime to an increased variability of weather conditions and the frequency of extreme events. Such changes can have dramatic consequences for many types of agricultural production systems such as grassland-based livestock systems for which climate change influences the seasonality and productivity of fodder production. We present a participatory design method called FARMORE (FARM-Oriented REdesign) that allows farmers to design and evaluate adaptations of livestock systems to future climatic conditions. It explicitly considers three climate features in the design and evaluation processes: climate change, climate variability and the limited predictability of weather. FARMORE consists of a sequence of three workshops for which a pre-existing game-like platform was adapted. Various year-round forage production and animal feeding requirements must be assembled by participants with a computerized support system. In workshop 1, farmers aim to produce a configuration that satisfies an average future weather scenario. They refine or revise the previous configuration by considering a sample of the between-year variability of weather in workshop 2. In workshop 3, they explicitly take the limited predictability of weather into account. We present the practical aspects of the method based on four case studies involving twelve farmers from Aveyron (France), and illustrate it through an in-depth description of one of these case studies with three dairy farmers. The case studies shows and discusses how workshop sequencing (1) supports a design process that progressively accommodates complexity of real management contexts by enlarging considerations of climate change to climate variability and low weather predictability, and (2) increases the credibility and salience of the design method. Further enhancements of the method are outlined, especially the selection of pertinent weather scenarios.

1. Introduction

Agricultural sustainability is facing substantial challenges from climate change. The variability of weather conditions and the frequency of extreme events are forecasted to increase along with changes in the mean of climatic variables (Seneviratne et al., 2012). Such changes can have dramatic consequences for many types of agricultural production systems such as grassland-based livestock systems for which climate change influences the seasonality and productivity of fodder production. Since climate change is a continuous process, responses based on current situations will likely become increasingly inappropriate over time. In this context, research is expected to produce knowledge, methods and tools to help farmers anticipate and cope with the effects of climate change on their systems.

Designing farming systems adapted to climate change should be conducted at the farm or enterprise scale to match the scale at which the farmer makes his/her decisions (Rodriguez et al., 2011). Methods that primarily rely on dynamic simulation models often fail to address this problem because of the complex relations between climatic, biophysical and management variables, which

* Corresponding author. INRA, UMR 1248 AGIR, F-31326, Castanet-Tolosan, France.

E-mail addresses: marion.sautier@gmail.com (M. Sautier), mathilde.piquet@orange.fr (M. Piquet), michel.duru@inra.fr (M. Duru), roger.martin-clouaire@inra.fr (R. Martin-Clouaire).

1 Present address: ODG Pays du Domfrontais, 61700, Domfront, France.

http://dx.doi.org/10.1016/j.jenvman.2017.02.050
0301-4797/

induce either oversimplification or loss of intelligibility and credibility of the models. Moreover, since adaptations are most often site-specific, it is necessary to develop a deep understanding of the system under study (Duru et al., 2015).

The design process must offer farmers the possibility to consider their own situations and use their knowledge and skills to generate salient, legitimate and credible responses (Cash et al., 2003). This could be facilitated through participatory workshops with scientists and farmers, since they constitute a privileged space for discussion and knowledge sharing, particularly around system adaptation to climate change (Bartels et al., 2013; Voinov and Bousquet, 2010). In participatory processes, participants are invited to cooperate in solving a problem by mobilizing their own experiences and skills in facilitated workshops. Basically, farmers, as managers of natural resources, have experiential knowledge, which is more focused and pragmatic than scientific knowledge and often supports a better understanding of system functioning and management risks (Fazey et al., 2006).

Existing methods to design farming systems are focused on gradual changes in mean climatic variables and, possibly, on risks related to extreme events. Although adaptation to climate change must include adaptation to climate variability (Smit et al., 2000), most current studies on farming system adaptation to climate change have been performed without considering climate variability (Estrada et al., 2011) and have probably underestimated the full impacts of climate change (Thornton et al., 2014). In such methods climate is regarded through sets of scenarios, each conveying a contextual perspective over several decades (typically 30 years). Scenarios may also be communicated through a virtual average climatic year (e.g. Martin et al., 2011a) or a succession of a few years (e.g. Lamarque et al., 2013), since yearly scenarios are usually easier to understand (Lamarque et al., 2013). In addition, these methods fail to take into account the system management impact of the limited predictability of weather since they assume full knowledge of the weather over the temporal horizon of interest. Consequently, the system designed may lack robustness because it is not accompanied with fine-grained adaptations that could deal with peculiarities of a specific year and cope with a large enough range of weather-induced situations and operational conditions.

With awareness of the above deficiencies, we present a three-stage participatory method, called FARMORE (for FARM-Oriented REdesign) that enhances the creativity of participants in designing grassland-based systems adapted to new climatic conditions. The method is tailored to allow farmers to practically assess consequences of climate change on grassland-based livestock systems and immediately estimate the worth of adaptations generated. The entire process enables simultaneous communication about climate change and its consequences to farmers at the farm level and engages them in the adaptation process. It consists of a sequence of three workshops (W) for which we adapted a pre-existing game-like platform ("Forage Rummy" - Rami fourrager®, Martin et al. (2011a)). Our design method has four original features: (1) it explicitly considers climate change, climate variability and the limited predictability of weather; (2) it breaks down the design effort into sequential steps, which is a way to keep the problem tractable, generate more robust solutions and increase the realism of the constraints considered in design process; (3) it uses dynamic simulation models to evaluate adaptation options in an innovative way, since no simulation is run during the design process, to avoid the *black box effect*, and (4) it considers the complexity of a livestock system in terms of the diversity of forage resources, animal herds and management options. This article focuses on the methodological aspects underlying our design method more than the designed systems that may be constructed with this method.

2. FARMORE: a sequential participatory design method

2.1. The Forage Rummy background

The method FARMORE draws on the use of a game-based design method called Forage Rummy (FR) (Martin et al., 2011a). FR aims to design livestock farming systems that are consistent with a selected combination of farmer's objectives (e.g. forage self-sufficiency) and production contexts (e.g. frequency and magnitude of extreme climatic events, doubling of fuel price). The design task takes place in a participatory workshop involving a group of farmers and one agent (extension agent or researcher) who acts as a facilitator. FR allows addressing complex issues at the farm level such as forage self-sufficiency, change in the grazing:cutting ratio of grasslands on the farm or climate extremes. As identified by the creators of the game, FR workshops benefit farmers and extension agents in different ways (Martin et al., 2011a; Piquet et al., 2013). Farmers can virtually test alternative land-use, livestock-management, feeding and forage-management policies. They can also assess the robustness of their system to a certain climatic or socioeconomic context. Extension agents can elicit farmer practices more easily than during an interview and then provide more relevant advice. It also helps extension agents in building trust with farmers. A list of selected materials to better understand FR (articles, video and game box) is provided in the Supplementary material.

FR relies on a number of intermediary objects that put relevant pieces of scientific knowledge in a tractable form for the design task (Fig. 1). They are:

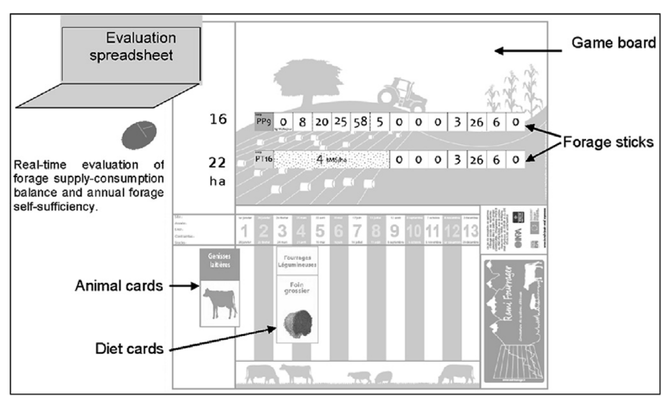

Fig. 1. The Forage Rummy (Rami Fourrager®) board game and the four elements used by players to design and evaluate a virtual livestock farm. Adapted from Piquet et al. (2013). Each of the elements is freely determined based on local parameters (soil, climate, farming practices, cultivated species, etc.).

- a temporally-structured game board that represents the farming system. The upper part of the board is dedicated to the farmland area (with "forage sticks"). The lower part represents feeding requirements and practices (animal cards and diet cards). The year is divided into 13 four-week periods.
- forage sticks, each describing a specific forage crop and its year-round management and productivity. Each stick indicates corresponding accessible forage yield in kilograms or tons per hectare and per four-week period across the calendar year for a given weather scenario (also called climatic year).
- animal cards, each with characteristics of a representative animal for each herd subgroup (e.g. breed, age) and the associated management practices (e.g. calving date, expected productivity level). Up to 3 herd subgroups can be represented.