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Bringing farmers into the game. Strengthening farmers' role in the innovation process through a simulation game, a case from Tunisia

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A B S T R A C T

While farmers are recognized as equally weighing sources of innovation in the Agricultural Innovation Systems (AIS) framework, their participation in knowledge co-production within multi-stakeholder settings such as innovation platforms is still often limited. Farmers participate more in implementing than in designing innovations or in shaping innovation process. Drawing on the companion modeling approach and critical companion posture, we designed a simulation game based method that we tested with dairy farmers in the irrigation scheme in the North-West Tunisia. The objectives were to engage farmers in a research project as equal knowledge producers, to support the process of collective construction of improved farm strategies and to create conditions for farmers to get empowered to pursue their innovation ambitions. The LAITCONOMIE game, based on the self-design principle, creates conditions for farmers to mobilize their knowledge and knowledge of others to respond to their local innovation needs. Despite a modest scale, the game experiment brought results in terms of knowledge co-production and of change in farming practice of the participants.

1. Introduction

The shift from the linear technology transfer model towards systemic approaches to innovation such as now widely used Agricultural Innovation Systems approach (AIS) (Hall, 2007; Spielman et al., 2009; Adekunle et al., 2012) theoretically changed the position of farmers in the innovation process. Instead of being perceived as passive recipients of science-produced technologies, farmers are now considered equally weighting source of knowledge among diverse interacting actors of innovation systems (Hall, 2007). How does it look in practice? The most common operationalization of AIS approach are innovation platforms (IPs) (Adekunle and Fatunbi, 2012; Ngwenya and Hagmann, 2011; Ergano et al., 2010), multi-stakeholder settings orchestrated to generate innovation. Platforms bring together different key actors, related to an innovation process and organize their interaction aimed at production, exchange and use of knowledge. Farmers are among these actors. However, their integration as equal participants in knowledge production still leaves much to be desired, despite their new theoretical positioning, and despite a large body of participatory methods and tools to draw from to organize their participation. Platforms are sometimes misunderstood as dissemination tools (Kabambe et al., 2012; Cullen et al., 2014) while farmers are considered consumers and not producers of knowledge and technologies (Mugittu and Jube, 2011). An overview of various case studies (Nederlof et al., 2011; Cullen et al., 2014) shows that more often than not, farmers are assigned a role to implement, but not to design innovation, and their participation in establishing the platform's agenda is weaker compared to other actors. As in the example coming from Oladele and Wakatsuki (2011), they may participate as testers of innovations, while platform's success is being measured by the number of farmers willing to provide their plots for experiments. Analyses (Dangbegnon et al., 2011) typically emphasize what farmers learned through their participation in platforms and not what platforms learned through farmers' participation. Furthermore, their knowledge and experience may be openly judged by other IP members as less adequate than their own (Cullen et al., 2014). As the actual position of farmers in knowledge production and dissemination (Fløysand and Jakobsen, 2011) and in shaping innovation practices and processes (Friederichsen et al., 2013) is object of concern, some authors call to explicitly address power issues in IPs (Swaans et al., 2014; Cullen et al., 2014).

It is clear that platforms may suffer from some of the limitations of participatory approaches. These include: mechanically incorporating participation into top-down approaches to serve external agendas (Cornwall et al., 1994); formatting local knowledge instead of truly taking it into account, when expert-designed methods determine what and how can be "known" (Mohan, 2001; Hailey, 2001) and finally,

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disempowering instead of empowering local communities, when they are involved in problem diagnosis but not in constructing solutions (compare Nelson and Wright, 1995). At the same time, innovation platforms seem to avoid some of the possible traps of participatory approaches, such as overemphasizing insider/outsider divide, romanticizing local knowledge, underplaying the contribution of external actors or neglecting links to wider processes and institutions (Kesby, 2005).

Criticism over how participation is implemented in practice has been voiced since the concept became widely used (Cooke and Kothari, 2001), also by its proponents (Guijt and Shah, 1998). At the core of the criticism are very often questions of power and empowerment. Some authors argue that participation itself is a form of power (Cooke and Kothari, 2001; Hickey and Mohan, 2005). Others, like Kesby (2007), believe in the potential of participatory methods to empower participants by providing them with resources that can be used to make a change in their lives (Kesby, 2007). From this perspective, the objective of participation goes further than to allow non-experts to articulate their knowledge, values and preferences in a group process (Van Asselt and Rijkens-Klomp, 2002), until modification in the distribution of power itself becomes the objective of participatory approaches (D'Aquino, 2007) and researchers choose to address the question of power directly in the design of participatory methods (D'Aquino et al., 2002a; Barnaud et al., 2010). This is the case of a type of participatory modeling known as companion modeling or ComMod, (Antona et al., 2005; Etienne, 2011). In this perspective on participation, derived from critical systems theories (Ulrich, 1995), dialogue and communication are considered insufficient in multi-stakeholder environments characterized by power asymmetries (such as innovation platforms). A strategic intervention on the side of less powerful is advocated instead. Such posture is named *critical companion* (Barnaud and van Paassen, 2013).

We have experimented with the integration of the framework, posture and some methods of companion modeling in the activities of an innovation platform at a local level. Through this experiment, we investigated the possibility of engaging farmers in a research project as equal knowledge producers. We describe our experience of designing and implementing a tool to mobilize and valorize farmers' knowledge in the context of a research project in an irrigation scheme in Tunisia - a simulation game-based method focused on facilitating a process of collective construction of improved farm strategies. Despite its modest scale, the method brought results not only in terms of learning but also of change in attitude and in farming practice of the participants.

1.1. Co-constructing knowledge with farmers

Production, exchange and use of knowledge are central to innovation. A lot of research has been done on how farmers learn. Many authors point out the group dimension of farmers' learning, be it inside farmer groups (Darré et al., 1989; Darré, 1991; Goulet, 2013) or in networks composed of farmers and other stakeholders (Chiffoleau, 2005, Oreszczyn et al., 2010). It is recognized, that learning through shared experience is particularly effective (Cristóvão et al., 2009) and that learning in a group improves analytical skills (Schad et al., 2011). The idea that farmers learn in groups has been used in setting-up farmer field schools (Davis et al., 2012; Friis-Hansen and Duveskog, 2012) or in the attempts to engineer farmers' communities of practice (Ison et al., 2014, Dolinska and d'Aquino, 2016). In innovation platforms, groups of farmers are typically present only through their representatives.

Next to the group dimension of learning, many scholars emphasize the role of dialogue (Chantre, 2011). This is consistent with the idea that informal communication plays an important role in innovation process (Sligo and Massey, 2007; Leeuwis and Aarts, 2011). Darré (1991) describes how farmers, through dialogue inside what he calls *localized professional groups*, develop and decide to adopt new ways of practicing agriculture. Before any change is incorporated into local practice, arguments to support it have to be formulated, communicated and defended inside these dialogue groups.

Experimentation is another recognized dimension of farmers' learning (Hocdé and Triomphe, 2006; Darnhofer et al., 2010) and has been used as part of on-farm research and farmer field schools' activities (Coudel, 2009).

Within the perspective of IPs, experimenting doesn't necessary mean learning by doing – it can be replaced with learning by simulating, which according to some authors has advantages over actual practice (Senge, 1990; Isaacs and Senge, 1992; McCown et al., 2009). Linking theories of experiential learning, simulation and gaming, Ulrich (1997) lists the characteristics of simulation that make it potentially more conductive for innovation development than other methods: an immediate feedback, a possibility to experiment without negative consequences and a learning situation that is abstracted and simplified. He points out that simulation creates an environment in which established perceptions can be challenged easier than in real life (Ulrich, 1997). Simulation allows self-reflection and questioning of one's own practice (Martin, 2014), exploration of new perspectives (Conjard, 2003) and discovery (Axelrod, 2003).

Simulation has been used in relation to farming in the field of Decision Support Systems or DSS (Nguyen et al., 2007; Matthews et al., 2008). In typical DSS scientists build precise hard models to indicate to farmers the best strategies to manage their farms, which is obviously prescriptive and not participatory. DSS has never become widely used by farming advisers (Farrié et al., 2015), and has been criticized for not addressing farmers' specific concerns and excluding experiential knowledge (Derner et al., 2012), among other things. A critical self-reflection in the DSS field led some researchers to shift away from using simulators to design the best practice for farmers towards other uses: to enable farmer discovery learning (McCown et al., 2009), to enhance learning of both farmers and advisers (Duru et al., 2012), to make farmers reflect on their strategies while exploring and simulating innovations to their farming systems (Le Gal et al., 2013). The group and dialogical dimensions were incorporated, and researchers started to use simulation models interactively in a discussion with farmers (Carberry et al., 2002) as well as in group workshops rather than individually. The models are sometimes used in a form of games (Martin, 2015, Farrié et al., 2015), which allows some integration of farmers' knowledge into the process, for example to parametrize a game or to fill-in the gaps in the game design by adding new elements (Martin, 2015).

These developments can be seen as a step towards modeling with stakeholders (Lynam et al., 2007; Daniell, 2008; Renger et al., 2008; Voinov and Bousquet, 2010), where one of the main objective and challenges is to incorporate plurality of values, epistemologies and knowledge (Ravera et al., 2011). Participatory modeling, next to promoting creativity and innovation, allows integration of analysis and deliberation, makes it possible to explicate tacit knowledge and to investigate both individual behaviors and collective dynamics (Squires and Renn, 2011).

Among different types of participatory modeling (Antunes et al., 2006; Voinov and Gaddis, 2008; Sandker et al., 2010), companion modeling or ComMod (Antona et al., 2005; Etienne, 2011) is the one that applies in practice the *critical companion* posture. ComMod is a participatory approach developed in 1990s, used mainly in natural resources management. It applies short lived simulation tools (agent based models and role-playing games) to deal with interactions among actors and between actors and their environment in complex systems. As it can be used both as a method to explore with stakeholders the functioning of their socio-ecological systems and as a decision support tool (Barreteau et al., 2003), its expected outcomes are social learning and/or technological/organizational innovation (Voinov and Bousquet, 2010). The level of participation can go from interactive participation, where participants share diagnostic tools and results, to self-organization where participants transform lessons from participatory process into decisions, according to the scale by Pretty (1995).

Among many documented ComMod cases, there are some that apply the "self-design" modeling principle (D'Aquino et al., 2002a; D'Aquino and Bah, 2013), pushing the participation of local stakeholders in the modeling process even further. The self-design principle, that was first used in 1998 in Senegal (D'Aquino and Bah, 2013), allows actors to actively participate in constructing models of their reality (games, computer-based models, geographical information systems) and to propose their own management solutions. Researchers do not build an expert model incorporating local knowledge, but leave a certain autonomy in constructing the model (in the form of a game) to players who play themselves. As explained by D'Aquino et al. (2002b) the rationale behind it is to explore the 'implicit' parts of their reality, and to mobilize their knowledge. The underlying assumption is that they know more about their system than researchers do. It is a bottom-up approach in a sense that it starts with local actors building their own conceptual framework (model) and identifying knowledge which they find useful, and only then other actors are invited into discussion. In a typical ComMod intervention, actors may be invited to participate in the workshops to co-construct a model. Researchers use this model to create a game through which different management scenarios can be simulated by the actors. Another way of proceeding is to build an expert model, transform it into a game and then adapt it, based on how actors play it. When the self-design principle is applied, the game has an open-end structure. The participants, who play themselves, define their roles, create new rules and add objectives while playing. They may also give new meaning to game elements, re-define the game board, invent new roles, propose their own scenarios, etc.

Berthet et al. (2016) in their comparison of participatory methodologies to support situated innovation (including companion modeling) make a difference between two types of innovation: *exploitative*, which means using existing knowledge to achieve clearly identified objectives for improvement, and *exploratory*, which means acting without pre-defined objectives and performance criteria and without predetermining what knowledge is required. The authors make an interesting parallel between these two types of innovation and two types of design process: *rule-based* versus *innovative*, respectively. In a rule-based design process design objectives are defined a priori and it is clear what skills are required to complete the process. In an innovative design process, objectives as well as knowledge and skills necessary to complete the process are poorly defined. This parallel suggests that explorative innovation could be supported with tools that are not yet completely designed. Tools based on self-design principle are a good example – the method is being co-constructed in the process by the participants. This makes these tools potentially useful in supporting an innovation process.

We used these insights to design a method to mobilize farmers' knowledge and empower farmers to engage in the innovation process. We were looking for a method which would recreate conditions for farmers' knowledge production, exchange and use. We wanted it to have a *group* dimension, a *dialogical* dimension and *learning by simulating* dimension, and to be based on a *self-design principle*. In subsequent sections, we present the method, together with the context and results of its implementation.

2. Materials and methods

Our research was part of a larger project, European and African Union for Food (EAU4Food), which aimed at co-developing and testing with local farmers improved farming practices in irrigation schemes in different parts of Africa. The EAU4Food methodology consisted of organizing at each project site an innovation platform operating at two levels: regional and local. At the local level, where we intervened, the approach was inspired by the concept of Community of Practice (CoP) (Lave and Wenger, 1991). The ambition was to create learning communities around specific locally identified innovation needs together with farmers and other relevant actors (e.g. extension agents, value chain actors). Our objective was to support co-creation of one such a learning community with the farmers in irrigation perimeter El Brahmi in the North-West Tunisia.

2.1. Project site

The El Brahmi scheme, constructed in 1978, covers 5000 ha, most of which are cultivated by approximately 500 individual farmers. Nowadays main crops are cereals, in rotation with horticultural crops and in part with forage crops or, rarely but increasingly, in monoculture. However, the original design of the El Brahmi scheme was based on a quadrennial rotation with cereals, forage crops, horticultural crops and sugar beet. El Brahmi, as many schemes of similar kind (Poncet et al., 2010) was centrally planned and based on state-managed innovation process supported by extension services diffusing technical innovations. The system included two milk factories and one sugar plant to secure markets for milk and sugar. Over the years, while Tunisia was undergoing political and economic changes, this system collapsed. The sugar plant and one of the milk factories were closed; the remaining milk factory was privatized. State extension services shrank to only two officers with hardly any financing. New private actors arrived in the scheme, offering contract farming (mostly tomatoes), while private technical advisors partly replaced the diminishing state extension services. Alongside uncontrolled private markets, there are still some elements of state intervention: the price of milk is centrally fixed, irrigation of forage crops is subsidized, and the state still buys the majority of wheat production. Farmers are longing for more active presence of the state. In conversations and interviews they often mention (not without resentment), their feeling of abandonment. They frequently complain about the lack of state control over the quality of the concentrate cow feed produced in private factories, the decentralization of the wheat bran market, the disappearance of state extension. They request that the state increases the price of milk each time the producers increase the price of the concentrate feed (due to fluctuations on the global soya and corn markets). Left to their own devices, farmers seem to seek to be given direction and to minimize their own decision-making – they opt for those tomato contracts that assure full technical follow-up, they become dependent on punctual technical advice, they sell their production crops-standing. They also turn to feeding systems that heavily rely on ready-made industrial feed with less forage production. At the same time, we observed some attempts by farmers to take matters into their own hands and seek both technical and organizational solutions in order to adapt to the new conditions. However, the lack of dialogue between farmers and the absence of space in which they could discuss their profession keeps such ideas from spreading.

2.2. Research strategy

Our understanding of the local situation and of the innovation dynamics in the research area developed first from participating in the general EAU4Food activities (a series of participatory diagnosis workshops), and then by a series of thirty in-depth semi-structured interviews with farmers, representatives of milk, cereal and tomato value chains, state extension agents, private technical advisors, administration and representatives of a local applied agricultural research institute (Dolinska and d'Aquino, 2016). We did not limit the scope of our research to technical innovations, we were looking at modes of organization, communication, etc. We asked about how knowledge was produced, exchanged and used between different actors in the scheme and whether it had led to changes in their practices. The interviews' duration varied between 40 min and 2 h.

During the participatory workshops farmers were asked to identify topics on which they would like the research project to focus. Among

Table 1
Problem identification by local actors.

Diagnosis of dairy farming problems by local actors	
Issue as formulated by local actors	Actors who formulated the issue
Suboptimal milk production due to the lack of technical knowledge of farmers	Farmers, extension agents, researchers, milk collectors, a OEP agent
Dependence on the industrial concentrate feed, moving away from forage crops	Some of the farmers, an OEP agent
Insufficient forage surface per cow ratio	A researcher
Lack of farmers' organization resulting in the weak position of farmers in the milk value chain	Farmers, regional administration representatives, OEP agents, a milk collector
Low quality of industrial concentrate feed, produced in the private sector with no quality control over the ingredients	Farmers
Lack of innovation capacity of farmers	Extension agents, researchers
Lack of strategy of farmers, lack of planning	A researcher, an OEP agent

four topics that emerged, two were: dairy farming and professional organization of farmers (with the focus on dairy farmers). From the interviews, dairy farming emerged as an area where a lot of local dynamics was concentrated. The need for innovation in dairy farming was directly expressed and already acted upon. Innovations in the area of forage crops and their storage, farming techniques and cow feeding were already tested by some of the local farmers. These few experiences were mostly individual and isolated. Two exceptions were a no-tillage program led by a local applied research institute and a project of creating a dairy farmers' cooperative, led by three farmers with an institutional support at the regional level (Dolinska and d'Aquino, 2016).

On this basis, we chose dairy farming as the topic of our intervention. Additional context information was derived via another thirty in-depth interviews with actors related to dairy farming, participatory observation and numerous informal interactions.

Dairy farming was a concern of an array of actors besides the dairy farmers themselves. We asked other actors of milk value chain, extension agents and researchers to share with us their representations of dairy farming's main dynamics, their analysis of its problems and their ideas for solutions (Table 1). Respondents were connecting dairy farming with other agricultural issues. On the scale of the irrigation scheme, some actors pointed out that the decreasing use of forage crops was affecting soil fertility and as consequence, the production of cereals. For dairy farmers, it was a matter of economic survival – they struggled to make their activity profitable.

We identified another potential intervention area – interaction between dairy farmers and their extension agent. Next to the general extension services (two officers present in the scheme) dairy farming has a specific extension service provided by the Regional Office of Livestock and Pasture. One officer regularly visits around 20 farmers in the scheme. From the interviews, we knew that both parties (farmers and the extension agent) had misconceptions about each other's knowledge, needs and objectives. Farmers criticized the extension officer as not having enough experience and judged his advice as “not useful” – he kept giving them the same basic information that they already knew, otherwise limiting his visits to routine checks and keeping statistics, without providing any real technical support. The officer described farmers as lacking basic technical knowledge and needing repeating the same information over and over again.

We used this information to design a general frame for a simulation game LAITCONOMIE (Fig. 1). The first idea for the game was presented and discussed during a session of the Simulation Community of Practice (Dionnet et al., 2013) in Montpellier, whereas the prototype was tested in Tunis, with researchers playing the roles of farmers (the roles were pre-defined, representing real farmer profiles from El-Brahmi). Some of the ideas were consulted with a small group of local farmers supportive to our research plan, who also validated the visual supports for the game.

3. Results

3.1. Phase 1: from problem identification to game design

3.1.1. LAITCONOMIE simulation game

The LAITCONOMIE simulation game revolves around the issue which was generating the main tension in dairy farming in El Brahmi at the time the research was conducted – the relation between the price of milk and the price of industrial concentrate feed. The basic scenario played in the game concerns the price of the concentrate feed – it changes unpredictably. In real life, the producers of concentrate feed adapt its price to world market prices of its main ingredients: soya and corn. The “result” of each round of the game is the invoice from the milk collection center. This invoice contains information about the volume of milk sold to the center and the volume of concentrate used to produce the milk – the price for concentrate is subtracted from the payment. In real life, farmers usually take concentrate from their milk collection center. They can pay for it after they produce and sell milk.

In the game, the problem of concentrate feed is an entry point to touch upon several technical issues identified as problematic in the study zone – cow feeding systems, the level of milk production, cultivation and storage of forage crops, dependence on industrial feed. We used it also to facilitate the introduction of the theme of farmers' organization. We introduced an option in the game: on-farm concentrate feed production (one of the local innovations we identified). The price of self-produced feed is lower comparing to industrial feed (calibrated according to real data). However, to be able to purchase ingredients (that can only be purchased wholesale), one needs a number of cows bigger than that of an individual player. In this way, a farmer who wants to opt for this solution needs to seek collaboration with others. In addition, players may opt to purchase an expensive mixing machine (instead of mixing manually) that allows for production of better quality feed (according to the view expressed in some of the interviews). In the game design process, we considered another option – the collective direct sale of milk to the dairy factory. However, after interviewing the factory director and some other actors, we discarded this option as unrealistic (it would be met with resistance of powerful local actors).

The players (farmers) enact dairy farmers. Each player sits at a separate table representing an individual farm and is given a set of cards and a table to fill in. There are five categories of cards: land, cows, crops, types of cow feed (including concentrate feed in kilograms) and milk production (in liters) (Fig. 2).

Each player is allocated a number of cows and a number of 1 ha plots. The combinations “number of cows/farm size” represent real situations in the perimeter (but not each player's own situation). Players get simple instructions about the steps to be taken in each round of the game (Fig. 3). The steps are:

Game development process

Stages	**Identification of the topic**	**Exploration of the topic**	**First design of the game canvas**	**Design of the game prototype**	**Testing the game canvas prototype**	**Game session**	**Game evaluation**
How ?	participatory workshops semi-structured interviews with actors of the irrigation scheme	semi-structured interviews with topic-related actors	session of community of practice to discuss the ideas for the game canvas	validation of game elements with a small group of farmers	session of community of practice with researchers playing roles of farmers (pre-written roles were representing real profiles of farmers from the irrigation scheme)	players (farmers, local dairy farming expert) developed roles rules objectives	interviews where players were asked to suggest directions for further development of the game (they suggested new players and scenarios)
By whom ?	researchers, **farmers**	researchers (with the input from **farmers**)	Researchers (with the input of an external dairy farming expert)	Researchers (with the input from **farmers**)	researchers	**farmers** (in interaction with a local dairy farming expert)	**farmers**, local dairy farming expert

Fig. 1. LAITCONOMIE – game development process.

1. To decide what crops to cultivate on their land (they display the cards in front of them), including a decision about how much of their surface to allocate to forage crops (they are asked to specify that).
2. To decide how to feed their cows, including decisions about how much concentrate feed to purchase, what other types of feed to buy and how much fodder to produce on their farm (they display cards representing elements of their choice).
3. To estimate how much milk (per cow) they produced with the chosen feeding system (they display cards representing volume of milk). They note down their decision and results in a table.
4. To present and explain their results to other players and to get them validated by the whole group. This means that players have to describe what they did and argue why it allowed them to achieve a claimed production level.
5. To sell their milk to the milk collection center and get their invoice.
6. The results are displayed on a large board, so that players can compare them with those of others and follow everyone's evolution.

A milk collection centre is represented by a simple computer program operated by a game facilitator. The program calculates more than famers' invoices. The players are given three additional pieces of

Fig. 2. LAITCONOMIE – game elements.

information: how big a part of their revenue was spent on the concentrate feed (in percent), what is the forage surface per cow ratio on their farm and what is their revenue per cow.

There is one more player – a dairy farming expert (played by the extension officer from the Office of Livestock and Pasture). Farmers are informed that he is there to provide them with information if they need it. He is instructed to give advice only at farmers' request.

Roles. The farmers do not get any role-description, and any information about their individual strategies, objectives, or constraints, other than an initial number of cows and land.

Rules. The farmers get no instruction about what is and what is not allowed in the game – there are no constraints.

Objective. The objective of the game is described as to "farm in the best possible way", which is not defined further. However, the architecture of the game implicitly suggests that the objective is a good financial result.

No-model. There is no model calculating milk production based on the feeding system. To estimate their results, farmers use their own knowledge, their own models. We assumed these individual models would evolve throughout the game while farmers would be learning from their interactions with the other players (farmers and the expert).

Selection of players. We wanted to recruit farmers who would have an opportunity to interact after the game. We invited three groups of farmers who were neighbours in three different areas of the irrigation scheme, of whom we knew they knew each-other and talked with each other. We also invited a farmer who produced his own concentrate and one of the leaders of the cooperative project, to see if they would share their ideas. The final group composition was different than what was planned. The innovators were not present and we had farmers from only two dialogue groups. Even though representation was not our primary ambition, we had players whose situations were representative for the perimeter: different combinations of number of cows/farm surface, different age groups, different levels of experience (old farmers, young farmers who took over after their fathers, a newly converted farmer). They came from two major areas of the irrigation scheme – one close to El Brahmi and another close to Ben Bechir – its two main villages. One group was followed by the extension agent and the other wasn't.

The game session was facilitated by a Tunisian facilitator (that we trained), in the local language.

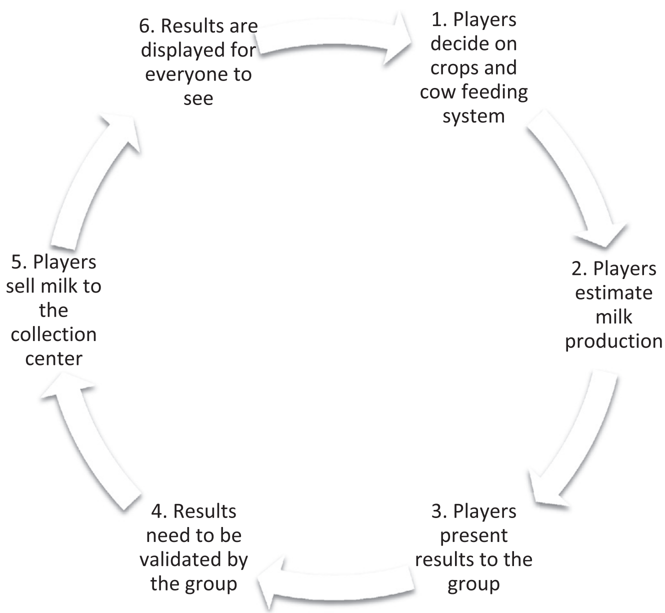

Fig. 3. LAITCONOMIE – game mechanics.

3.2. Phase 2. The game session

3.2.1. Introducing change

Farmers (all except one) started by reproducing their current farm strategies and introduced changes throughout the game. These changes had technical or social/organizational character. Technical changes concerned forage crops and diversification of cows' diet. Farmers were introducing new forage crops, crop associations and crop storage techniques (e.g. corn for silage, alfalfa, ryegrass and *berseem* clover association) then improving technical itinerary to obtain better yields, more fodder and, as a result, to improve milk production. They all improved their gains by increasing milk production, without lowering their consumption of the industrial concentrate feed. The forage per cow ratio first increased in all farms but at the end of the game mostly lowered as many farmers opted to expand their herds after they got access to the cheaper self-produced concentrate. The social/organizational change concerned farmers' interaction with each other and with the expert. All farmers except two (one of whom later changed his decision) chose to produce concentrate feed on farm. They opted directly for the more expensive option, using a mixing machine. They discussed it and decided that such a setting needs a formal union rather than just a verbal agreement – they created a cooperative that was supposed to take care of the purchase of the machine, its maintenance, purchase of the ingredients and production. The expert was to provide the receipt for a good mixture. They re-arranged the space by joining their tables together. From this moment, they started to collectively plan their next steps, introducing discussion time before decisions about strategies were made. The arguments that farmers were giving when justifying their production estimations were becoming more and more detailed and more technical with each round.

From the beginning, participants introduced new elements to the game. Some of them were actions (new rules): selling and purchasing cows, renting land. Others appeared in their arguments: different races of cows, quality of industrial feed, soil characteristics. One player introduced a whole new activity – meat farming. When it comes to the game's objective, for most players it was to increase the herd, even if it meant lower financial results from the sale of milk.

3.2.2. Difficult transition towards new rules of interaction

We had to intervene in the way the expert was constructing his role. At first, he did not follow our instructions, but would spontaneously go in front of the group and start lecturing about technical aspects of dairy farming. After we reminded him that he can provide expertise only when asked by other players, he started to respond only to farmers' open questions or to individual requests, providing information that was needed to develop or defend a farmer's idea. Often armed with pen and paper, a farmer and the expert were making detailed calculations concerning yields and the impact of nutrition on milk production.

3.2.3. Expanding the boundaries of the game

While farmers explained their strategies, they often used arguments that went further than the scope of the game. For example, they would evoke improved soil fertility as leading to higher income from cereal production, which would in turn secure financing for expanding the herd, or they would speak of increased quantity of manure that would make them save money on fertilizers to be allocated elsewhere. They also explained their preference for buying more animals as a need to secure future educative needs of their children or cover extra costs related to life events such as a wedding.

3.2.4. Feedback session: players' perception of the game

All participants evaluated the game as easy to play, understandable and representing well their reality and mentioned learning as the main result of the game. The expert saw it as an innovative extension tool, but also as a way to explore the state of farmers' knowledge. He learned what farmers already knew and which information needed to be complemented or provided all together, as well as which extension messages failed. One farmer remarked that the game created an opportunity for researchers to learn what farmers knew about their environment. According to farmers, playing the game improved their understanding of their own situation. But they also saw its potential to improve the understanding of other actors of the value chain. Although the players knew that the game was used for research purposes, they saw it as a tool that they could use themselves (Table 2). Even if farmers, until they formed a cooperative, played individually (they were not interacting with others during the stage of decision making), they appreciated the opportunity to share their ideas with other farmers and pointed out a collective character of what they constructed in the game. Farmers concluded from the game that collective action is needed to improve their situation.

Table 2
Farmers' perception of the game according to feedback session results and evaluation interviews.

Farmers' perception of the game	Farmers' quotes
Diagnosis	*When we play the game, we are like a doctor who makes a diagnosis. We understand what our problems really are.*
Boundary object to communicate with other actors	*We could interest the milk collection centres with our problems if we made them play the game.*
Decision support	*You gave us a new tool that we can use to make our farming better*
Enabling collective decision	*Discussing with others always brings new ideas. When we discuss together, we create our own collective rules, our sharia.*
Introspection	*The game extracts what is deep in the farmer.*
	When you play, you look [at farming] through the eyes of someone who has all the possibilities, this allows you to understand, to discover, what is really important for you.
	[When you play] you use your imagination, but this imagination comes from the core of what it is to be a farmer.

3.3. Phase 3: back to real life

All the players admitted speaking about the game and its results after the session (inside their dialogue group and with family members). Some of them were willing to discuss again with the participants they first met during the game. Those who had not been in contact with the extension agent before the game, said they could now call him for information or would be informed by him about the activities organized by his institution.

3.3.1. Introducing change

Some of the players admitted to changing their real practice after the game session. One farmer (who during the game turned to meat farming) designed a new system for his farm. He spoke of a change that playing the game provoked in him, making him understand what kind of farmer he wanted to be. He said that the game reminded him of times "when farming felt like a profession" and when "it was a pleasure to be a farmer and have projects". After the game, he formulated his 'dream project' that he described to us in detail. He also showed us what steps he had already taken to implement it – rearrangement of the stables and purchase of new cows. He also joined the leaders of the local cooperative project (together with another game player) and spoke of his dedication to the project.

Another farmer (who prior to the game session was described to us as 'underperforming' by his milk collector), changed his rotation system, introducing more forage and corn for silage, and abandoning contract tomato. He also diminished the quantity of the concentrate feed and planned for purchasing new cows. This was the exact strategy he tested during the game. Before taking his decision, he consulted the expert who played the game, but also verified his choices with other sources. He claimed that it was the game that convinced him, as he saw that this strategy was working for him. He advised his brother (who did not play the game) to introduce similar changes. He supported his choice with arguments, referring to soil fertility and cow nutrition rules. He also evoked regaining control over his own farming (and his land) after abandoning contract tomato.

Another participant decided to re-introduce alfalfa in his rotation (that he rejected before as occupying a plot for too long), referring to the long-term strategy, using soil fertility and impact on milk production arguments and listing advantages in comparison with previously cultivated crops. One participant (the least experienced in dairy farming) started using an adapted version of the table which the players were requested to fill in during the game, for follow up and planning on his farm. Two of the players, at their own initiative, explored further the question of on-farm feed production – they looked for information about the price of the mixing machine and for people who tried this solution. They did not take the decision to try it, explaining that they would prefer to do it while in an organized collective rather than individually.

3.3.2. Participants' suggestions for game improvement

Three months after the game session, players proposed further developments - introduction of new players (a veterinary, an inseminator, a bank), new elements (machines) and new game scenarios (use of antibiotics and control of milk quality). The extension agent proposed to accompany game session with field visits to see some of the solutions tested in the game implemented in real life.

4. Discussion

4.1. Knowledge co-construction and innovation

One of the main goals of our intervention was to create conditions in which farmers would get involved in the innovation process. As our results show, this goal was achieved, both in a virtual environment and in real life. This supports the idea that simulation creates a situation in which established perceptions are challenged and learning occurs (Senge, 1990; Ulrich, 1997; McCown, 2002). Judging by all the participants' comments during the debriefing session and individual interviews, LAITCONOMIE acted as an effective learning environment. We could observe clear advantages of learning through shared experience (Cristóvão et al., 2009) and putting in use analytical skills while in a group (Schad et al., 2011). Even though in our case, practice was only simulated, we may argue that the game session allowed for a temporary community of practice to be created (Dolinska et al., forthcoming).

While farmers' learning is a commonly quoted outcome of innovation platforms (or other interventions), what is characteristic for our case is that the participants were authors of their own learning; they deconstructed and reconstructed their own knowledge (see Paul, 2009 on accompaniment). They were also the ones to evaluate their knowledge and the effects of its use. There was no transfer of expert knowledge inside the game, but knowledge co-construction by farmers and an expert. This changed typical power relations. As for our intervention, we cannot speak of innovation transfer, as we did not transfer any solutions through the game, but we can describe the game session in terms of *innovation process transfer* (Le Bellec et al., 2012).

The process of knowledge exchange and co-construction was mediated by the game that acted as boundary object (compare Klerkx et al., 2012), with its shared vocabulary represented by cards and computer program (Farrié et al., 2015).

The use of simulation game had also an effect of discovery, as previously described by Axelrod (2003) and Barreteau et al. (2003). The players of LAITCONOMIE reconstructed and explored their system, and both farmers and expert used the game as a diagnostic tool, identifying individual and collective knowledge gaps, which according to Berthet et al. (2016) is an important factor driving innovation. Farmers contributed also to defining the innovation system, by proposing additional actors to be incorporated in the game, and hence potentially in the innovation platform (veterinary, inseminator, bank) or pointing at the need to explore additional scenarios (quality control).

The knowledge produced during the experiment was exactly the knowledge suited for the specific local conditions and for participants to achieve their goals. As Dung (2008) observed in his own research, during a game a 'smart' player may make use of the game to gather knowledge from other players or researchers to support his hypotheses in technology development. The kind of knowledge produced through simulating in interaction with others was described by McCown et al. (2009: 1020) as personal knowledge of a participant that was meaningful to his/her future practice while at the same time shared and 'negotiated' through discussion. The spatial proximity of the participants and the situated character of the process, make it possible to integrate tacit knowledge (Healy and Morgan, 2012) and to develop solutions that can be integrated in the local system and provide value, a condition for a finished innovation (Leeuwis and Van den Ban, 2004, Aguilar-Gallegos et al., 2015).

4.2. Empowerment

In LAITCONOMIE we tried to recreate the collective process of knowledge construction by farmers, by introducing collective evaluation of farmers' estimations of the effects of their strategies on milk production. This encouraged farmers to negotiate how to better do things but also to build their own arguments for why to do them. This can be seen as contributing to regaining agency. According to authors such as Darré (1985) and van der Ploeg (2008) farmers' agency is negatively affected by the dominant trends in agricultural development - transformations of food systems that have occurred as a result of privatization and globalization that limit the control of farmers over how they farm, leaving them a very narrow margin of initiative, while keeping them dependent on a technical control from a distance, on being told 'what to do'. Part of our results is in line with these observations. Lifting limitations to farmers' agency in the game acted as an incentive for farmers to implement changes, not only to innovate, but to innovate in the direction that made sense for them. Even if we introduced solutions that made sense for us by adding options to the game, it was up to the farmers whether to test them or not when constructing their own projects.

Our objective during the intervention was to leave as much space as possible to farmers. The basic elements of any game: the rules, the objective, the construction of roles (see Dionnet et al., 2008) in LAITCONOMIE were constructed by players during the game, which we believe to have an empowering effect. The game objective – to farm better – was open for farmers' interpretation. The activities in which the participants engaged while playing – constructing, analyzing, negotiating and collectively evaluating and validating strategies to achieve their goals – provided them with resources on which to draw in order to transform their farming practice (compare Kesby, 2007). Participatory intervention can create space where participants can rehearse for reality and when empowered practice is 'reperformed' beyond the arena of intervention, we can talk of empowerment (Kesby, 2007). We can tell that some of the LAITCONOMIE players, used the game as an opportunity to rehearse steps to be taken beyond the game session. None of the solutions were unrealistic nor impossible to implement in real life. In transforming lessons from the participatory intervention into decisions, they transformed the process from interactive participation into self-organization (Voinov and Bousquet, 2010). Mwaseba et al. (2015) make a distinction between instrumentalist and transformative perspective on empowerment. The former focuses on the process and in general is translated into capacity building, while the latter is focused on outcome of empowerment. In that sense, a simulation game acting as a real decision support tool may be an appropriate method if we take a transformative perspective on empowerment.

5. Concluding remarks

Joining the debate about the potential of empowerment through participation (Cooke and Kothari, 2001; Kesby, 2005; Hickey and Mohan, 2005) seems to be particularly interesting in the context of the need to improve farmers' position in innovation platforms. By leaving as many elements open as possible, we create space for participants to decide their own development priorities and, to a certain extent, to imagine their own innovation system (compare Scoones et al., 2008).

The fact that it's the local farmers' knowledge that is principally mobilized by this method makes it particularly interesting in projects that have an ambition to co-construct solutions with local actors. As there was no need to mobilize technical expertise to design our simulation game, we were free to follow the participants and their choice of the topic, even though there was no dairy farming or cow nutrition expert in our research team. There was no constraint of having to compromise between our interests and expertise and those of farmers.

The game itself is very simple and requires minimal technical input as well as minimal human, technological and financial resources to be deployed, other than a skillful and open-minded facilitator. However, the basic elements around which the game is constructed have to be chosen carefully and with a good understanding of how local actors perceive their system and its dynamics, therefore a preliminary analysis is needed. It is possible to envision including other platform actors in the game.

While we realize that our experiment was very modest in scope and scale, its results suggest that there is a real interest in further exploring the potential of self-design simulation tools in participatory projects in the area of agricultural innovation.

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References

Adekunle, A.A., Fatunbi, A.O., 2012. Approaches for setting-up multi-stakeholder platforms for agricultural research and development. World Applied Sciences Journal 16 (7), 981–988.

Adekunle, A.A., Ellis-Jones, J., Ajibefun, I., Nyikal, R.A., Bangali, S., Fatunbi, O., Ange, A., 2012. Agricultural innovation in sub-Saharan Africa: experiences from multiple-stakeholder approaches. In: Accra, Ghana: Forum for Agricultural Research in Africa (FARA). Ghana, Accra.

Aguilar-Gallegos, N., Muñoz-Rodríguez, M., Santoyo-Cortés, H., Aguilar-Ávila, J., Klerkx, L., 2015. Information networks that generate economic value: a study on clusters of adopters of new or improved technologies and practices among oil palm growers in Mexico. Agric. Syst. 135, 122–132.

Antona, M., d'Aquino, P., Aubert, S., Barreteau, O., Boissau, S., Bousquet, F., Daré, W., Etienne, M., Le Page, C., Mathevet, R., Trébuil, G., J. Weber (Commod Collective)., 2005. La modélisation comme outil d'accompagnement. Natures Sciences Sociétés 13, 165–168.

Antunes, P., Santos, R., Videira, N., 2006. Participatory decision making for sustainable development. The use of mediated modeling techniques. Land Use Policy 23 (44).

Axelrod, Robert, 2003. Advancing the art of simulation in the social sciences. Journal of the Japanese and International Economies 12 (3), 16–22. http://dx.doi.org/10.1002/(SICI)1099-0526(199711/12)3:2<16::AID-CPLX4>3.0.CO;2-K.

Barnaud, C., Van Paassen, A., 2013. Equity, power games, and legitimacy: dilemmas of participatory natural resource management. Ecol. Soc. 18 (2), 21. http://dx.doi.org/10.5751/ES-05459-180221.

Barnaud, C., d'Aquino, P., Daré, W., Fourage, C., Mathevet, R., 2010. Dispostifs Participatifs et Asymétries de Pouvoir: Expliciter et Interroger les Positionnements. In: In Colloque OPDE (Outils pour Décider Ensemble) Aide à la Décision et Gouvernance, Montpellier.

Barreteau, O., Le Page, C., d'Aquino, P., 2003. Role-playing games, models and negotiation processes. Journal of Artificial Societies and Social Simulation 6 (2).

Berthet, Elsa T.A., Barnaud, Cécile, Girard, Nathalie, Labatut, Julie, Martin, Guillaume, 2016. How to foster agroecological innovations? A comparison of participatory design methods. J. Environ. Plan. Manag. 59 (2), 280–301. http://dx.doi.org/10.1080/09640568.2015.1009627.

Carberry, P.S., Hochman, Z., McCown, R.L., Dalgliesh, N.P., Foale, M.A., Poulton, P.L., Hargreaves, J.N.G., Hargreaves, D.M.G., Cawthray, S., Hillcoat, N., Robertson, M.J., 2002. The FARMSCAPE approach to decision support: farmers', advisers', researchers' monitoring, simulation, communication, and performance evaluation. Agric. Syst. 74, 141–177. http://dx.doi.org/10.1016/S0308-521X(02)00025-2.

Chantre, E., 2011. Apprentissages des Agriculteurs vers la Réduction d'intrants en grandes cultures: Cas de la Champagne Berrichonne dans les années 1985–2010. Doctoral dissertation, AgroParisTech.

Chiffoleau, Y., 2005. Learning about innovation through networks: the development of environment-friendly viticulture. Technovation 25 (10), 1193–1204.

Conjard, P., 2003. Formation et simulation de situations de travail. Distances et savoirs 1 (3), 361–374.

Cooke, Bill, Kothari, Uma (Eds.), 2001. Participation: The New Tyranny? Zed Books, New York.

Cornwall, A., Guijt, I., Welbourn, A., 1994. Extending the horizons of agricultural research and extension: methodological challenges. Agric. Hum. Values 11 (2–3), 38–57.

Coudel E. 2009. Formation et apprentissage pour le développement territorial: regards croisés entre économie de la connaissance et sciences de gestion. Réflexion à partir d'une expérience d'Université Paysanne au Brésil. Thèse de doctorat, Universtié de Montpellier - Supagro, France.

Cristóvão, A., Ferrão, P., Madeira, R., Tibério, M.L., Raínho, M.J., Teixeira, M.S., 2009. Circles and communities, sharing practices and learning: looking at new extension education approaches. Journal of Agricultural Education and Extension 15 (2), 191–203.

Cullen, Beth, Tucker, Josephine, Snyder, Katherine, Lema, Zelalem, Duncan, Alan, 2014. An analysis of power dynamics within innovation platforms for natural resource management. Innovation and Development 4 (2), 259–275. http://dx.doi.org/10.1080/2157930X.2014.921274.

Dangbegnon, C., Tarfa, B.D., Mando, A., Amapu, I.Y., Ezui, S.K., Ahmed, B., Saleh, M.K., Abu, S.T., 2011. Improved maize-legume production systems in Nigeria. In: Nederlof, S., Wongtschowski, M., van der Lee, F. (Eds.), In Putting Heads Together: Agricultural Innovation Platforms in Practice. KIT Publishers, KIT Development, Policy & Practice.

Daniell, K., 2008. Co-engineering participatory modelling processes for water planning and management. In: Doctoral Dissertation. Australian National University and Institut des, Sciences et Industries du Vivant et de l'Environnement.

D'Aquino, P., 2007. Empowerment et Participation : Comment Mieux Cadrer les Effets Possibles des Démarches Participatives? (Cirad).

D'Aquino, P., Bah, A., 2013. Land policies for climate change adaptation in West Africa a multilevel companion modeling approach. Simulation & Gaming 44 (2–3), 391–408.
D'Aquino, P., Barreteau, O., Etienne, M., Boissau, S., Auber, S., Bousquet, F., 2002a. The Role Playing Games in an ABM Participatory Modeling Process: Outcomes from Five Different Experiments Carried out in the Last Five Years. Paper presented at the IEMSS, 24–27 June 2002, Lugano.
D'Aquino, P., Le Page, C., Bousquet, F., Bah, A., 2002b. A novel mediating participatory modelling: the 'self-design' process to accompany collective decision making. Int. J. Agric. Resour. Gov. Ecol. 12 (1), 59–74.
Darnhofer, I., Bellon, S., Dedieu, B., Milestad, R., 2010. Adaptiveness to enhance the sustainability of farming systems. A review. In: Agronomy for Sustainable Development. 30. pp. 545–555.
Darré, Jean-Pierre, 1985. Du discours scientifique au dialogue entre praticiens: rupture et emprunts. Form. Empl. 12, 11–16.
Darré, Jean-Pierre, 1991. Les hommes sont des réseaux pensants. Sociétés Contemporaines 5 (1), 55–66.
Darré, Jean-Pierre, Le Guen, Roger, Lémery, Bruno, 1989. Changement technique et structure professionnelle locale en agriculture. Economie Rurale 192 (1), 115–122.
Davis, K., Nkonya, E., Kato, E., Mekonnen, D.A., Odendo, M., Miiro, R., Nkuba, J., 2012. Impact of farmer field schools on agricultural productivity and poverty in East Africa. World Dev. 40 (2), 402–413.
Derner, J.D., Augustine, D.J., Ascough II, J.C., Ahuja, L.R., 2012. Opportunities for increasing utility of models for rangeland management. Rangel. Ecol. Manag. 65, 623–631.
Dionnet, M., Kuper, M., Hammani, A., Garin, P., 2008. Combining role-playing games and policy simulation exercices: an experience with Maroccan smallholder farmers. Simulation and Gaming 39 (4), 498–514.
Dionnet, M., Daniell, K.A., Imache, A., von Korff, Y., Bouarfa, S., Garin, P., Jamin, J.-Y., Rollin, D., Rougier, J.-E., 2013. Improving participatory processes through collective simulation: use of a community of practice. Ecol. Soc. 18 (1), 36.
Dolinska, Aleksandra, d'Aquino, Patrick, 2016. Farmers as agents in innovation systems. Empowering farmers for innovation through communities of practice. Agric. Syst. 142, 122–130.
Dung, Le Cahn, 2008. Environmental and Socio-Economic Impacts of Rice-Shrimp Farming: Companion Modeling Case Study in Bac Lieu Province, Mekong Delta. Chulalongkorn University, Thailand, Vietnam. Doctoral Dissertation.
Duru, M., Felten, B., Theau, J.P., Martin, G., 2012. A modelling and participatory approach for enhancing learning about adaptation of grassland-based livestock systems to climate change. Reg. Environ. Chang. 12 (4), 739–750.
Ergano, K., Duncan, A., Adie, A., Tedla, A., Woldewahid, G., Ayele, Z., Alemayehu, N., 2010. Multi-stakeholder platforms strengthening selection and use of fodder options in Ethiopia: Lessons and challenges. In: ISDA 2010, Cirad-Inra-SupAgro.
Etienne, M., 2011. Companion Modeling. A Participatory Approach to Support Sustainable Development. In: QUAE Editions, Collection Update Sciences & Technologies.
Farrié, B., Jouven, M., Launay, F., Moreau, J.C., Moulin, C.H., Piquet, M., ... Martin, G., 2015. Rangeland rummy–a board game to support adaptive management of rangeland-based livestock systems. J. Environ. Manag. 147, 236–245.
Fløysand, Arnt, Jakobsen, Stig-Erik, 2011. The complexity of innovation: a relational turn. Prog. Hum. Geogr. 35 (3), 328–344.
Friederichsen, Rupert, Minh, Thai Thi, Neef, Andreas, Hoffmann, Volker, 2013. Adapting the innovation systems approach to agricultural development in Vietnam: challenges to the public extension service. Agric. Hum. Values 30 (4), 555–568.
Friis-Hansen, E., Duveskog, D., 2012. The empowerment route to well-being: an analysis of farmer field schools in East Africa. World Dev. 40 (2), 414–427.
Gal, Le, Pierre-Yves, Jennifer Bernard, Moulin, Charles-Henri, 2013. Supporting strategic thinking of smallholder dairy farmers using a whole farm simulation tool. Trop. Anim. Health Prod. 45 (5), 1119–1129.
Goulet, F., 2013. Narratives of experience and production of knowledge within farmers' groups. J. Rural. Stud. 32, 439–447.
Guijt, Irene, Shah, Meera Kaul, 1998. Waking up to power, conflict and process. In: Guijt, Irene, Shah, Meera Kaul (Eds.), The Myth of Community: Gender Issues in Participatory Development. Intermediate Technology, London, pp. 1–23.
Hailey, John, 2001. Beyond the Formulaic: Process and Practice in South Asian NGOs. In: In Cooke and Kothari Participation: The New Tyranny? Zed Books, New York, pp. 88–101.
Hall, Andy, 2007. Challenges to strengthening agricultural innovation systems: where do we go from here? In: In UNU-MERIT Working Paper. United Nations University/ Maastricht Economic and Social Research and Training Centre on Innovation and Technology, Maastricht, The Netherlands.
Healy, Adrian, Morgan, Kevin, 2012. Spaces of innovation: learning, proximity and the ecological turn. Reg. Stud. 46 (8), 1041–1053. http://dx.doi.org/10.1080/00343404.2012.672725.
Hickey, Sam, Mohan, Giles, 2005. Relocating participation within a radical politics of development. Dev. Chang. 36 (2), 237–262.
Hocdé, H., Triomphe, B., 2006. L'expérimentation en milieu paysan. In Memento de l'agronome. Eds CIRADGRET pp. 511–530.
Isaacs, Williams, Senge, Peter, 1992. Overcoming limits to learning in computer-based learning environments. Eur. J. Oper. Res. 59 (1), 183–196.
Ison, Ray, Blackmore, Chris, Collins, Kevin, Holwell, Sue, Iaquinto, Ben, 2014. Insights into operationalizing communities of practice from SSM-based inquiry processes. Syst. Pract. Action Res. 27 (2), 91–113.
Kabambe, V.H., Chilimba, A.D.C., Ngwira, A., Mbawe, M., Kambauwa, G., Mapfumo, P., 2012. Using innovation platforms to scale out soil acidity-ameliorating technologies in Dedza District in Central Malawi. Afr. J. Biotechnol. 11 (3), 561–569. http://dx.doi.org/10.5897/AJB10.2227.
Kesby, Mike, 2005. Retheorizing empowerment-through-participation as a performance in space: beyond tyranny to transformation. Signs J. Women Cult. Soc. 30 (4).
Kesby, Mike, 2007. Spatialising participatory approaches: the contribution of geography to a mature debate. Environ. Plan. 39 (12), 2813–2831.
Klerkx, L., van Bommel, S., Bos, B., Holster, H., Zwartkruis, J.V., Aarts, N., 2012. Design process outputs as boundary objects in agricultural innovation projects: functions and limitations. Agric. Syst. 113, 39–49.
Lave, Jean, Wenger, Etienne, 1991. Situated Learning: Legitimate Peripheral Participation. Cambridge University Press.
Le Bellec, F., Rajaud, A., Ozier-Lafontaine, H., Bockstaller, C., Malezieux, E., 2012. Evidence for farmers' active involvement in co-designing citrus cropping systems using an improved participatory method. Agron. Sustain. Dev. 32 (3), 703–714.
Leeuwis, Cees, Aarts, Noelle, 2011. Rethinking communication in innovation processes: creating space for change in complex systems. Journal of Agricultural Education and Extension 17 (1), 21–36.
Leeuwis, C., van den Ban, A., 2004. Communication for Rural Innovation. Blackwell Publishers.
Lynam, T., de Jong, W., Sheil, W., Kusumanto, T., Evans, K., 2007. A review of tools for incorporating community knowledge, preferences and values into decision making in natural resource management. Ecol. Soc. 12 (1).
Martin, L., 2014. Les Serious Games, instruments d transformation des situations de travail ? Education Permanente 198, 219–228.
Martin, G., 2015. A conceptual framework to support adaptation of farming systems-development and application with forage rummy. Agric. Syst. 132, 52–61.
Matthews, K.B., Schwarz, G., Buchan, K., Rivington, M., Miller, D., 2008. Wither agricultural DSS? Comput. Electron. Agric. 61 (2), 149–159.
McCown, R.L., 2002. Changing systems for supporting farmers' decisions: problems, paradigms, and prospects. Agric. Syst. 74. http://dx.doi.org/10.1016/S0308-521X(02)00026-4.
McCown, R.L., Carberry, P.S., Hochman, Z., Dalgliesh, N.P., Foale, M.A., 2009. Re-inventing model-based decision support with Australian dryland farmers. 1. Changing intervention concepts during 17 years of action research. Crop and Pasture Science 60, 1017–1030. http://dx.doi.org/10.1071/CP08455.
Mohan, Giles, 2001. Beyond participation: strategies for deeper empowerment. In: In Cooke and Kothari Participation: The New Tyranny? Zed Books, New York, pp. 153–167.
Mugittu, V F and J T Jube. 2011. The poultry sub-sector innovation network in Tanzania. In Putting Heads Together: Agricultural Innovation Platforms in Practice, Edited by S Nederlof, M Wongtschowski, and F van der Lee. KIT Publishers, KIT Development, Policy & Practice.
Mwaseba, D.L., Kaarhus, R., Johnsen, F.H., Mattee, A.Z., Mvena, Z.S.K., Eik, L.O., 2015. Empowering farmers? Collaborative research at Sokoine University of Agriculture, Tanzania. Dev. Pract. 25 (3), 347–359. http://dx.doi.org/10.1080/09614524.2015.1019340.
Nederlof, S., Wongtschowski, M., Van der Lee, F. (Eds.), 2011. Putting Heads Together: Agricultural IPs in Practice. Bulletin Vol. 396 KIT publishers, Amsterdam.
Nelson, Nici, Wright, Susan (Eds.), 1995. Power and Participatory Development Theory and Practice. Intermediate Technology, London.
Nguyen, N.C., Wegener, M., Russell, I., 2007. Decision support systems in Australian agriculture: state of the art and future development. Australian Farm Business Management Journal 4 (1/2), 15.
Ngwenya, Hlamalani, Hagmann, Jürgen, 2011. Making innovation systems work in practice: experiences in integrating innovation, social learning and knowledge in innovation platforms. Knowl. Manag. Dev. J. 7 (1), 109–124. http://dx.doi.org/10.1080/19474199.2011.593867.
Oladele, O., Wakatsuki, T., 2011. Learning alliances in Sawah rice technology development and dissemination in Nigeria and Ghana. Life Science Journal-Acta Zhengzhou University Overseas Edition 8 (2), 622–627.
Oreszczyn, Sue, Lane, Andy, Carr, Susan, 2010. The role of networks of practice and webs of influencers on farmers' engagement with and learning about agricultural innovations. J. Rural. Stud. 26 (4), 404–417.
Paul, M., 2009. Accompagnement. Recherche et formation 62, 91–108.
Poncet, J., Kuper, M., Chiche, J., 2010. Wandering off the paths of planned innovation: The role of formal and informal intermediaries in a large-scale irrigation scheme in Morocco. Agric. Syst. 103 (4), 171–179.
Pretty, J.N., 1995. Participatory learning for sustainable agriculture. In: World Development. 23(8). pp. 1247–1263.
Ravera, F., Hubacek, K., Reed, M., Tarrasón, D., 2011. Learning from experiences in adaptive action research: a critical comparison of two case studies applying participatory scenario development and modelling approaches. Environmental Policy and Governance 21 (6), 433–453.
Renger, M., Kolshoten, G., De Vreede, G., 2008. Challenges in collaborative modelling: a literature review and research agenda. Int. J. Simul. Process. Model. 4, 248–263.
Sandker, M., Campbell, B.M., Ruiz-Pérez, M., Sayer, J.A., Cowling, R., Kassa, H., Knight, A.T., 2010. The role of participatory modeling in landscape approaches to reconcile conservation and development. Ecol. Soc. 15 (2), 13. URL: http://www.ecologyandsociety.org/vol15/iss2/art13/.
Schad, I., Roessler, R., Neef, A., Valle Zarate, A., Hoffmann, V., 2011. Group-based learning in an authoritarian setting? Novel extension approaches in Vietnam's northern uplands. Journal of Agricultural Education and Extension 17 (1), 85–98.
Scoones, I., Thompson, J., Chambers, R., 2008. Farmer First Revisited: Innovation for Agricultural Research and Development Workshop Summary. IDS, Brighton. www.future-agricultures.org/farmerfirst/files/Farmer_First_Revisited_Post_Workshop_Summary_Final. pdf.
Senge, P., 1990. The Fifth Discipline: The Art and Practice of the Learning Organization. Doubleday Currency, New York.

Sligo, F.X., Massey, C., 2007. Risk, trust and knowledge networks in farmers' learning. J. Rural. Stud. 23, 170e182.

Spielman, David J., Javier Ekboir, and Kristin Davis. 2009. The art and science of innovation systems inquiry: applications to sub-Saharan African agriculture. Technol. Soc. 31 (4). Elsevier Ltd: 399–405. doi:http://dx.doi.org/10.1016/j.techsoc.2009.10.004.

Squires, Heather, Renn, Ortwin, 2011. Can participatory modelling support social learning in marine fisheries? Reflections from the invest in fish south west project. Environmental Policy and Governance 21 (6), 403–416.

Swaans, K., Boogaard, B., Bendapudi, R., Taye, H., Hendrickx, S., Klerkx, L., 2014. Operationalising inclusive innovation: lessons from innovation platforms in livestock value chains in India and Mozambique. Innovation and Development 4 (2), 239–257.

Ulrich, W., 1995. Critical Heuristics of Social Planning: A new Approach to Practical Philosophy. Wiley, Chichester, UK.

Ulrich, Markus, 1997. Links Between Experiential Learning and Simulation & Gaming. Proceedings of the 28th Annual International Conference of the International Simulation and Gaming Association (ISAGA), July. pp. 269–275.

Van Asselt, M., Rijkens-Klomp, N., 2002. A look in the mirror: reflection on participation in integrated assessment from a methodological perspective. Glob. Environ. Chang. 12 (3), 167–184.

van der Ploeg, J.D., 2008. The New Peasantries, Struggles for Autonomy and Sustainability in an era of Empire and Globalization. Earthscan, London.

Voinov, A., Bousquet, F., 2010. Modelling with stakeholders. Environ. Model. Softw. 25, 1268–1281.

Voinov, A., Gaddis, E., 2008. Lessons for successful participatory watershed modeling: a perspective from modeling practitioners. Ecol. Model. 216 (2), 197–207 24 August.