Participatory Cropping and Farming System Design among multiple stakeholders to contribute to sustainable agricultural production. Experiences and lessons with the Agrarian Reform Sector in the Brazilian Cerrados

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Abstract: *Involving users in the development of innovations has become not only legitimate, but necessary, especially when users face strong constraints. The Unai project in the Brazilian Cerrados is using such an approach for accompanying small holders of the Agrarian Reform sector in their struggle towards sustainable agriculture. Several stakeholders are involved, including research, education, local development institutions and farmers. Direct-seeding systems (DSS), improved livestock feeding and milk marketing, and also capacity-building of farmers and their organizations are among the key innovations being tackled.*

The paper highlights results obtained with focus groups in developing milk marketing and direct-seeding, in their technical, organizational and training / learning dimensions. The Unai project also facilitated the emergence of a new cooperative extension service comprised of young farm advisers originating from the Agrarian reform sector households. Work is also under way to help farmers and their organizations play a more active role in the emergence of sound agricultural policy instruments at the level of the whole Unai region.

More generally, the Unai project strives to give a concrete meaning to key concepts such as responsabilizing farmers, formalizing the relationships among stakeholders, negociating rules for collective action, adjusting dynamically the roles and functions of the various partners, and favoring mutual learning. In doing so, it aims to enable all stakeholders, and especially the weaker ones, to gradually become true co-designers of innovations. Installing effective mediation and catalyzer functions, developing effective strategies for coping with conflicts, risk and unexpected occurences, reasoning the dynamics of interventions over time and at multiple scales, and finally creating adequate space for mutual learnings are part of the continuing challenges the Unai project faces.

This experience illustrates the interest and challenges of approaches aimed at rejuvenating the thinking and the practice of how research may accompany innovation processes. Implementing the corresponding changes require time and continuity of efforts. It also requires active, imaginative support by the institutions hosting the corresponding work, with the eventual aim of achieving an effective integration of scientific and institutional approaches on one hand, and of agronomic, ecological and social sciences on the other hand.

Keywords: *participatory design, innovation processes, direct-seeding, learning, capacity-building*

Introduction

Use of top-down, hierarchical approaches to innovation design is still frequent nowadays in the agricultural sector. Researchers working under the corresponding paradigm tend to play a sovereign role in identifying problems to be addressed, designing a suitable research process and shaping the resulting innovations. The latter are usually passed over to specialized agencies (such as extension) in charge of disseminating them to potential users who are then left with the decision of using / adopting them. Many successes were and are still being reached with such approaches. They have however been criticized for quite some time, particularly due to the perverse impacts of hierarchical decision-making (Lewin, 1946) and their inability to deliver the types of innovations needed by the poor, such as the small scale farmers.

A first step was taken in the 1970s and 1980s; with the emergence of Farming System and Research Development approaches (Norman, 1982, Jouve et Mercoiret 1987), which emphasized the need to get out of the research station and understand the diversity of farming systems at various scales, and the many constraints under which farmers operate and strive to adapt to a rapidly evolving set of livelihood and societal demands and a fast-changing natural and socio-economic environment. They were soon followed by a blossoming of participatory approaches of various types (Chambers, 1989; Ashby and Sperling, 1995; Veldhuizen and al., 1997; Scoones at al., 1994), placing the emphasis on involving farmers actively in key steps of the research / innovation process. Starting in the 1990s, the focus gradually shifted away from processes in which researchers play a leading role, to ones in which other actors play a prominent role, such as farmers' organizations, private sector operators or even to entire innovation systems in which multiple stakeholders interact and coordinate their efforts to design innovations (Röling & al., 2004; Engel, 1997; Ison & Russell, 2000; Hocdé, 2000, World Bank, 2006). A number of authors also point out to the importance of political factors related to innovation processes, by putting a premium on empowerment (Gonzalves and al., 2005), or technical democracy (Callon, Lascoumes and Barthe, 2001).

The evolution affecting the agricultural R&D sector is but a special case of the more general increasing involvement of users in technology design (Mc Cown, 2002; von Hippel, 2005). There has been furthermore a re-assessment of the role of technology per se as a necessary and sufficient driving force for innovation, which was taken for granted for a long time. Today, many argue that technologies are rather the hybrid result of scientific and technical necessities on one hand, and economic, social, cultural and political choices on the other hand (MacKenzie & Wajcman, 1999). Several authors also point to the role of networks and collective action around technologies and artifacts (see for example Pinch & Bijker, 1984; Latour and Woolgar, 1979, Vinck, 1999).

This brief review illustrates the ample justification indeed for involving farmers in the design of new technology. Using it as our background, we will turn our attention to the specific experiences of a R&D project operating in the Brazilian Cerrados. It tackles cropping and farming system design in partnership among a number of stakeholders from the research, development and education spheres, with a specific emphasis on direct-seeding systems. We first provide a brief overview of the context in which the project operates, and then focus on the evolving set-up and approaches being used for dealing with technology and innovation design. We then discuss a number of lessons and challenges coming out of this experience.

Context and project description

The Cerrados and the Agrarian reform sector

The Cerrados cover 200 millions hectares in the mid altitude savannahs of central Brazil. They possess a tropical humid climate (1300 - 2000 mm), marked by a fairly long rainy season. The flat Cerrados (or *chapadas*) are home to large-scale agro-industrial agriculture. For their part, the margins of these *chapadas* and the uneven, sloppy zones between them are home to small-scale agriculture which originates partly from recent land distributions under the Agrarian reform process. This is particularly the case in the municipality of Unaí, in the North-western corner of the state of Minas Gerais, a mere 150 km away from the capital city of Brasilia. Due to poor soils, severely restricted access to capital, cash, credit, markets, information and institutional services (such as technical assistance), the corresponding farmers are facing considerable difficulties in making a decent living out of diversified agriculture and cattle raising.

The Unaí project and key methodological choices

Since 2002, a small EMBRAPA (the Brazilian federal Agronomic Research Institute) team has been leading a consortium of partners (including the University of Brasilia, the State technical school of Agriculture of Unaí, the Syndicate of Rural Workers and farmers from various communities) in the implementation of a participatory R&D project usually referred to as the Unaí Project, focused on the smallholders of the Agrarian reform sector (Xavier et al., 2004). CIRAD (French Center for Tropical Agronomic Research) joined the consortium in 2004.

The Unaí project has its initial methodological roots in classic R & D and Farming systems approaches (Jouve and Mercoiret, 1987). Since 2005, under the catalyzing role of CIRAD, it has initiated an evolution towards an approach more akin to action-research (Liu, 1997; Thiollent, 1999, Morin, 2004) or what has been referred to within the project as “innovation design in partnership” (Triomphe and Sabourin, 2006). Action-research as practiced in Unaí is based on principles and attitudes (such as the value placed on participation, interactive dialogue and negotiation, cooperation and solidarity, transparency, mutual learning, ethical attitude), rather than on methodological prescriptions. While participatory tools do not play a central role in the approach usesd in Unai, a number of them were critical throughout the project implementation up to this day. They include participatory strategic planning at the level of entire communities or focus groups, technical and economic monitoring of a sample of reference farms, and participatory on-farm experimentation, among others. Semi-structured interviews of individual farmers and collective workshops during which farmers often times play pivotal roles in sharing their experiences are also common place at key moments during the project cycle, be it for diagnostic, monitoring, evaluation or planning purposes.

The key objective of the Unaí project is to contribute to the improvement of Agrarian Sector farmers’ livelihoods. It operated initially mostly in 3 communities of the Unaí district, and was designed around 4 key components: (1) generating technico-economic references covering the diversity of farming, cropping and livestock systems, (2) contributing to improved natural resource management, (3) improving access to market and (4) strengthening farmer organizational capacity. Significant efforts were also devoted to improving the education and training of the youth of the Agrarian reform sector, by preparing a number of them to become agents of change for the promotion of a sustainable, equitable rural development process.

Designing innovative cropping and farming systems

Rationale for introducing direct-seeding systems in Unaí

Direct-seeding systems (DSS) are notoriously widespread in Southern Brazil among large and small-scale farmers (Wildner de Prado, 2004, Scopel et al., 2004, Bolliger et al., 2006, Triomphe et al., 2007). Such systems rely on developing a successful local solution for applying simultaneously three key principles: minimum disturbance of the soil by tillage implements, maintaining soil cover as much as possible throughout the year, and diversifying crop rotations or associations. DSS are already used extensively by large-scale Cerrados farmers because they contribute to increasing profitability of grain production while simultaneously controlling erosion. Diagnostic studies conducted in 2004 and among Unaí Agrarian reform farmers and confirmed subsequently showed that properly designed DSS could contribute to solving several constraints farmers face for their maize production. These include dependency on externally hired tractors for land preparation, poor quality of planting and weed control, competition for labor use with other activities such as livestock keeping and off-farm work, overall high production costs and low levels of productivity (Xavier et al., 2004; Scopel et al., 2005). Furthermore, if and when multi-purpose cover crops with a forage value are included as part of DSS, they have the potential to contribute to the successful intensification of milk production. The latter is an objective shared by many small-scale farmers, as milk production is one of the few options available to them for generating steady incomes and improving their farming systems.

Designing direct-seeding systems for the small-scale farmers of Unaí

Switching from conventional cropping systems based on tillage to DSS is by no means a straightforward process: first, because DSS have to be constantly re-invented and fitted locally to suit the local physical and socio-economic environment of each region or even farm, and also, because their adoption by small-scale farmers requires a fair degree of conceptual, technical and practical learning as well as access to suitable implements and inputs, such as no-till seeders and herbicides.

Unsurprisingly, the approach used in Unaí for adapting DSS to local conditions and promoting them among farmers was not devised overnight. It evolved gradually to accommodate the often times conflicting needs of generating new generic knowledge about DSS (an objective pursued by researchers who are accountable to the scientific community at large) and answering the diversity of local farmers’ research and development needs. Initially quite focused on biophysical and technical issues related to DSS, the approach developed in Unaí has now evolved into a more comprehensive approach to participatory cropping systems design integrating the agronomic, socioeconomic and organizational dimensions.

The first forays into designing locally adapted DSS took place during the 2004-2005 cropping cycle. It consisted mostly of a handful of demonstration trials conducted in close collaboration between farmers and researchers acting in their capacity as DSS experts and surrogate technical advisers. The corresponding DSS relied on animal traction as a source of draft power for pulling simple no-till direct-seeders, and the use of herbicides such as glyphosate and 2-4,D for managing weeds. Herbicides at the time was an innovation in its own right as farmers were mostly used to practicing mechanical and manual weed control.

The initial success obtained in such trials (in terms of boosting maize yields, decreasing production costs and labor use) led to an expansion in the number of participatory trials and farmers, a first "spontaneous" diffusion of no-till direct seeders at the regional scale, and the development of an approach to cropping system design which today comprises the following four inter-related components (Mischler et al., 2008):

1. The first component consists of controlled trials on- station, pursuing a triple objective; test different combinations DSS components, such as cover crop species and planting dates for intercropping them into a maize crop, calibrating biophysical models for simulating the agronomic behavior of such systems, and providing a handy way of showcasing DSS for visitors (farmers, extension agents, decision-makers, donors) from the region during large-scale field-days.
2. The second component includes a series of fairly simple participatory whole-field trials with farmers, which are used as learning devices about DSS implementation and management such as no-till seeder calibration, herbicide uses, and getting to know cover crops. Such trials, which are closely linked with activities conducted within the framework of DSS focus groups (see below) also serve as support to farmer exchange visits at the local and district level. They are also used to calibrate biophysical models developed under step 1 under a large array of environmental and socioeconomic conditions.
3. The third component involved setting up and accompanying direct seeding focus groups. These are small groups of 5 to 15 farmers from a given community interested in direct-seeding, who attend meetings, training events and for some of them, carry out DSS experiments in their own fields. Focus groups have multiple objectives: they facilitate individual and collective learning of its members, they make it easier to acquire direct-seeding equipment and inputs, and they facilitate discussions among farmers, researchers and farm advisers. The ultimate objective however from the viewpoint of researchers is for these groups to become gradually more autonomous by freeing themselves from the strong initial influence of outsiders on its activities and priorities.
4. The fourth component consists of conducting a holistic assessment of the performances of DSS, encompassing biophysical and socioeconomic criteria and indicators at the cropping and farming system levels through integrated modeling. Modeling is especially relevant for dealing with complex systems such as DSS because it allows to take into account multiple criteria and multiple scales simultaneously and to explore a larger array of cropping and farming systems combination than those which could be tested empirically. Modeling is also able to simulate cumulative effects and impacts of DSS over a number of years on soil fertility, weed pressure or whole-farm operation and profitability for example.

A fifth component is being developed: it consists of framing the previous tools, or a fraction thereof in the form of a user-friendly decision support system or a companion toolbox, with the purpose of offering farmers and technical advisers a framework to discuss, select and design cropping and farming systems responding to their needs.

Functional linkages among the above components are being refined. The aim is to develop a comprehensive approach for ex-ante assessment of cropping systems, taking fully into account factors and constraints related to cropping systems and farming systems as well as farmers' perceptions and objectives.

Selected results

While DSS development in Unaí is far from being over, the project has already produced a number of interesting results. For instance, experimental trials on-station and on-farm showed that maize production under DSS yielded similarly to conventional tillage systems (between 3 and 5 $t.ha^{-1}$, with a potential of 6 $t.ha^{-1}$ in the best situations), even under the low levels of chemical inputs that farmers can afford. The inclusion of a cover crop in the rotation increases total biomass produced during the rainy season by 0.5 to 5 t/ha depending on the year, the species used and the actual planting date.

Confirming the validity of ex-ante diagnostic studies, producers indicated that their interest in DSS stems from their desire to get autonomy from hiring external tractors, and to increase weed control efficiency, easiness and speed through herbicide use. Conversely, most of them tend to be sceptical about cover crops because benefits derived from their use are not immediate whereas costs (in terms of additional work) have to be paid upfront.

Identifying farmers' own criteria for assessing existing or future cropping systems is not straightforward, not least because of language, communication and simple listening / translation problems between researchers and farmers (Lenné et al., 2007). The latter do not seem to perceive indirect or non material impacts of new cropping systems and do not necessarily plan ahead at the cropping system scale. Some of them however mention indirect advantages of cover crops such as their capacity for increasing soil fertility or decreasing weed seed banks and competition (Levasseur pers. com.). .

Validating farmers' perceptions about DSS, modelling results based on a linear programming approach at the level of the whole farm further illustrate and quantify the economic attractiveness of DSS. For one, buying no-till seeders and herbicides costs less than hiring external tractors for land preparation and planting, something farmers had understood very quickly. Crucially, modelling shows that labour productivity increases under DSS, a clear advantage for farmers who require more time for cattle management as they intensify their milk production. Modelling also shows that cover crops are economically interesting only in as much as they contribute to feeding dairy cattle during the dry season in terms of amount and quality of the biomass produced (Alvarez, 2007).

Indeed, integrated modelling coupled with participatory experimentation and a careful identification of farmers' perceptions is contributing to a better understanding of the roles and functions DSS may play in the evolution of local farming systems towards more sustainable forms of agriculture. When companion modelling will have been developed, modelling will undoubtedly contribute even more directly to facilitating the dialogue among stakeholders. Meanwhile, the Unaí project is already more and more considering DSS as part of integrated, sustainable, mixed farming systems relying on crop and dairy production, instead of looking at it merely as a neat way of achieving higher crop productivity in an environmentally friendly way, as it tended to do initially.

Multiple stakeholder partnerships as a key to designing innovations

DSS development is but one example of how the Unaí project strives to develop an effective partnership approach to address jointly identified problems and negotiated objectives among multiple stakeholders. The partnership, still under construction at the moment, has many constitutive elements and takes on a distinct geometry depending on the specific issues being tackled. For example, the collaboration built around rural youth education was mostly between a working group from the University of Brasilia, a local agricultural technical school, EMBRAPA and the local farmer trade union. It developed a training curriculum for a group of 60 youths over a 3-year period, consisting of periods of intensive conceptual and practical courses related to sustainable rural agricultural development and agroecology, interspersed with longer off-school periods dedicated to diagnostic work, project development and routine participation of the students in the activities of their families and communities. Another type of collaboration developed around improving milk marketing for dairy farmers of agrarian reform communities. This involved mostly EMBRAPA, another group from the University of Brasilia and several community boards. This group of stakeholders engaged jointly in extended negotiations in 2 directions: externally, with donors and the regional milk cooperative about the acquisition of collective refrigerated milk tanks, and internally, around the development of sensible management rules for such tanks, and the subsequent routine management of milk marketing and input purchases. Yet another type of collaboration evolved among the various individual researchers and the various research teams involved in the Unaí project, to come up with a unified vision about the future of the project and the type of research needed within the Unaí project, about the balance among the various research components, the respective room given to knowledge generation vs. the engagement of researchers into action alongside farmers and their organizations. Partnership geometry also evolves dynamically over time in Unaí, with some partners coming in (such as CIRAD in 2004), others becoming gradually more prominent (such as the technical Agricultural School or the local farmer trade union) and others yet becoming less active (such as the University of Brasilia). This dynamic nature reflects the changing objectives pursued by the project, and the periodic adjustments in the balance of power among partners as learning takes place.

The Unaí project shares many characteristics common to all live partnerships, such as the recurrent role of negotiations about values, goals, objectives, means, activities and calendars, the constant learning that takes place among stakeholders, and the non-lineal, unpredictable pathways of the innovations such partnerships strive to develop (Waters-Bayer et al., 2007; Hocdé et al., in press). Effective partnering goes beyond allowing participation of various stakeholders in an otherwise conventional research process in several ways. For once, many activities agreed upon among partners may not have much to do with research per se, as was illustrated with rural education, or the development of milk marketing. Yet they are key to legitimizing research as a valid, action-oriented partner. Also, partnership set-ups strive to create the conditions for a gradual empowerment of the weakest partners (in this specific case, farmers and their organizations), by developing individual and collective skills and competencies. In Unaí this also took the form of facilitating the emergence of a cooperative of young extension agents, willing and able to provide their services to the Agrarian reform farmers.

Partnerships are never a given, nor a simple label that can be attached to a project. One cannot necessarily expect to start a project from day one expecting it to behave as an effective partnership. This is because partnerships emerge only gradually over time assuming a number of conditions are met along the way. These include identifying shared values and true common objectives (as opposed to simple statements to this effect) through recurrent negotiations and time spent working alongside each other, acquiring confidence and trust in each other, and overcoming inescapable tensions and conflicts. As an example of tensions, in Unaí, they arose about the balance of activities dedicated to a technical innovation such as DSS, vs. to organizational work and innovation. Tensions can also have to do with the geometry of the partnership: in Unaí, some consider the all-important regional milk cooperative almost as a class enemy that the project must fight against, while others looks at it as a potential partner who should soone or later be invited to join the project. Working in partnership also involves proving through concrete commitments (time, resources, mental energy) and attitudes (such as effective respect for the other side, democratic behavior, keeping promises) each other's willingness and ability to pursue common objectives over extended periods of time. Another characteristic of effective partnerships is that they involve sooner or later a minimum degree of formalization of their functioning: written or oral agreements, clear protocols for implementing activities, transparent decision-making mechanisms, planning and evaluation, etc. Conversely, the lack of formalization usually reflects the relative ambiguities, confusions and the ad hoc nature of the operation of many multi-stakeholder arrangements.

To make sure, the Unaí project itself is still struggling to become an effective partnership (Hocdé and Triomphe, 2007). Proposals are indeed on the table that would allow the emergence of more explicit governance mechanisms and rules, a better identification of roles and functions of each partner, joint evaluation and programming of activities, and the establishment of an effective, systematic communication within the core project team and with the world at large.

A major positive factor contributing to the gradual transformation of the existing multi-stakeholder platform into a true partnership relates to the intensity and quality of interactions taking place among stakeholders. Relationships between researchers, farmer leaders and individual farmers take place in multiple settings: meetings of community boards and direct-seeding or milk and fruit marketing focus groups, routine follow-up of trials, exchange visits at key moments during the cropping season, training and educational events, joint negotiations with decision-makers and donors, etc. These high-occurrence, affectively and emotionally loaded encounters bring mutual benefits to those involved: for example, researchers gradually get a better grasp of farmers' and farmers' organization objectives, practices and perceptions, and vice versa. Content-wise, most meetings in which farmers take part tend to involve a strong technical flavor (such as how to practice direct-seeding or how to improve milk production). But a recurrent discussion also take place about organizational and market issues (e.g. how to get access to a no-till seeder, where to find herbicides, where to get good advise, etc.).

On the negative side, the Unaí project faces difficulties in moving away from strong, mostly ad hoc inter-personal relationships and towards a better formalization and institutionalization of those relationships. Researchers still have a tendency to assume too many functions in the current project configuration, ranging from research design and implementation to surrogate technical advice, to facilitators of the partnership and educators, up to brokers of relationships with donors and policy-makers. Researchers have yet to learn how to take a back seat and a more relaxed attitude in the activities and projects they are some time so keenly interested in implementing, to the risk of falling back on a participatory research mode rather than a true partnership one. Also having farmers take a more active, responsible stand in the partnership remains a challenge under the inherited paternalism which characterizes the relationships of agrarian reform farmers with whoever works with them (Lenné et al., 2007).

Discussion: Lessons and challenges for conceiving innovations in partnership

As things continue to unfold within the framework of the Unaí project, both advantages and limitations of adopting a partnership approach for conceiving innovations are starting to emerge. Some of the corresponding preliminary lessons and challenges can be summarized under the five following domains.

A first domain involves the kind and diversity of objects around which partnership operate. In Unaí, objects include the tangible ones, such as cropping systems, plants, inputs, and field days. Most stakeholders tend to focus on such objects, because they are easy to grasp and seem to be immediately real. They behave frequently as intermediary objects in the relationships among stakeholders (Vinck, 1999). Immaterial objects such as social and organizational arrangements, the very approach to innovation design or also the construction of a platform of stakeholder, seem as important as material ones in shaping the contours of partnerships: While tangible objects maintain a strong relationship to technical challenges, immaterial ones relate strongly to the dynamics of organization, of learning and power (Sabourin et al., 2007).

A second domain involves the extent to which mutual learning takes place. This seems to be a major factor for explaining the project dynamics and the results obtained so far. Learning takes place in multiple forms, in varying intensities and qualities, and with a huge diversity of content. It relates to the ability of all stakeholders to blend their specific knowledge and skills, with researchers bringing in formal scientific and institutional knowledge, and local actors bringing in more practical-oriented knowledge and perceptions (Béguin, 2003). In Unaí, researchers have learned form farmers the need to keep an open view on the functions of cropping systems such as DSS. They have also learned new ways of dialoguing with farmers (Lenné et al., 2007), and of conceiving activitiies with rather than simply for for them. Farmers on the other hand have learned among other things the importance of well-organized and well-thought out collective action if they are to get access to the services of the State they so critically need. They have also learned to see researchers not only as technicians and providers of knowledge and support, but as human beings with emotions, shortcomings and idealism. Whether farmers and the local farmer trade union have learned how to get away from paternalistic relationships remains to be seen.

A third domain has to do with the time dimensions of such approaches. Time has a multi-faceted influence on the Unaí project, and this is true to some respect of any project. There is a specific time line related to the work invested on cropping system development, which has to do mostly with the natural cropping cycles, with the gradual mastery by researchers and farmers of new inputs and vegetative materials such as cover crops, and with the cumulative effects that DSS have on soil fertility or weed dynamics (Mishler et al., 2008). Another time line involves the relationships that develop among stakeholders over the course of the project. It indeed requires significant amounts of time for i) getting to know and appreciate each other, ii) engaging in fruitful dialogue, and iii) building together. There are also the distinct time lines of research vs. action-oriented activities, with researchers being at times slower, at times faster than other stakeholders in addressing specific issues. Then there are the institutional time lines, related to how projects are approved, or to when leadership changes occur within an institution or a community board. Under such conditions, ensuring continuity of efforts to obtain the desired outcomes is a challenge that few projects working in partnership manage to achieve to their satisfaction, as time lines tend to conflict one with the other. Hence trade-offs are necessary. This also points once again to the necessity of putting in place an effective yet flexible piloting system for managing them (Liu, 1997).

A fourth domain has to do with the vast amount of resources invested in capacity building. Ideally, capacity building should be a major, continuous component of any partnership approach in which asymetries among partners are strong (Simson et al. 2003; Hocdé et al., in press). It should focus on the varying individual and collective needs of the involved stakeholders, from acquiring simple individual skills (such as becoming an able facilitator of collective meetings, or a good communicator of results) to more complex and collective ones, such as acquiring negotiating skills, or the capacity to organize collective action. Capacity-building should also contribute to changing the institutions, which is one key way of effecting durable change beyond the duration of the project (Liu, 1997). But implementing capacity building in practice remains a challenge. Individual turn-over rates in key project positions are usually higher than desirable, especially for stakeholders belonging to small, non-formal or emerging institutions, and hence capacity building of individuals has periodically to be started all over again, if at all possible. Collective capacity building also has its up and down cycles, as it depends heavily on who takes or leaves leadership position within each stakeholder group. Also, energies being in short supply, project staff tends to invest relatively more in implementing actual activities than in capacity-building per se. In Unaí, investment in capacity-building was very much emphasized initially, with many positive effects. It has now become a much smaller component of the overall project activities, not that needs have decreased, but because energies are invested elsewhere.

A fifth domain is emerging. It has to do with the need for stakeholders to acquire sufficient mastery of specific tools and methods in order to contribute efficiently to participatory innovation design. Many of these tools are by nature very context-specific, as they reflect priority and choices made by each project. But some of them are fairly generic. In Unaí, they include cropping system design and evaluation, biophysical and economic modelling, management of focus groups, participatory experimentation, participatory monitoring, communication, facilitation, and the list could easily go on. Who should master such tools and methods is another key issue. While the answer is of course variable, the key point is to make sure there is a fair level of collective appropriation, if it is to make a useful contribution to achieving the project's overall goals and outcomes. In Unaí, modelling which has received a lot of attention in recent years has not yet reached a satisfactory degree of collective appropriation. To this day, it remains much more of a researcher's tool than a clear contributor either to two major project objectives: (1) strengthening the collective capacity to understand the functioning of complex systems such as DSS, and (2) providing stakeholders with a capacity to transform their cropping practices and their environment based on a better understanding of DSS systems (Jeuffroy et al., 2008).. Obviously, mastering tools collectively (such as modelling) does not guarantee per se that a partnership will function (placing too much emphasis on tools can even become a type of tyranny by itself, as is the case for participation itself: Cooke and Uthari, 2001). However, the reverse, i.e. not mastering tools sufficiently has adverse consequences on a partnership's functioning and efficiency, by favouring the emergence of potentially mutually exclusive sub-cultures of users and non-users of various types of tools, which may lead to mutual scepticism and mistrust among project members..

Conclusions and perspectives

The Unaí project is far from being over and may yet witness several turns of fortune in its approach and in its objectives. As it stands today, it provides an opportunity to reflect on the specificities and contributions of participatory innovation design at various scales to achieving objectives related to sustainable agriculture. In our view, participatory design is certainly the way forward, at least under the heavily constrained conditions prevalent in the Brazilian agrarian reform sector, and is probably useful under a host of other circumstances as well. While an individual experience such as the one analyzed in this paper does not provide the necessary basis for extrapolating, we can safely conclude from this single case study that whatever its advantages, participatory design is far from being straightforward. The challenges and risks faced when trying to implement a project using such an approach are many, from the unpredictability of outcomes to the high, recurrent transaction costs or the frequent confusion about what constitutes the agreed-upon objectives, the rules of operation and the commitments of the various stakeholders to the eventual success of the project. Thus researchers and other stakeholders keen to embark in such endeavours are well advised to be prepared for uncertain, rough yet also exciting times and discoveries, be they about the technical objects (e.g. cropping systems) they agree to focus on, or the social and organizational dynamics they will necessarily immerse themselves into by doing so.

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