Project design and management based on a co-innovation framework: Towards more effective research intervention for sustainable development of farming systems

Walter A.H. Rossing[a], Santiago Dogliotti[b], Gian-Franca Bacigalupe[b], Eduardo Cittadini[c], Claudia Mundet[c], Valentina Mariscal Aguayo[e], Boru Douthwaite[f], Sophie Álvarez[f], Diana Cordoba[f], Mark Lundy[f], Katherine Tehelen[f], Conny Almekinders[g]

[a]*Biological Farming Systems group, Wageningen University, the Netherlands*
[b]*Universidad de la Republica, Facultad de Agronomía, Montevideo, Uruguay*
[c]*INTA, Centro Regional Patagonia Sur, Trelew, Argentina*
[d]*INTA, Agencia de Extensión Rural Sarmiento, Sarmiento, Argentina*
[e]*CRUOC – Universidad Autónoma de Chapingo, Guadalajara, Mexico.*
[f]*CIAT, Cali, Colombia*
[g]*Technology of Agrarian Development group, Wageningen University, the Netherlands*

Abstract: *Most of the budget for agricultural research-for-development is spent through projects and therefore project impact is important for funding agencies. Impact assessment is commonly performed ex-post for the purpose of accountability and has provided little guidance to more effective project design and management. Here we present a project design that bases its project theory on co-innovation, seen as an approach that combines farming systems theory, social learning and dynamic project monitoring and evaluation. The design is implemented in the EULACIAS project, focused on stimulating strategic re-orientation of family farm strategies in three case studies in Latin America. The paper sketches the conceptual basis of the co-innovation approach and the program theory of the project. Following a description of the case studies illustrations of the implementation of the approach are provided. The paper ends with first impressions of the outcome of the approach, pending full analytical results in the cases.*

Keywords: *project design and management, hard systems, soft systems, social learning, sustainability, livelihoods.*

Introduction

To farmers and other resource users experimenting and inventing is part of their way of life. However, small farmers are increasingly confronted with situations for which their experience provides little guidance. Here, researchers can play a role in supporting the resource users' own learning capabilities so that they can make better-informed decisions to adaptively manage their land. In such processes, researchers themselves learn by being able to analyze the many experiments that farm practices represent and by submitting their approaches to close scrutiny by local actors. Such innovation processes appear to be more effective when also involving actors from the wider farmer network, such as extension agents, suppliers, merchants and policy makers (e.g. Biggs and Smith, 1998).

Systems analysis and quantitative modeling constitute important tools in modern agricultural sciences to evaluate and consolidate the state of knowledge on agro-ecosystems. Experimentation in combination with model-based analysis and exploration is the way agronomists learn about their objects of research (Kropff et al., 2001; Carberry et al., 2002). In the literature on on-farm innovation, a substantial number of examples of collaboration between scientists and farmers can be found. Usually these examples deal with a few components of the system – integrated pest management, integrated crop management – in a rather qualitative manner. In other cases, quantitative and integrative tools made essential contributions to an ongoing learning process (Ten Berge et al., 2000; Carberry et al., 2002; Sterk et al., 2006). Such cases, however, are still rare and our understanding on how quantitative and quantitative approaches together interact with the learning process is in its infancy (Walters, 2007; Sterk et al., 2008). A range of conceptual frameworks on learning for sustainable natural resources management were put forward (e.g. Armitage et al., 2008; Giller et al., 2008; Pahl-Wostl, 2009), but the practical implementation of these frameworks requires further attention (Armitage et al., 2008; Cundill and Fabricius, 2009).

Much of the budget for agricultural research in general and research-for-development in particular is spent through projects and therefore project impact is an important concern for funding agencies (Douthwaite et al., 2003). Impact assessment is commonly performed in an ex-post manner, and aims to identify and value the changes in practice that can be attributed to the project for the purpose of accountability. Such analyses are wrought with controversy over aims and methodologies (Bickman, 2000), and have as yet provided little guidance for better project design and management (Horton and Mackay, 2003). A different perspective on project impact assessment suggests to use project monitoring and evaluation not only for accountability but also to enhance learning during the implementation of the project (Carberry et al., 2002; Douthwaite et al., 2003). Aim of this paper is to present the concepts and tools mobilized for a learning-oriented project design and management scheme in the EULACIAS[1] project. The project started early 2007 and focused on stimulating strategic re-orientation of family farm strategies in Latin America, based on a combination of hard and soft systems approaches. We describe the conceptual framework that was used to guide the project's design and management, and present the assumptions underlying the project's activities. We then introduce the case studies, and describe the approaches mobilized in the three core domains of the project. Awaiting comprehensive analysis of results, we end with a discussion of first impressions emerging from the project.

Conceptual framework

Complex adaptive systems and innovation

In EULACIAS, farms and their institutional context are understood as Complex Adaptive Systems (CAS) *(*Axelrod and Cohen, 2000). A CAS consists of agents, entities which can make things happen, along with the artefacts and strategies that they use in their interactions with other agents and with artefacts. Evaluation of the results of these interactions leads to selection of strategies or artefacts to copy, or recombine or to the invention of new ones. This evolutionary process introduces novelty. Learning selection has been proposed (Douthwaite, 2001) as a process by which the generated variation is evaluated and discarded or remoulded and included in practices. Such CAS cannot be managed in a linear way due to many unknown interactions and feedbacks between system components. Management should rely on stimulating and understanding variation in the types of agents, strategies, artefacts and their interactions, the selection processes by which the "fitness" of an agent, strategy or artefact is assessed, and the subsequent processes that allow the fitter to survive and spread (Douthwaite, 2001). This implies that management of variation, selection and survival, and spread of novelties requires attention in development-oriented research projects. Another implication of a CAS perspective is that the many unknown interactions and feedbacks between system components create systems that are inherently uncertain or to some degree unknowable in their dynamics and likewise the effects of management interventions. Therefore, while planning is important to coordinate activities between project partners, readiness to adapt planning becomes part of the planning activity.

Program theory of EULACIAS

The program theory of a project or program describes the underlying assumptions on how a program or project will work to achieve intended outcomes (Petrosino et al., 2000). Developing a program theory is assumed to increase transparency and tractability of activities, for both accountability and learning.

[1] European – Latin American Co-Innovation of Agro-ecoSystems; FP6-2004-INCO-dev-3; contract nr 032387; http://www.eulacias.org/

EULACIAS departs from the assumption that smallholders in emerging economies such as those in Latin America who are producing for markets are easily caught in a vicious cycle of unsustainability. The typical farmers' response is to increase the intensity of production by increasing inputs and share of cash crops, and by taking up farming on marginal parts of their land. This intensification uses substantial inputs of labor and capital and has often resulted in resource base degradation which in turn negatively impacts on productivity as well as net farm income. A major cause of this downward spiral is that the adaptation of farmers to changing conditions is mostly incremental, short-term oriented and only rarely involves strategic re-design of their rural livelihood strategies as a whole (IAASTD, 2009). As a result, livelihoods become locked-in on unsustainable development tracks. Alternative developmental tracks are possible when socio-economic improvements are combined with improved natural resource use. Such economically and agro-ecologically diversified livelihood options do not come as validated technology packages waiting to be adopted by farmers. Alternatives need to be built up on farms and in complete value chains in a process of innovation of the prevailing socio-technical system.

In innovation systems thinking (e.g. Smits and Kuhlmann, 2004; Fagerberg et al., 2005), innovation is seen as an interactive, non-linear process resulting from the interaction between heterogeneous actors and emerging technological and institutional change. Farms are equivalent to complex adaptive systems and subject to continuous production, evaluation and selection of novelty. In this framework, any significant innovation in farming systems is seen as a result of a change in human conduct and therefore requiring an individual and collective learning process (Leeuwis, 1999). Researchers can play a role in supporting the learning of resource users and other stakeholders. Researchers themselves learn by being able to analyze the many experiments that farm practices represent. Learning for innovation thus involves cognitive learning (about 'things you did not know') but also reframing, i.e. learning to understand the mindset or mental models that underpin how oneself and others operate. The new, emerging mental frames form the basis for the search for more creative and more collective solutions (Aarts, 1998).

The innovation systems perspective considers researchers to be one of the actor-networks which needs to link to other networks in the innovation system to be successful (Sumberg, 2005; Edquist, 2007). The stakeholders to link up with are considered to be next users or end users of technologies as well as politically important actors. In the research cycle, Giller et al. (2008) distinguish 4 phases, labeled describe, explain, explore and design. Each phase has a different mix of qualitative and quantitative systems methods to understand current systems or explore potential changes. This kind of systems thinking provides the means to explore consequences of changes in systems management at different levels, from field to farm and institutional environment to reveal conflicts between alternatives and to provide directions for promising development tracks.

In EULACIAS the focus is on the farming system and its components soils, crops, feed, animals and manure. Not in all farming systems all components will occur, but it is important to start from an inclusive perspective. Performance indicators are negotiated. The performance of the farming system is expressed in terms that are locally specific, partly based on global considerations, partly based on local agendas. The farming system is affected by management of the farmer, and by the prevailing socio-technical system, which includes the markets the farmer uses for buying and selling, and the rules and regulations that s/he is subject to.

The collective learning process about the innovation system needs to be embedded in project design. Monitoring and evaluation tools should be mobilized and developed to allow continuous reflection on project progress and to guide adjustments in project goals and activities. Thus, systems approaches, dynamic project monitoring and social learning are the three key constituents of the project's 'co-innovation' approach, which itself needs to be built up in situ.

Three case studies

Case studies were developed in Argentina (AR, sweet cherry production systems in Patagonia), Mexico (MX, dairy production systems in west Michoacán) and Uruguay (UY, peri-urban vegetable systems around Montevideo). Criteria for selecting the cases were: i) existing involvement of the lead researchers with local stakeholders; ii) occurrence of innovation dynamics independent of the project; iii) willingness of researchers to develop the three elements of co-innovation; iv) willingness of local stakeholders to host the project.

The cases had different innovation histories. In Patagonia, Argentina, production takes place in three valleys. In one valley production started as long ago as 30 years, while the others started 15-20 years later. Stimulus for uptake of cherry production came from government programs. Low and variable yields along with marketing problems had prompted intensification of farmer demand for support. Research and farm communities had developed relatively independently, the intermediary extension service mainly having the role of giving operational and tactical advice. The case study leader had completed a model-based exploration of technical development options for the cherry production systems (Cittadini, 2007; Cittadini et al., 2008). The model suggested the need to diversify to reduce peak labour demand and reliance on a single commodity, in order to increase net return and reduce risk. A clear intervention proposal did not exist at the start of the project. In the course of the project, participatory diagnosis of production techniques and product quantity and quality were carried out on all farms.Based on these results farm-specific action plans were developed, decided on and executed. The researcher team consisted of agronomists and one social scientist in training. The institute supported the idea of more interactive work linking research and extension, and had experimented with new ways of working in a previous project.

In Mexico, researchers had done a scoping study for the region and identified both on-farm technical problems and social and institutional issues as hindrances for development of dairy farms. The study created the basis for interaction between the region and the researchers who provided courses on technical and marketing topics in the run-up to the project. Farmers were particularly interested in making their businesses more profitable and saw environmental issues as secondary. Interventions were targeted both at the farm and the farm community level. At the farm level,researchers hypothesized that costs could be reduced by better using internal resource flows, especially related to feeding strategies. Discussing this idea with the farmers prompted a diagnosis of the biophysical functioning of the participating farms to identify resource flows and reflect on alternatives based on researcher experience. At the farm community level, stimulating social organization and marketing was taken up, using cheese production as a focal point. A proposal which would provide funding for a development-oriented project to which EULACIAS could link up early-on was unexpectedly rejected. As a result the representation of the project in the region was limited to 2-3 permanent staff. The researcher team consisted of animal scientists, a dairy processing expert, and social scientists. During the project the leadership changed. At the start of the project there had been little prior exposure to systems approaches and quantitative models.

In Uruguay scoping studies and model-based design had been done a few years before the start of the project (Dogliotti, 2003; Dogliotti et al., 2005). Farmers were concerned about decreasing yields which they ascribed to decreasing soil quality and climate change. To test strategic re-arrangement of vegetable farms a project had been started in close interaction between researchers and 6 farmers, supported by farmer unions and local policy makers. The EULACIAS project continued and expanded this initial project. Instead of continuing to intensify cropping systems, the researchers proposed to grow crops in wider rotations, using green manures and animal manure, and focus on the quality of labour input. In addition, infrastructure on farms was adjusted to better cope with erosion events. A team of extension agents, agronomists, farm economists and rural sociologists was created to interact with 16 farms and monitor changes in farm operation and the farmers' experiences thereof. Already one year after implementation of the radical changes, farmers saw improvement of their soils and yields, and the project became well supported by institutions.

The cases constitute different biophysical and social contexts in which a similar approach was adopted; however the actual implementation differed, depending on the production system, the researcher teams and the institutional settings including markets.

Implementation of the three co-innovation constituents

This section describes the implementation of the three cornerstones of co-innovation - dynamic project monitoring, systems approaches and social learning – in the project. Each description ends with an illustration taken from the cases. As explained in the introduction, a comprehensive analysis is pending. Instead, the final section will address first impressions.

Dynamic project monitoring

The execution of the EULACIAS project was embedded in an evolving framework of dynamic project monitoring activities – the first of the three cornerstones of co-innovation - at different levels: the project as a whole, the case study subproject, the case study team, the interaction with individual farmers, and the interaction with the biophysical-social-economic farming system (Table 1). At each level, activities were defined to contribute to project monitoring, and feedback of results to planning and decision making was decided.

At the level of the project as a whole, i.e. the three case studies and the 7 research partners, monitoring concerned accountability to the funding body through yearly reports. Adjustment of activities among the scientific partner teams and sharing of experiences took place during 4 full project meetings and approximately half-yearly Management Team meetings.

At the level of the case studies, planning started with a Participatory Impact Pathways Analysis (PIPA) workshop (Douthwaite et al., 2003) in which key stakeholders in the case study designed the project logic frame based on a problem tree, a visioning exercise and an assessment of the different networks of actors and institutions that needed to change to achieve the project's objectives. The PIPA workshop was followed up by reflection workshops each 6-10 months in which the multi-stakeholder case study team reviewed progress and planning, capturing results in an outcomes logic framework. Most Significant Change (MSC; Davies and Dart, 2005) stories were collected from stakeholders that were part of the identified networks, to provide a way to take feedback into account. Field days provided a means to scale out results to other farmers and local policy makers.

The case study research teams also had their meeting cycles, varying from monthly (UY) to half-yearly (AR and MX). The most frequent interactions took place between researchers and farmers during farm visits. These encounters were recorded in a number of cases. Finally, the biophysical and socio-economic performance of the farming systems were recorded based on the MESMIS sustainability indicator framework (Masera et al., 2000). Choice of indicators was partly common across the cases, partly case-specific. Selection of the indicator framework was part of a long process in which research leaders discussed by Skype which indicators to use from the original framework, which to skip, and which to add. An example of the way the case study teams organized their interactions is given in Fig. 1 for the UY team. An illustration of an MSC story from Argentina is given in Fig. 2.

Table 1. Role of dynamic project monitoring at different levels in the project.

Level in project	Dynamic monitoring activities	Frequency	Formal M&E Methods
Project as a whole	Reporting to funding body; Full project meeting reports; Management team	Yearly 4x in 3.5 yr 6-10-monthly	Deliverables and milestones As above + timeline As above + assessment
Case study (farmers, extension, policy makers, researchers)	PIPA workshop; Reflection workshops Field days	At start 1-2x yearly 4-5x yearly	Problem tree; network analysis; outcomes logic framework Exit polls
Case study research team	Recording and observation	Between monthly and 2-4x yearly	Outcomes logic framework, MSC
Individual farmer	Observation, discussion	Fortnightly (Mx and Uy); monthly (Ar)	MSC
Farming system	Observation	Fortnightly (Mx and Uy); monthly (Ar)	MESMIS[1]

[1]Masera et al., 2000

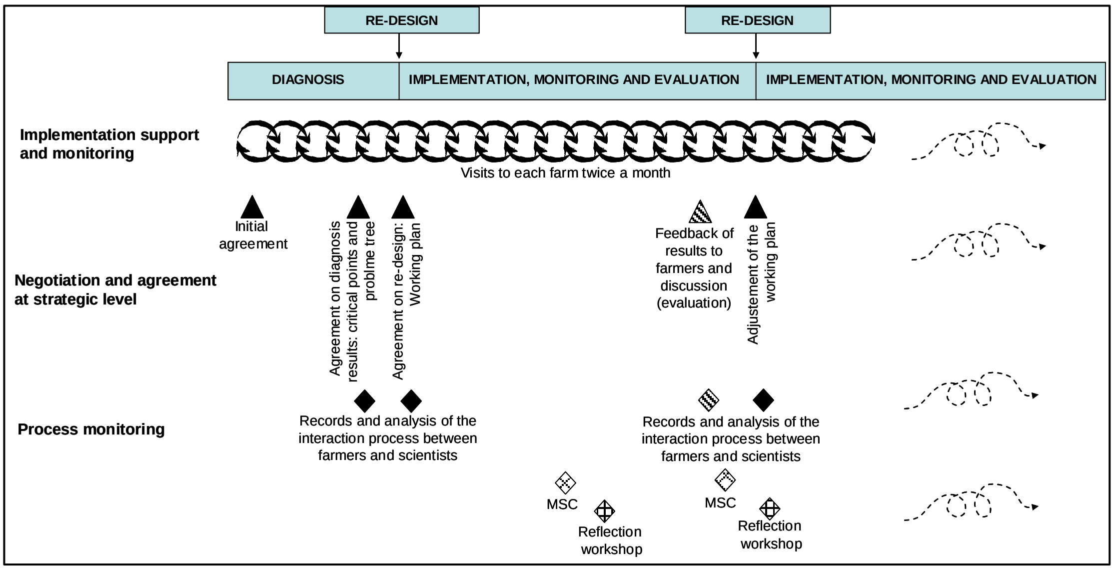

Figure 1. Timeline and activities in the Uruguay case study.

Systems approaches

During the full project meetings the system under consideration was defined as described in Fig. 3. Most detail was distinguished in the on-farm part. Here, a distinction was made in soil, crops, feed, animals, manure and their management. The biological components are measurable 'states' in the cycles of matter (e.g. expressed as carbon, nitrogen, phosphorous, potassium, money) and energy. Such cycles are found on mixed farms. Not all farms in the project were mixed farms. Yet this representation was chosen to stimulate thinking on options to reduce external dependence of the farms, in the EULACIAS program theory at the root of the vicious cycle of unsustainability on family farms. Markets, rules and regulations, and organizations involved in providing inputs and absorbing outputs from farming systems were considered 'driving factors' of the farming systems. They were assumed to determine the conditions under which farms had to operate. Farming systems in turn were assumed not to be able to influence the drivers. This is a classical way of distinguishing a system in ecology, described as consisting of interrelated components which is affected by its environment but does not influence the environment. The farms the project worked with were considered to be representative for farm types in the wider region. Studies were executed to delimit the various farm types. In this way, results found for individual farms could be 'scaled up' to regional consequences.

FARMER: 1; LOCATION: SARMIENTO; DATE: July 2009

What changes have you observed in the last season that can be attributed to the work done by EULACIAS team?

Firstly I can remark that the monitoring of phenological stages and foliar index estimation were done accurately and now we have that information.

Secondly I think it was important that they help us define exactly which varieties are asked by markets. We understood that this is a great disadvantage in our orchards and we have made the decision to change varieties during this season. There is support from the team and activities are achieved as planned. I have also understood that my training system needs more evaluation and experimentation. I have decided to change spacing as a trial.

And the most innovative practice I have incorporated this year is the leaching of salts by irrigation. I think I will continue performing this practice as we use drip irrigation and fertigation. I know the types of soils that I have and I realize that they erode with usage. The sustainability research should put emphasis on the cost analysis. The business is not profitable enough at the moment.

Figure 2. Example MSC story from the Argentinean case study.

Thus, the project dedicated most of its resources to describing and explaining current farming systems, and exploring options for changes-to-the-better. This is different from an inclusive innovation system approach in which many of what here are called drivers are assumed to be components of the system that need to be analyzed and re-designed to improve the functioning of the system as a whole. The reason for this focus on what could be called a sub-system of the innovation system is that the project felt that farmers could insufficiently be mobilized unless their day-to-day on-farm management problems would be addressed in a substantial way. However, particularly when considering development options for farms, the way in which drivers are thought to evolve has major repercussions on conclusions about the success of alternative farming systems.

The evolution of system drivers was addressed in a subproject aimed at elucidating scenarios (Contini et al., this volume). A Delphi methodology was developed for the case studies in AR and UY. In a first round, questionnaires were distributed to experts that had pledged their participation. In a second round the results of the first round were summarized. Experts were asked to reflect on their initially taken positions in view of the opinions expressed by the other experts, thus aiming for a consensus result. In MX a questionnaire-based approach was deemed not fitting due to too little expert commitment. Instead, focus groups were organized during which opinions were sought via a facilitator-directed process. Only one round was completed. In addition, stakeholders in some cases were sensitized to the approach by doing an exercise during a reflection workshop. The results of the scenario studies were used as feedback to the reflection meetings, and resulted in input for the explorative bio-economic model studies. The latter were so far only executed in UY (Casagrande et al., this volume).

Quantitative models were applied particularly by some members of the research teams to better diagnose critical elements in the farming systems, i.e. to direct the description and explanation of observed phenomena. A second use of models was to explore the consequences of changing current land use strategies, i.e. use the models to reveal the window of opportunity and how it is affected by current land use and current system drivers. This design-oriented application was only achieved in Uruguay, where diagnosis of current systems was more advanced at the start of the project than in the other cases. Computer models were mobilized on feed rations of animals, quality and quantity of manure produced, soil organic matter dynamics, NPK balances, wind and water erosion, and optimal pruning (Table 2).

In none of the cases models took an emblematic position. The concept of a systems approach, however, did have a central role, and served to put items on the agenda (e.g. role of leaf area index and soils in cherries, role of manure use in dairy farms) and create a distinctness of the research group as 'systems scientists'.

Social learning

The third cornerstone of co-innovation, social learning, constituted part and parcel of activities at each of the levels distinguished for dynamic project monitoring (Table 1) and the systems approaches. Nature and quality of interactions among researchers and between researchers and others in the innovation system and farming system were constantly on the agenda of the case study teams, driven forward by the Co-innovation workpackage and the case study leaders. In AR, the large variation in quality of soils prompted a series of soil studies. Results of these studies were discussed in study groups of researchers and farmers in the field. Topics started on remediation of soil problems, but evolved into a general diagnosis of critical success and failure factors on farms. This was revealing for both the farmers (e.g. Fig. 2) and for the scientists who started to understand the reservations of the farmers to the current organization of extension. In UY, the diagnosis revealed high labour input at low returns per hour. Plans were discussed in which the cultivated area was reduced drastically to just meet market demand, and planned rotations brought further structure to farm planning. To the farmers this constituted a major shift in perception, as their response to decreasing returns had been to increase the area cultivated. To the researchers it became clear that their earlier strategic planning tools should now be complemented with tactical planning tools in order to better meet farmer demand for discussion support.

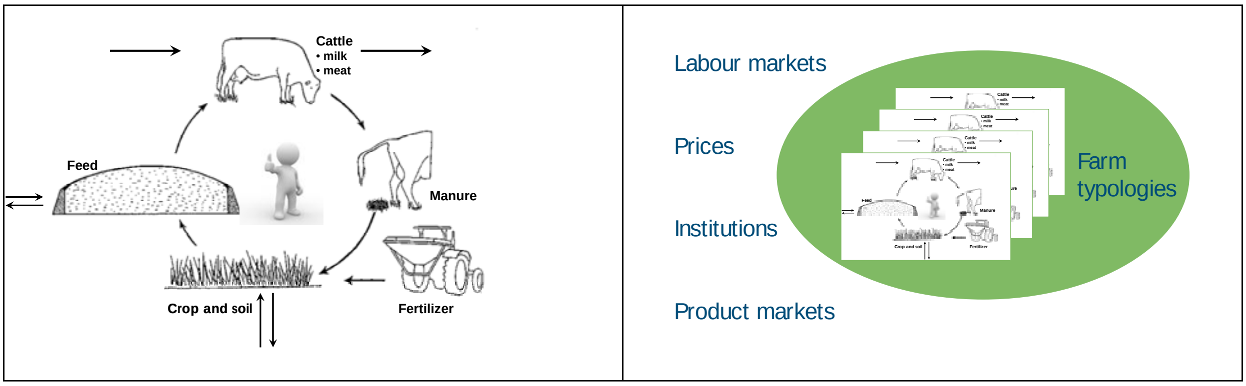

Figure 3. System representation in EULACIAS: The farming system, its components and their interactions (left), and the regional population of farming systems and their drivers (right).

First impressions

Pending the full analysis of the co-innovation approach based on the final reflection workshops, we here present some preliminary observations on the skill of the project design in achieving more effective research intervention.

The complex adaptive systems (CAS) perspective that is the conceptual basis of co-innovation stimulated thinking about generating and valuing variation, rather than trying to impose a generic blueprint per case study. Generating variation particularly involved making visible existing variation in farming methods and their consequences through diagnosis. This involved describing and explaining farming systems and their setting in terms of markets and institutions and took up most of the time in most of the case studies. Diagnosis did not add material variation, but revealed existing variation in terms and perspectives which were new, e.g. nutrient balances, money flows and leaf area index. In the UY case new variation was generated by exploring new farming systems in computer models (Casagrande et al, this volume). For some farmers this very quickly resulted in new ideas which they implemented. In AR for example, the participatory soil studies showed major impediments to root development due to soil compaction and sodic layers. Farmers started experimenting with soil flushing methods. In MX dry-season feedlot feeding was shown to result in substantial amounts of plant nutrients in the feedlot area. By suggesting the feedlots to be part of the crop rotation farmers were able to benefit from the manure deposited by the cattle. This was quickly taken up by some, who then started to think about moving the cattle through several feedlots to manage the manure amounts deposited in relation to crop demand. This 'innovation' – new composition of existing parts - created a bridge between plant and animal production and reduced in theory the dependency on external inputs of plant nutrients.

The systems approach created a perspective that enabled disciplinary specialists to see their knowledge as part of a larger relevant whole. Thus the approach may have contributed to a broader perspective of action-oriented researchers on the object of research. Instead of considering 'just' plant nutrition, weed dynamics or erosion, these aspects were confronted with each other and with other knowledge domains. This meant that researchers also had to arrive at a basic understanding at the interdisciplinary level. A few researchers worked with quantitative models. It was interesting to see how these experiences re-focused attention based on the relative quantitative importance of various phenomena. In contrast to these positive aspects, treating markets and institutions as exogenous drivers of the system under consideration (Fig. 3) may not have been most effective, as important market constraints might have warranted attention alongside on-farm technical constraints. This seemed to be especially the case in AR, where major distrust existed between growers and marketing partners, and to a lesser extent also in Mexico.

The emphasis on building agreement on the dynamic project goals with the group of stakeholders, i.e. next users, end users and politically important actors, may well have questioned the traditional distribution of responsibilities: researchers as experts, farmers as problem owners and extension as (partial) problem solvers. Farmers appreciated commitment of the teams to their specific situation, rather than seeing them as experts who visit occasionally and offer general advice. Researchers and extensionists molded and remolded their initial ideas on key problems of a farm and on alternatives until sufficiently convincing information was obtained and farmers agreed on conclusions. Keeping policy makers in the loop was a minor but constant activity of the case study leaders, in line with the ultimate desire to scale up the results. Thus, the notion of constructed reality and coalition building played a major role in thinking in the project, in line with the CAS basis.

Both in AR and UY the project was linked to other projects that provided a development setting. This allowed the project to keep its research-orientation. The link also offered financial, personnel and infrastructural scale-benefits. In MX a similar development-oriented project did not materialize. This may well have affected the effectiveness of the case study. Senior researchers were stationed several hundreds of kilometers away from the case study, tied up in teaching duties while a small local team had to take care of day-to-day operation. This may have interfered with full unfolding of the project's potential. If confirmed, this supports earlier views that project-based interventions are best linked to existing and ongoing local innovation dynamics (Biggs and Smith, 1998).

Constructing the co-innovation approach constituted very much work-in-progress during the project. It took some time until this became apparent. Once apparent and agreed upon, co-innovation became a term that researchers started to fill in and give meaning, supported by their experiences in the cases. Thus, the term acted as a condensation point for experiences and expertise of the project participants. During this construction process the case study teams felt 'alone' at times, because both the process and the products were not always clear at the micro-level. The project would have benefitted from systemic instruments that map reflection and social learning more clearly, supported by a larger team of social scientists with relevant background to support project management on a day-to-day basis.

In a review of 30 adaptive management programs in fisheries Walters (2007) identified three key difficulties in their implementation: failure to comprehend the need for management experiments, lack of leadership in implementation and inadequate funding for monitoring. In the EULACIAS project the CAS perspective may well have overcome the first key difficulty by stimulating identification and explanation of variation. Dynamic project monitoring and the emphasis on social learning were operationalized to counter the second and third key difficulties. The outcomes of the project will have to be measured in terms of changes in practices as well as changes in ways of working. The results of the final reflection workshops in the case studies with the stakeholders planned in May 2010 and an in-depth evaluation of all monitoring information collected will provide a test of the tentative conclusions arrived at here.

Table 2. Role of quantitative systems approaches in each of the case studies.

Role	*Argentina*	*Mexico*	*Uruguay*
Describe	Database at sector level; database per farm (N=15)	Database at sector level; database per farm (N=6)	Database at sector level; database per farm (N=16)
Explain	Modules on - cherry production - water use - nutrient balances - wind erosion - labour film - farm gross margin	Modules on - dairy production - crop production - nutrient balances - water erosion - labour film - farm gross margin	Modules on - crop production - beef production - water use - nutrient balances - water erosion - labour film - capital needs - family income
Explore	Multi-period LP, time horizon 20 yr; scenarios	Farm balance model; scenarios	Short term: cropping plan tool; Mid term: Scenarios + LP
(Select a) Design	Not implemented	Not implemented	Cropping plan tool

References

Aarts, M.N.C. (1998) Een kwestie van natuur; een studie naar de aard en het verloop van communicatie over natuur en natuurbeleid. Ph.D. Thesis, Wageningen University, The Netherlands.

Armitage, D., Marschke, M. and R. Plummer (2008) Adaptive co-management and the paradox of learning. *Global Environmental Change* 18: 86-98.

Axelrod, R. and M.D. Cohen (2000) *Fostering complexity*. Basic Books.

Bickman, L. (2000) Summing up program theory. *New Directions for Evaluation* 87: 103-112.

Biggs, S. and G. Smith (1998) Beyond methodologies: Coalition-building for participatory technology development. *World Dev.* 26: 239-248.

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. and M.J. Robertson (2002) The FARMSCAPE approach to decision support: farmers', advisers', researchers' monitoring, simulation, communication and performance evaluation. *Agricultural Systems* 74: 141-177.

Casagrande, M., Dogliotti, S., Groot, J., Aguerre, V., Abbas, A., Albín, A., Chilibroste, P. and W. Rossing, 2010. Exploring options for sustainable farming systems development for vegetable family farmers in Uruguay using a modeling toolkit. Proceedings 9th European IFSA Symposium, 4-7 July 2009, Vienna (Austria).

Cittadini, E.D. (2007) Sweet cherries from the end of the world: options and constraints for fruit production systems in South Patagonia, Argentina. Ph.D. Thesis Wageningen University.

Cittadini, E.D., Lubbers, M.T.M.H., de Ridder, N., van Keulen, H. and F. Claassen (2008) Exploring options for farm-level strategic and tactical decision-making in fruit production systems of South Patagonia, Argentina. *Agricultural Systems* 98: 189-198.

Contini, C., M. Gabbai, L. Omodei Zorini and B. Pugh (2010) Involving stakeholders in the exploration of sustainability perspectives and innovations of farming systems: a case study from Latin America. Proceedings 9th European IFSA Symposium, 4-7 July 2009, Vienna (Austria).

Cundill, G. and C. Fabricius (2009) Monitoring and adaptive co-management: Towards a learning-based approach. *Journal of Environmental Management* 90: 3205-3211.

Davies, R. and J. Dart (2005) The 'Most Significant Change' (MSC) Technique: A Guide to Its Use. http://www.mande.co.uk/docs/MSCGuide.pdf

Dogliotti, S. (2003) Exploring options for sustainable development of vegetable farms in South Uruguay. Ph.D. Thesis Wageningen University.

Dogliotti, S., M.K. van Ittersum and W.A.H. Rossing (2005) A method for exploring sustainable development options at farm scale: A case study for vegetable farms in South Uruguay. *Agricultural Systems* 86:29-51.

Douthwaite, B., 2001. *Enabling innovation*. Zed Books. London and New York.

Douthwaite, B., Kuby, T., van de Fliert, E. and S. Schulz (2003) Impact pathway evaluation: an approach for achieving and attributing impact in complex systems. *Agricultural Systems* 78: 243-265.

Edquist, C. (1997) *Systems of innovation, technologies, institutions and organizations*. Pinter, London.

Fagerberg, J., Mowery, D.C and R.R. Nelson (2005) *The Oxford handbook of innovation*. Oxford Univ. Press.

Giller, K.E., Leeuwis, C., Andersson, J.A., Andriesse, W., Brouwer, A., Frost, P., Hebinck, P., Heitkönig, I., van Ittersum, M.K., Koning, N., Ruben, R., Slingerland, M., Udo, H., Veldkamp, T., van de Vijver, C., van Wijk, M.T. and P. Windmeijer (2008) Competing claims on natural resources: what role for science? *Ecology and Society* 13(2): 34. [online] URL: http://www.ecologyandsociety.org/vol13/iss2/art34/

Horton, D. and R. Mackay (2003) Using evaluation to enhance institutional learning and change: recent experiences with agricultural research and development. *Agricultural Systems* 78: 127-142.

IAASTD (2009) *Agriculture at a crossroads: synthesis report*. Washington, DC: Island Press

Kropff, M.J., Bouma, J. and J.W. Jones (2001) Systems approaches for the design of sustainable agro-ecosystems. *Agric. Syst.* 70: 369-393.

Leeuwis, C. (ed.) (1999) Integral design: innovation in agriculture and resource Management. Mansholt Studies 15. Wageningen University.

Masera, O., Astier, M. and S. López-Ridaura, 2000. Sustentabilidad y manejo de recursos naturales. Mundi-Prensa Mexico, S.A., 109 p

Pahl-Wostl, C. (2009) A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change* 19: 354-365.

Petrosino, A., Rogers, P.J., Huebner, T.A. and A. Hacsi (2000) Editors' notes. New Directions for Evaluation 87: 1-3.

Smits, R. and S. Kuhlmann (2004) The rise of systemic instruments in innovation policy. *International Journal of Foresight and Innovation Policy* 1: 4-32.

Sterk, B., van Ittersum, M.K., Leeuwis, C., Rossing, W.A.H., van Keulen, H. and G.W.J. van de Ven (2006) Finding niches for whole-farm design models - contradictio in terminis? *Agricultural Systems* 87: 211–228

Sterk, B., Leeuwis, C. and M.K. van Ittersum (2008) Land use models in complex societal problem solving: Plug and play or networking? *Environmental Modelling & Software* 24: 165–172.

Sumberg, J. (2005) Systems of innovation theory and the changing architecture of agricultural research in Africa. *Food Policy* 30: 21-41.

Ten Berge, H.F.M., van Ittersum, M.K., Rossing, W.A.H., van de Ven, G.W.J., Schans, J. and P.A.C.M. van de Sanden (2000) Farming options for The Netherlands explored by multi-objective modelling. *European Journal of Agronomy* 13:263-277

Walters, C.J. (2007) Is adaptive management helping to solve fisheries problems? *Ambio* 36: 304-307.