Impacts of science-based research and innovation program: The case of farmers' transition to organic production in Camargue

Quiédeville Sylvain[1], Barjolle Dominique[2], Stolze Matthias[1], Mouret Jean-Claude[3]

Abstract

This paper attempts to assess the impacts of science-based research and innovation program (ISRIP) of farmer's transition to organic rice in Camargue. We applied a methods-mix revolving around the Impact Pathway Analysis (IPA) with the goal of shedding light on complex mechanisms that occur along innovation processes and ex-post reconstructing the impact pathway of the "basket of innovations" which was identified as the main innovation in the theory of change of the program. The analysis allows identification of the specific role of the research. We demonstrate that the French National Institute of Research Agriculture (INRA) contributed to change in supporting growers through experimental trials, discussions and leaflets even though the rice producers underlined that their trials played a more important role to find relevant techniques. Farmers also reported other driving factors like the selling price of organic rice or CAP subsidies for conversion and maintenance of land for organic rice. Finally, the analysis emphasises that the research system is not the central node in the innovation pathway, although it does play a substantial role.

KEY WORDS – Evaluation, Science-based research, program theory, Innovation process, Ex-post Impact Pathway Analysis, Camargue rice.

[1] Department of Economics and Social Sciences, Research Institute of Organic Agriculture (FiBL), Ackerstrasse 113 - Postfach 219, 5070 Frick, Switzerland.
[2] Institute for Environmental Decisions IED, ETH Zürich, CH-8092, Switzerland.
[3] National Institute of Agronomic Research (INRA), UMR Innovation, 2 Place Pierre Viala, 34000 Montpellier

1. Introduction

We call innovation the first commercialisation of an invention, which is the first occurrence of an idea for a new product or process. Switching from invention to innovation needs different types of knowledge, competences, resources and capabilities to be combined (Fagerberg 2003; Diamond 1998). An innovation occurs within the market, firms or society when new routines are emerging while current routines start losing ground (Bianchi and Miller 1996). This can imply pioneering ideas, new behaviours or other novel aspects breaking with the established routines (Bianchi and Miller 1996). As to research program it stands for a set of interventions (projects) implemented by researchers with a view to attaining sector development objectives at a local or broader level.

There is a large degree of consensus on the rationale of evaluating ex-post innovation processes and research programs. The reasons are essentially to report to stakeholders on the return to their investments (FAO 2000) and develop improvements in policies and projects (Mackay and Horton 2003). But there is less degree of consensus as to how innovation processes should be assessed as evaluation methods are largely focused on a linear vision in comparing inputs with outputs while agricultural innovations are increasingly perceived as the result of complex interaction processes in a network of actors. Evaluation methods based on linear conception of innovation do not explain the complex underlying mechanisms of innovation processes, nor recognize systems of reflexive and learning interactions (Knickel et al. 2009).

Evaluating “impacts of science-based research and innovation program” (ISRIP) is a topical issue in the agricultural sector. In particular, the ASIRPA (Evaluating Impact of public agricultural research) and IMPRESS projects (Impacts of research in southern countries), respectively handled by INRA (French National Institute of Research Agriculture) and CIRAD (French Agricultural Research and International Cooperation Organization), are involved in this movement (Gaunand et al. 2015; Temple et al. 2014; Barret et al. 2015; Colinet et al. 2014; Joly et al. 2015; Joly et al. 2014). They endeavour to develop a method for evaluating ISRIP in an ex-post manner. INRA advocates for the non-use of an econometric analysis, which undertakes a very broad level of analysis in somehow considering the research system as a “black box”. Such an analysis is looking at the concrete results rather than the detailed process by which they have been generated (Colinet et al. 2014). In addition, the time span between research and impacts is often important, more than 30 years for the agronomic research (Alston et al. 2009), and acts as a brake preventing the consideration of socio economic impacts (Colinet et al. 2014). INRA and CIRAD both conducted an Impact Pathway Analysis (IPA) with the aim of helping to comprehend how research projects have led to impacts through outputs and changes (outcomes). More specifically, the Impact Pathway analysis is designed to describe what the research did, the circulation of the knowledge and its transformation as well as its utilization by the socioeconomic actors.

A case-study focusing on the transition to organic rice farming in the Camargue was performed to test our mixed method and to ex-post evaluate the extent to which the research program contributed to the transition towards organic farming. The main objective is to assess if the research program conducted by INRA, with the support of the CFR (French Centre of Rice) and the CIRAD, has met the targeted objectives and the beneficiaries’ expectations. A second objective is to identify the accurate role of factors unrelated to the

research program: (1) the institutionalization of the organic rice value chain; (2) the high market value of organic rice; and (3) the respect for the environment.

This paper proceeds as follows: In the next section we presents the contextual elements regarding the case-study in Camargue. This is followed by a section providing some key definitions as well explaining the concept of impact pathway analysis. We then present the methodology and approach followed. Finally, case-study results are outlined, while the paper concludes by summarising the main lessons learnt and giving recommendations for future ex-post impact assessments.

2. Contextual elements and research program under review

The Camargue territory is located in the south east of France extending to 145,300 ha with rice as its main crop production. Camargue is the only French region where rice is cultivated. Rice was introduced by Henry IV in the 16th century and has experienced wide problems during its history. With the introduction of the CAP in 1962 and the opening of the markets, the Camargue rice was not able to compete with Italian rice because of higher production costs (especially labour costs). As a result, the surface of rice farmed has decreased and there have been problems of salinization of the land[4]. A rice production recovery plan was thus initiated in 1978-1980 to improve the situation. The intervention price for rice was increased and irrigation plans were developed. Those measures led to a significant increase in the area under rice, expanding from 5,000 ha in 1980's to circa 20,000[5] ha in 2013.

[4] The land in the Camargue is very low in relation to sea level and is constantly subject to salt rising to the surface. As long as rice farming allows the land to be flooded by freshwater, these upward salt flows are blocked.

[5] The surface area fell to 12,000 ha in 2014 (Delphine Roucaute, Le Monde.fr).

Organic rice production increased in the 1980's through the initiative of pioneer producers and today accounts for 10% of the total rice farming area and for 16% of the rice producers (35 out of total of 215). The main storage operator is the SARL Thomas which processes around 5000 t of organic rice per annum. Other storage companies that trade with Camargue organic rice, increase the Comptoir Agricole du Languedoc (also called "Madar") (1000 t), BioCamargue (1000 t) that commenced trading in 2005, and the cooperative Sud Céréales (300 t) which maintains strong relationships with the SARL Thomas through the intermediary of BioSud. In addition to these operators, some institutions and private companies operate within the supply chain, including the CIRAD, INRA, FranceAgriMer (National Institute of the Agricultural and Seafood Products), the CFR, the Natural Park of Camargue, and the Rice-Farmers Union (Syndicat des Riziculteurs).

In the year 2000, a research program for organic rice production was launched by the INRA together with its boundary partners (CIRAD, CFR, FranceAgriMer), with the goal of creating new technical incremental innovations adapted to organic production and fostering the development of organic rice production in Camargue.

For this paper we assessed 6 projects which have been identified as "main projects" in the theory of change within the program (consistent funding amount, relevance for organic rice production):

(1) The CEBIOCA project (2000-2004): Agronomic diagnosis.

(2) Experimentations in farming plots (2005-2006): Weeds and fertilization management.

(3) The ORPESA project (2008): Participatory training with farmers (Bayot et al. 2009).

(4) Technical operations prototyping (2011): Weed management.

(5) Developing international relationships (2012): To develop a collaborative movement for organic rice management techniques.

(6) Experimentations from CIRAD (since 2012): Weed management.

Our study endeavours to estimate the extent to which those research activities have led to changes linked to a transition to organic farming. The changes are the "basket of innovations" which have been identified as the main innovations in the theory of change of the program, on the basis of stakeholders' statements. Those incremental innovations are both technical and organizational:

- The development of crop rotation systems: it consists in extending and diversifying crop rotations. The rationale is to reduce risks linked to pests and weeds. This technique faces difficulties given the hot climate that limits the range of suitable spring crops and by the fact that the salinization of lands makes cultivating deep-rooted crops (colza, sunflower…) difficult.

- False-seed bed techniques (mechanical): this incremental innovation lies in working the soil to allow the germination of weeds seeds, followed by further cultivation to remove and control weeds. In the Camargue, the presence of Cyperaceous raises particular challenges given the difficulty to eradicate their bulbs.

- Sowing the paddy fields at a later date: The interest of deferring the sowing date is to boost the growth of the rice through higher temperatures, which in encourages the smothering of weeds.

- Strategic flooding of the paddy fields: This technique aims to smother weeds, but the adjustment of both the flooding dates and the level of water require specific skills.

- Increasing the crop seeding rate: The objective is to smother weeds as soon as they emerge.

- Organization of the organic value chain through the creation of BIOSUD in 2003.

3. Framework

3.1. Definitions

In the context of impact pathway analysis, we call inputs the resources (material, financial, human) invested into a research program. The outputs represent tangible results (services, capital goods, products) from a research intervention (OECD 2002). As to “outcomes” we took a slightly different definition into account than the one CIRAD defined in their last methodological guideline (Barret et al. 2015), because we made use of the Outcome Harvesting method (Earl, Carden, and Smutylo 2001). Earl et al (2001) argue that “outcomes” stand for changes in the behavior, relationships, activities and/or actions of a boundary partner that can be logically linked to a program; while CIRAD defines an outcome as being a short or medium effect linked to the use of a product, derived from the research, by actors who interact directly with the research. Those views are quite similar: they both claim that outcomes are short and medium effects resulting from research’s outputs, even though CIRAD attaches the utmost importance to capacity building of the actors. Moreover, we should specify that we took changes related to all stakeholders into account and not only from boundary partners. Finally, the impacts are the effects produced by the outcomes in a long-term perspective and can be intended or unintended (OECD 2002).

3.2. Concepts

The Impact Pathway Analysis or IPA (Boru Douthwaite et al. 2003; B. Douthwaite et al. 2007) is inspired from the program-theory (PT), which is often referred as theory of change, theory-based evaluation (Weiss 1998), intervention logic (Vanheukelen 1997), or program theory-driven evaluation science (Donaldson 2005; Coryn et al. 2011). Program-theory (PT) refers to a set of possibilities for developing a comprehensive impact logic model of the

program with the aim to guide evaluation of an intervention (Rogers et al. 2000). Logic model development is the centrepiece of rebuilding program theory, which intends to link investments in projects' inputs with observed or intended outputs, outcomes and impacts. PT usually develops an ex-ante causal model to identify how research and development projects are likely to and should occur. In other words, an innovation pathway is developed and established before the research program is implemented. Is the researcher fully responsible for rebuilding the theory (the innovation pathway), or only a facilitator within the setting of participatory impact evaluations, whose interest is to enhance responsiveness during evaluation process in empowering stakeholders for mobilising changes as well as increasing the plausibility that results will be used (Weiss 1998; Cousins and Whitmore 1998). Greene (1987, 1988) even demonstrated that the participation level was correlated with political, emotional and intellectual implications, but Alkin advocated for the non-necessity to please all stakeholders at once as they are not necessarily the primary users of the evaluation (Alkin 1991). In this paper, the intervention evaluation is conducted in an ex-post manner, which needs innovative methodological developments.

In line with the approach developed in the ASIRPA project, our reflection clearly fits within a participatory vision of the evaluation, for reasons outlined above. This has led to us focusing on the "Participatory Impact Pathway Analysis" or PIPA (B. Douthwaite et al. 2007), which is inspired from IPA and takes stakeholder's views into account by letting them draw the ISRIP pathway within focus groups. The participatory nature of the meetings (focus groups) is however diminished through two main points. The first is that the meetings are guided by a draft problem tree, previously prepared by few project designers (B. Douthwaite et al. 2007) with the purpose to tackle current problems and related causes and thus clarify the program's logic model (B. Douthwaite et al. 2007; Renger 2002). Secondly, we argue that the

participatory nature of the focus group can be called into question since recent PIPA approaches only involve designers i.e. the actors who imagined the program before it started (B. Douthwaite et al. 2007; Alvarze et al. 2010). It follows that diversity in group discussions is not created and maintained. Diversity is important for two main reasons (Mathie and Greene 1997): (a) To balance power with the different types of stakeholders (implementers, beneficiaries, main and minor actors); (b) to take all experiences and views into account. However, Leeuw (2003) is rather in favour of minimising diversity into group discussion to maximise convergence of opinion while maximising divergences between groups. The latter are then reunited in a plenary to present the drawn impact pathways to each others, for generating fuller debate around very dissimilar pathways and to arrive at a well-considered consensus. This approach is attractive to us but would however reduce the available time in the plenary as unifying highly different impact pathways would be time consuming, especially as the procedure to be followed is not specified.

Similarly to IMPRESS or ASIRPA, we attempt to evaluate ISRIP in an ex-post manner. We face the problem that IPA and PIPA are not designed for ex-post assessment and reconstructing the impact pathway after it has occurred. For instance, there is no evidence of whether we should reconstruct the impact pathway from inputs to impacts or backwards. Furthermore, ex-post reconstructing the story requires participants to remember how events occurred and necessitate to do an exhaustive reflection exercise. However, given the time constraint and the difficulty to conduct numerous meetings with extensive discussions, some issues would probably not be raised or reflected deeply. Particularly, even if PIPA is originally designed to raise the actor network issue by drawing existing and projected network maps (B. Douthwaite et al. 2007), it would be very demanding to ex-post reconstruct the actor network in a plenary in following this method. What is more, stakeholders may not be able

to identify main players nor evaluate with precision what their respective role is or was. Participants may indeed overestimate their own role or that of stakeholders closed to them and not mention important "hidden actors". The latter situation occurred[6] when studying the systemic sustainability of the organic Camargue rice value chain (Bassenne et al. 2015). Moreover, a power game may occur among participants (Mathie and Greene 1997) as well as a lack of actors' memories; leading to stakeholder's statements and the ensuing results to be both biased and unlikely to comprehensively cover innovation and program's impact pathway. In addition, the PIPA approach does not provide a template for tackling causes unrelated to research projects although the program theory usually offers this possibility in order to avoid attributing the whole impact to projects' investments (Rogers et al. 2000).

4. Method

4.1. Towards a mixed-method for evaluating ISRIP

For the purpose of ex-post participatory analysis of impact pathway, we have chosen a procedure that grants more responsibilities to stakeholders. Indeed, the PIPA approach excels at designing projects and linking inputs with outputs, outcomes and impacts but presents some limitations when applying ex-post for reconstructing ISRIP. We have chosen to take the Outcome Harvesting method into account. This approach was developed by Ricardo Wilson Grau and Britt (2002) to overcome the shortcoming of Outcome Mapping (Earl, Carden, and Smutylo 2001), which is similar to PIPA (B. Douthwaite et al. 2007; Earl, Carden, and Smutylo 2001) but provide a template for conducting ex-post analysis while facilitating an in-depth study of all issues by offering additional ways of collecting

[6] Stakeholders did not acknowledge the influence of the cooperative SudCéréales on the organic rice value chain contrary to what the results of SNA demonstrated. Note that this result can in no way be compared with the present study as the approach taken and the questions posed to stakeholders were different.

information (publicly available documents, in-depth interviews) and thus helps to ease the time constraint. The method suggests reconstructing the pathway retrospectively to how the story has unfolded, that is, in starting out from effective changes (outcomes) before looking further back at outputs and activities. That said, the procedure moves away from participatory approaches (no focus groups are suggested) even though the question of a power game would not manifest itself. We have tried a mixed solution through using Outcome Harvesting in combination with PIPA: one stakeholders meeting (with funders, program implementers, beneficiaries and persons who are negatively affected by the program) focusing on the impact pathway of the program in keeping with the *Outcome Harvesting* approach while face-to-face interviews are conducted for gathering enabling and disabling factors to the projects. The rationale is to pay as much attention as possible on direct effects of the research program in a participatory manner.

However, there is still the issue of a time constraint in focus group. We have chosen to study the actor network separately (i.e. not during stakeholders meetings), which allowed us to study the network in greater depth while increasing the available time in focus groups. To perform the network analysis, a Social Network Analysis (SNA) is done to permit the identification of the type and intensity of relationships as well as helping to represent theories of changes through network graphs (Davies 2015). Interesting indicators are the degrees, the clustering coefficient[7] , the betweenness[8], and the distance. They allow an investigation into the evolving intensity of relationships between pairs of actors (degrees), into the development of clusters or group of actors who are strongly connected together (clustering coefficient) and in the distance among stakeholders (more the number of

[7]Coefficient which can provide information on a "gregariousness trend" within the network.
[8]Allows an operator to be deemed to have a privileged position insofar as it is an intermediary between different operators within the network.

intermediaries an actor has to pass through to reach another actor, more the distance is), while studying the effect on the "innovation trend". Note that the origin of the changes must be studied to explore which ones were due to the research program.

It was also mentioned the possible occurrence of a power game between stakeholders during the focus group as well as a difficulty in providing an accurate recollection of events (lack of actors' memories and possible bias in stakeholders' statements). The process tracing method (Bennett 2010; Mahoney 2012) can correct the situation by evaluating the "truthfulness" of what the actors claimed. The approach first allows a screening of the pathway's events by evaluating whether the necessary parts of the process were present (the underlying mechanisms of the hypothesised links). In other words, we go to the best evidences: proof provided in scientific papers, documents on the research program, official statistics and information (e.g. the creation of a new company), etc. If the explanation is proved not to be logic because a necessary part of the process is missing (e.g. better understanding of the innovation process), the underlying mechanisms should be studied in more details with the concerned stakeholders. When no evidences can be provided i.e. if neither sufficient nor necessary conditions are fulfilled, the events, the related pathway's links and stakeholder's statements are rejected. In cases where the evidences appear no to be strong enough to fully confirm the impact pathway, stakeholders are asked counterfactual questions: If they argue the first event of a link can be removed without calling into question the subsequent incidence, the link is eliminated.

To complete the approach, we evaluate the contribution of the accurate links to the success of the impact pathway. Alternative explanations to the effectiveness of the pathway are then collected and verified through the process tracing method. More the number of the valid alternative explanations, less the contribution of the initial link is. We also estimate the

importance of the pathway routes in accordance with a rating scale, by asking involved actors through face-to-face interviews.

Finally, two feedback rounds are organized to assess and validate results. The first meeting focuses on general influent factors, which were raised by stakeholders during first in-depth interviews; and the second on the final results. Contrary to the original idea offered by the Outcome Harvesting method, however, the feedback meetings involve stakeholders or key involved actors instead of undertaking face-to-face interviews with independent specialists, in order to remain in line with participatory approaches.

4.2. Approach

4.2.1 Initial screening, SNA and identification of the main impacts

We conducted in-depth interviews with actors in the different stages of the value chain (idea derived from Outcome Harvesting), namely respondents from INRA, the CFR, the Natural Park of Camargue, private storage companies (the SARL Thomas, the Comptoir Agricole du Languedoc and BioCamargue) and 15 farmers (4 organic, 7 partial-organic, and 4 conventional). Researchers (INRA, CIRAD and CFR) were interviewed with the aim to (a) identify the outputs produced from research activities; and (b) gather understandings as to the role of the research for supporting farmer's transition to organic rice production. Storage companies were interviewed for collecting overall views and shedding light on changes related to scaling-up of the value chain. As to producers, they were primarily interviewed to identify general factors (not necessarily linked to research) that facilitate or hinder farmers' transition. They were also asked to identify the most important impacts. The case study

team has then completed the list with projects' expected impacts, on the basis of the program documentation.

Furthermore, we collected information for Social Network Analysis (with the UCINET 6 software; Borgatti, Everett, and Freeman 2002). We took three dimensions into account: information flows, collaboration and financial links (with an average calculated). Intensities of relationships (clustering coefficient, betweenness, degrees, distance) were defined by stakeholders in accordance with a rating from 0 to 3. Note that we did not consider the direction of the relationships as this information was not collected in both directions for all the potential relations: the CIRAD and the Union-Farmers Rice were not interviewed at their decision. In those cases, the score stated for one direction has been duplicated in the other direction. In addition to the current relationships, we asked stakeholders to reconstruct the actor network at 6 periods (1999, 2001, 2003, 2005, 2006, and 2010). The year 1999 provides a comparative context (baseline) for the findings as the research program was not launched yet. The rationale of taking the other years into account is as follows:

- 2001: The cooperative SudCéréales and the CFR have developed stronger relationships. The cooperative was granted the exclusive right to sell varieties selected by the CFR.
- 2003: Scaling-up of the organic rice value chain through the creation of the firm BIOSUD.
- 2005: The Camargue has observed the rise of the storage company BioCamargue, which today collects and sells around 1000 tonnes of organic Camargue rice.
- 2006: The relationships between SudCéréales and farmers have changed, given the economic difficulties encountered by the cooperative. It had excess storage capacity and was operating at a loss.
- 2010: The Comptoir Agricole du Languedoc (Madar) ceased collaborating with the SARL Thomas.

We made the assumption that the innovation process is derived from changes in the system actors and thus correlated to the "SNA trend". In fact, the SNA survey asked stakeholders for useful relationships that help switch to organic farming or maintain this production system. Actors were also asked to detail what has changed, when, why and how.

A group discussion was organised (11 persons attended[9]) to undertake a review concerning general factors that positively or negatively influenced the farmers transition to organic rice production.

With the initial impact pathway completed, we decided to "activate" the links depending on how frequently they were raised by stakeholders. Links were "activated" between the outputs and outcomes when a majority of farmers raised them. Regarding the activities-outputs links, we took account of statements from researchers working at INRA, CIRAD and CFR and for the institutionalisation of the organic rice value chain, we considered the opinions of the organic storage companies.

4.2.2. Stakeholder's pathway building

We organised one focus group (20 persons attended[10]) with the aim of reconstructing the theory of change of the program and drawing the related impact pathway. Stakeholders were asked to identify changes (outcomes), related to transition to organic rice production (adoption of new techniques to fight weeds, relationships and behavioural changes) before defining how, when and where they occurred by identifying the milestones, the outputs and the respective roles of the main actors, and then drawing the impact pathway. The changes identified by stakeholders have been interpreted as being main innovations (technical or

[9] Present: 6 farmers, 2 researcher from INRA, 1 speaker, and 2 researchers from the case study team.

[10] Present: 2 researchers from INRA, 3 researchers from the CFR, 2 participants working at the SARL Thomas, 1 respondent from BIO Camargue, 1 moderator, 1 speaker, 7 farmers, and two assistants.

organizational) in the theory of change of the program. The identification of the changes (outcomes) was conducted in the plenary[11] session while the completion of the subsequent steps was undertaken through discussions within three diversified groups. At the end of the workshop, we presented the impact pathway built at the preceding step. However, we were unable to reflect the impact pathways with each other because of limitations of time.

4.2.3. Refinement (a) of the pathway and collection of impact pathway indicators

The objective was to complete the stakeholder's pathway with relevant elements from the "researcher's pathway" (first step); to collect impact pathway indicators by asking INRA and studying the literature on organic Camargue rice; and to collect the underlying causal mechanisms of the pathway's links as well as the plausible alternative explanations. The hypothetical alternative explanations were defined from logical reasoning, views from researchers working at INRA, studies on Camargue Rice, theories on innovation, SNA results, and "minor" stakeholders' statements collected during the first two steps. "Minor" statements do not appear in either the first impact pathway (first step) or that of the stakeholders (second step), but they could however be important: (1) Some stakeholders may have forgotten to raise some issues in face-to-face interviews; (2) power games in focus groups may have occurred; and (3) some actors may not have had time to fully express their views.

4.2.4. Evaluation, refinement (b) of the pathway, and measurement of the impact pathway indicators

[11] The stakeholders refused to work into groups for this.

We applied the process tracing method. The links were removed if no explanation was found. Then, the importance of the outputs and outcomes was estimated by asking 12 organic and partial organic farmers (the beneficiaries of the innovation). The scale used was: null (0), low (1), moderately important (2), and important (3). However, the events focusing on relationships among actors was studied by SNA, attributing the scores in relative terms, and for the other links we asked key researchers from INRA. The analysis was completed by identifying links which cannot be removed without calling into question the occurrence of pathway's events, based on responses to counterfactual questions addressed to stakeholders (12 organic farmers and researchers from INRA) in the second round of individual in-depth interviews.

Another objective of the interviews conducted with farmers was to collect information to measure Impact Pathway indicators i.e. indicators for measuring impacts. For example, we used the indicator "net margin" to measure the revenue of the farmers.

4.2.5. Final feedback round

We invited all the interviewed stakeholders in a final feedback-round (9 persons attended[12]) to present the findings, secure the agreement from stakeholders and acknowledge their contribution to the study.

[12] Attendance: The president of the rice farmers union, two researchers from INRA, one organic farmer, and two researchers from the case study team.

5. Results

5.1 Ex-post reconstruction of the story of the research program

The CEBIOCA project (over the year 2000-2004) was the cornerstones of the program under review. CEBIOCA stands for "céréaliculture biologique en Camargue"(organic cereals in the Camargue). This project attempted to explore the conditions of developing organic cereals in the Camargue. The total cost of the project lies in the range of 220,000 to 270,000 euros[13]. INRA and its partners saw the organic production development as being a response to depressed prices and poor economic returns. From INRA researchers' views, this project had functioned well, permitting a deepened knowledge on organic production systems. It highlighted yield variability factors, the other main agronomic problems encountered by farmers as well as the constraints that were being faced in accordance with the different types of farms. This learning phase allowed the discovery of new technical systems and innovative cultural practices. Furthermore, experimentations in farming plots (in 2005-2006) would not have happened without the CEBIOCA project and related results. Indeed, the INRA would not have set up suitable experimentations without being aware of organic production systems and the main issues to be studied. The purpose of these experimentations in farming plots, of which the investment is estimated between 50,000 and 90,000 euros (INRA and FranceAgriMer), was to develop new crop management techniques in response to issues resulting from the CEBIOCA project. The experimental trials aimed to develop technical responses for fighting weeds and improving the fertilisation management. Note that the trials were conducted on agricultural holdings of partner's farmers with the support of INRA's partners, namely the CFR and the CIRAD.

[13] We made an estimation given the difficulty to attribute each spending euro to the tasks done by researchers from INRA as well as a lack of data as to the operating budget.

The ORPESA training scheme (2006-2007), funded by the European Union around 60,000 euros (total cost of between 140,000 and 180,000 euros), was completed thanks to experimentations in farming plots and the “trials” set by farmers (refinement and optimization of the production system). The ORPESA project stands for “Organic Rice Production in Environmentally Sensitive Areas” and was part of the Leonardo Da Vinci program funded by the European Union. The ORPESA project was executed with the goal of developing organic rice production in environmentally sensitive areas. To answer this, the INRA established a professional training (called “ORPESA Table”) to support farmer’s conversion to organic rice production, mainly by sharing knowledge on weeds management and fertilization and the main interest areas were then embodied into leaflets and circulated by INRA in placing them at the CFR for free consultation. There is clear evidence that the ORPESA “Table” would not have occurred if the CEBIOCA project and experimentations in farming plots had not taken place. In fact, the INRA would not have been able to participate without being aware on organic rice production systems and issues to be studied as well as possessing significant knowledge to bring into the exchange platform. In the same context, “trials” conducted by producers annually on-farm were needed to implementing the ORPESA “Table” as it allowed growers to bring knowledge as well. At the end of the ORPESA project, producers recommended to test the most relevant crop management techniques mentioned during exchanges. Their advice has been followed by the INRA in developing new experimental trials in the year 2011. The investment was between 55,000 and 85,000 euros (INRA and FranceAgriMer).

Those new experimentations have importantly supported the development of international relationships aiming at exchanging knowledge with foreign researchers and learning of each other’s experiences through high quality interactions. The underlying mechanism is that new

issues and challenges were arising from testing and that no response was available at the national level. The development of global relationships greatly assisted organisation of the first international conference on organic rice which was held in Montpellier in 2011 for a total cost around 90,000 euros (Agropolis, INRA, SupAgro, The Region, and FranceAgriMer). The event's intent was to facilitate exchanges on organic rice production systems between rice producers, researchers and other actors operating at the different stages of organic rice value chains throughout the world. But none of the stakeholders aside from INRA offered any evidence of a link between the international conference and likely related outputs and outcomes.

Other experimentations[14] on organic rice production have been conducted by the CIRAD since 2012. They are focused on the technicality of the following machines; harrows, hoes, and rotavators. Flat (Z) and chain harrows were tested with the goal of encouraging the weed seed germination (first pass) followed by a second pass to control them. These two runs are made before bringing ducks in lands with a view to fighting weeds as well (a technique coming from Japan). As surprising as it may sound, the ducks like eating weeds but eat the rice to a very limited extent. The experimentations are conducted in collaboration with an organic farmer who made a part of his fields available to CIRAD. Although this organic grower is very satisfied with results, the other farmers do not consider them, given the time-consuming nature of the technique.

Moreover, a crucial and organizational incremental innovation was the improved market access due to the packer BIOSUD. It was agreed in the focus group that the growth in the number of organic farmers has encouraged the SARL Thomas and SudCéréales to organize a specific value chain for organic rice by creating the firm BIOSUD in 2003. This

[14] The cost is unknown.

institutionalization, in turn, has allowed sustaining farmer's conversion, mainly through the increase in storage capacities for organic products.

The research activities and the institutionalisation of the supply chain have implied the actors' network to be developed. The relationships between farmers and BIOSUD were being developed through creating BIOSUD in 2003. In addition, the CEBIOCA project, the experimentations from INRA and its partners as well as the ORPESA "Table" have led to a rise of the INRA's influence in the network through establishing relationships with farmers who hosted scientific experimentations, and by doing in-depth discussions with producers during the ORPESA "Table". Apart from the ORPESA "Table", the research activities increasing INRA's influence, also have led to a growing centrality of the CIRAD in the network.

5.2 SNA

The SNA demonstrates an increase in relationships between BIOSUD (previously called SARL Thomas[15]) and farmers since the year 2003 (bilateral "degrees": 15 in 2003, 23 in 2005 and 25 in 2014). Nonetheless, the BIOSUD's "betweenness" has not increased and even diminished since 2006 (785 to 612) as the Comptoir Agricole du Languedoc (MADAR) stopped collaborating with BIOSUD in 2010. This means that the position of BIOSUD in the overall actors' network has not changed substantially.

The SNA also allows confirming the growing influence of both CIRAD and INRA within the network. The "betweenness" [16] score (degree of intermediation) of the INRA has evolved from 370 in 1999 and 415 in 2006 to 542 in 2014 (+46% and +31%) whereas other players'

[15] Farmers made reference to BIOSUD when talking about the SARL Thomas.
[16] Allows an operator to be deemed to have a privileged position insofar as it is an intermediary between different operators within the network.

betweenness has remained stable or even decreased, apart from the CIRAD. The average "degrees" evolvement (intensity of relationships among actors) also illustrates the increasing centrality of the INRA. They have increased about 84% over the last 15 years (from 19 in 1999 and 21 in 2005 to 35 in 2014) for the INRA compared with 29% (from 4.9 in 1999 to 6.3 in 2014) for the entire network: this difference provides clear evidences on the growing role played by the INRA on the network. However, the INRA has not allowed for reducing distance among actors. It has decreased about 12% (2.5 in 1999 to 2.2 in 2014) whether INRA is taken into account in the analysis or not. The increasing centrality of the INRA in the network is explained by four elements. First is the increase in relationships between the INRA's neighbours, which is demonstrated by a growth of 60% of the INRA's clustering coefficient[17] (from 0.1 in 1999 to 0.16 in 2014). The underlying mechanism is that individuals with high clustering coefficients (central actors) are linked to actors who are well connected together, increasing the importance of relationships between the central actors and their direct neighbours. The increase in relationships among the INRA's neighbours is mainly due to stronger relationships between CIRAD and FranceAgriMer and particularly since 2012: experimentations implemented by CIRAD, since 2012, are financed by FranceAgriMer. A second factor explaining the increasing centrality of INRA is the increase of around 80% in the "degrees" between INRA and farmers (from 15 over the years 1999-2005 to 27 over the years 2010-2014). These bilateral "degrees" started increasing from the year 2005, which means that the CEBIOCA project (2000-2004) did not create significant relationships between farmers and INRA although it was crucial to implementing other research activities. The first experimentations in plots and the ORPESA "Table" boosted interactions between INRA and farmers while the advanced trials (2011) allowed maintaining the same level of

[17] Coefficient which can provide information on a "gregariousness trend" within the network.

relationships. Third, the INRA and CIRAD developed stronger relationships as a result of the CEBIOCA project. They did not exchange about organic crop production before this (the bilateral “degrees” switched from 0 in 1999 to 1 over the years 2001-2014). Finally, we noted the steadiness of the relationships between INRA and other stakeholders apart from farmers and CIRAD, and the absence of declining relationships among network’s actors when excluding the INRA (the average “degrees” among them has even increased from 4.1 in 1999 to 4.8 in 2014). With respect to the CIRAD, its “betweenness” score increased about 34% (from 175 in 1999 to 235 in 2014) and the average “degrees” around 61% (from 14 in 1999 to 22.5 in 2014). The latter increased more than for the entire network (+29%), nonetheless, the CIRAD has not contributed to reducing the distance in the network. The growing importance of CIRAD in the network is explained by two elements. The first is a growth of 60% of its clustering score (from 0.2 in 1999 to 0.32 in 2014) due to increasing relationships between INRA on the one hand and CFR & FranceAgriMer on the other hand. Those changes were resulting from the first experimentations in farming plots (2005-2006). The second is the stronger relationships between CIRAD and farmers that are revealed by an increase in the bilateral “degrees” about 45% (from 11 over the years 1999-2010 to 16 in 2014). But we should specify that some farmers confused the CIRAD with the INRA: during the second round of in-depth interviews with farmers, 4 farmers out of a total of 12 made references to CIRAD when talking about researchers from INRA.

5.3 Changes

5.3.1 Socio-economic

Four socio-economic impacts were raised by the stakeholders, both at the farm and the Camargue territory level:

- The number of organic rice producers that has reached 16% of the total number of rice producers in 2014 (35 out of total of 215).
- The surface dedicated to organic rice production, which has steadily increased between 1980 and 2015. It has achieved 1400 ha in 2014 (around 200 ha in 1980).
- The increase in net margins per hectare (higher selling prices) about 111% on organic crop production, without taking account the single payment entitlements (Bassenne et al. 2015).
- The reduction of the total surface devoted to rice, about 45% at the farm level (farms that converted to organic production) and 8% within the Camargue, given the fact that switching towards organic rice requires an extended crop rotation to control weeds. Note that the rice surface has globally declined about 45% in the Camargue from 1999 to 2014 as farmers are discouraged to produce rice since they get the same CAP payment when cultivating others cereals (decoupling of the CAP aids), which are less costly to produce.

5.3.2 Environmental

Four environmental impacts were raised by the stakeholders.

- The fall in the use of pesticides with a decrease of the treatment frequency index (TFI[18]) around 51% at the farm level (farms that converted to organic production) and 8.5% within the territory.
- The reduction of the water[19] used about 45% at the farm level and 8% in the territory. It is directly due to the decrease in the rice surface (rice is the only crop production being flooded in the Camargue).
- The diminution of the fuel[20] consumption about 17% at the farm level and 3% within the territory. This is the result of the introduction of grasslands and alfalfa less demanding in terms of soil working.
- The decrease in nitrogen requirements about 24% at the farm level and 4% within the territory. This is due to a decrease in the yields and the cultivation of crop production requiring few or zero units of nitrogen (grasslands and alfalfa).

5.4 Interpretation of the impact pathway

The ISRIP analysis we have done has shown that the CEBIOCA project, the first experimentations, the ORPESA "Table" as well as the advanced experimentations were

[18] TFI equals the ratio of the dose applied to the approved dose. The approved dose were found on the official website: e-phy.agriculture.gouv.fr.

[19] None of the farmers reported changes concerning the consumption of water per hectare: the increase in the level of water is balanced by a reduction of the inflows and outflows.

[20] We asked farmers to report their technical itineraries with the material used. We then calculated the consumption of fuel on the basis of the "barême d'entraide" (scoring grid) of the French agricultural chamber. Finally, we deduced the consumption per hectare by measuring the consumption per hour as well as the performance (ha/hour).

strongly linked together and have contributed to attain some expected impacts through mainly involving INRA in the actors' network, adopting incremental innovations (like extending crop rotations) and switching towards organic farming (see the impact pathway diagram in Appendix 1). That said, the overall influence of the research activities has remained relatively limited given the importance of the on-farm "trials", the external economic factors (subsidies, important selling price), the absence of peer-to-peer exchanges between producers, and the lack of involvement of the CFR.

The research program has increased the role of the INRA in the actor's network and especially the exchanges with the farmers, but the latter reported that the exchanges were "informal". The stakeholders and the farmers in particular stated that the recommendations given by INRA were not derived from "real" scientific experimentations. As a consequence, the increase in exchanges and relationships in the network has not greatly contributed to conversion to organic farming and therefore to reaching impacts. It has facilitated the development of crop rotation systems to a very limited extend and moderately contributed to the transition towards organic farming. This result can also be explained by the fact that the majority of the technical innovations were not reported as being very important (moderately influent) to support farmer's transition, apart from the development of the crop rotation systems which is even crucial to switch to organic production system.

Furthermore it was underscored that the adoption of technical incremental innovations was principally derived from the "tests" set by the farmers (refinement and optimization of the rice production system) and, in a more limited extent, from leaflets produced by INRA (built on the basis of the experimentations and the ORPESA "Table"). Note that all incremental techniques for fighting weeds were the subject of an INRA communication in an oral form but the beneficiaries (farmers) did not recognize this. This raises two important social

aspects for implementation of innovation. First is the communication support (orally, leaflets, documents). Second is the way by which the information is received farmers (door to door talking, plenary sessions…). In the present case, the fact that the INRA has not sent leaflets to farmers may explain its lack of acknowledgement from producers. But the crux of the problem is the specific and heterogeneous local conditions in the Camargue (heterogeneity of the texture, the structure, and the height[21] of the land compared to the sea level), which reduce the effectiveness of generalised information to all the farms. Note that the INRA is more acknowledged by farmers who have hosted a part of its scientific experimentations (they rated a double score of relationships with INRA when asking information for SNA).

One disable factor is the absence of peer-to-peer exchanges between farmers. None of the farmers have justified their decision to adopt incremental innovations through inspiration from their neighbour's practices. But this result was not surprising for two main reasons: (1) there is no common work nor sharing of material goods between farmers, which is very uncommon within the agricultural sector in France; (2) all collaborations (CUMA, joint work) between farmers were unsuccessful in the past (litigations over outstanding accounts, disagreements on the use of the materials…).

The stakeholders stated a second disable factor which is the lack of involvement of the CFR. This was considered as a strong barrier to the innovation pathway likelihood by farmers, but the other stakeholders did not state it as being an obstacle as such. The French Rice Centre's missions are to provide information and advices to farmers, experiment cultivation techniques and implement a breeding program. However, the fact that organic farming is

[21] The height of the land influences salt concentration in land and thus the development of the crop productions.

not recognized as an important issue and given the budget constraint, the CFR has not made specific experimentations for organic rice. Two reasons can explain why the growers consider the CFR's strategy strongly hinders the success of the innovation pathway. Firstly, they said that the CFR should answer to issues both arising from conventional and organic rice insofar as it is a specialized research centre on Camargue rice. Secondly, they think the CFR should work in specialist areas that the INRA currently engages in but CFR should be undertaking.

6. Conclusion and discussion

The developed mixed method allowed identification of the specific role of research in the whole theory of change of the research and innovation program. It also permitted stakeholders to report external factors being the most important for them to switch to organic farming. We underlined the limited role played by the research to support farmer's transition to organic farming on three main evidences: (1) informal testing made by farmers on crop rotation were very important to switch towards organic farming; (2) economic factors were also crucial; (3) the institutionalization of the supply chain was seen as a decisive factor (the research did not contribute substantially).

We identified research activities and related outputs being primary crucial components in the structure of the pathway:

- First experimentations would not have happened without the CEBIOCA project.
- The ORPESA "Table" acted thanks to the CEBIOCA project and the first experimentations.
- The ORPESA "Table" has led to additional experimentations.

But the research activities and outputs were not acknowledged by the interviewed farmers as being important factors to adopting incremental innovations and switching to organic farming. The perception of the farmers reflected a situation where there was a gap between research outputs and the story telling about their individual decision of adopting new techniques. The SNA highlights that the knowledge exchange flow was not very strong between them and INRA and quasi non-existent among themselves (when excluding the ORPESA "Table").

We may first question the strategy to make available the leaflets at the French Centre of rice and not to send them to farmers. A second issue is the appropriateness of the advices for each of the farm, which raises the necessity to further link experimentations and particular local conditions. Finally, the question of which institutions undertake experimentations should be more investigated since farmers underlined that the CFR should work in specialist areas that the INRA currently engages in but CFR should be undertaking: The institutional factors influencing the behaviour of the farmers should be studied deeper.

We have faced some difficulties when applying the method, especially on the procedure followed during the second focus group for reconstructing ISRIP pathway. Stakeholders were asked to first define the outcomes (changes) before linking them to activities and outputs. Not providing inputs to stakeholders had allowed to grant significant responsibilities to them but they encountered difficulties to identify the outcomes (changes) related to the transition towards organic farming. Maybe, it would have been more appropriate to ask changes that occur in personal situations instead of generally, in order to make the exercise more concrete and understandable. But on the basis of the feedbacks from stakeholders, it is quite clear that they would have preferred to react on first results to be provided by the case study team instead of starting discussing “out of nothing”. The changes may be collected during face-to-face interviews before the focus group and used as a basis for discussions, leading the impact pathway story to be more effortlessly discussed. In addition, it would leave more time for reflecting on the different ISRIP pathways at the end of the stakeholders meeting.

Furthermore, the issue of the lack of diversity in focus group was not completely solved since we did not get funders nor “victims” of the program to the focus group, probably because they did not benefit from the research under review. Likewise, we probably got too

many farmers compared to the number of researchers who attended the meeting. It follows that the discussion was relatively dominated by farmers and left little room for researchers from INRA, CIRAD, and CFR to express their own opinions. Having said that, the stakeholders remembered well how the events happened and were able to reflect deeply on the impact pathway despite the difficult start of the focus group and the reluctance of some farmers to draw the impact pathway on a poster by linking cards representing research activities, outputs and outcomes.

Then, the first feedback round was one too many, whilst some overlaps occurred with the focus group aiming at drawing the ISRIP pathway; making the stakeholders less willing to continue to participate in the process, especially for the final feedback round.

Finally, the decision was made to choose to stick to a participatory approach in taking into account both the primary program's objectives and the beneficiaries' opinions (in that case, the farmers) as basis for the evaluation. This may be viewed as an important bias in the theory of change. Indeed, general impacts such as the ones on the environment were not raised although they probably are important in the eyes of the society. We may bring some modifications in the method we followed by asking experts to complete the list of impacts.

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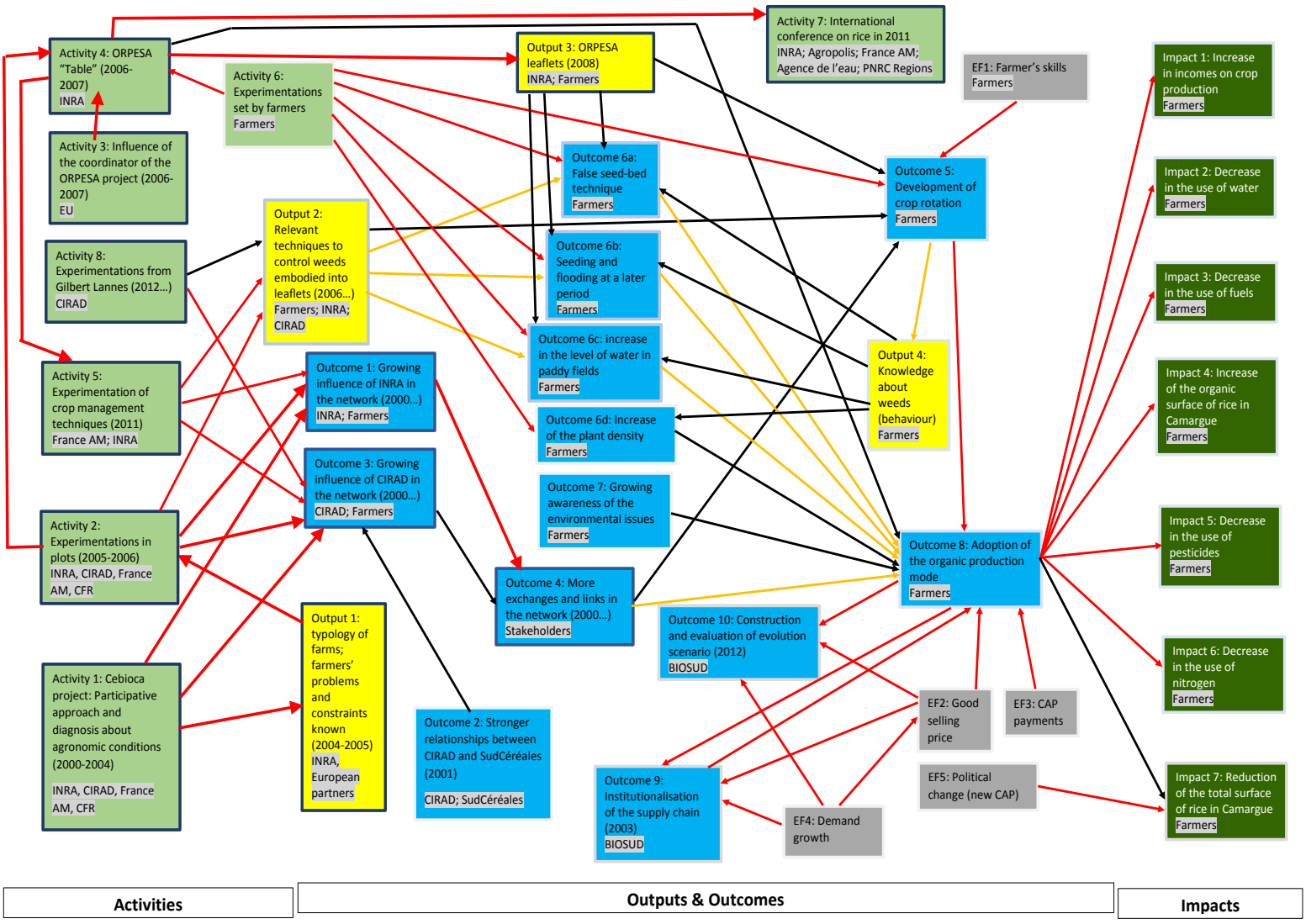
Appendix 1: Impact Pathway Diagram



Legende:

"Strength" of the links		**Contribution of the research**	
Strong and "critical points"[22]		Very important	Limited role
strong		Important	Low importance
Moderately strong		Quite important	Very low importance
Weak		Satisfactory	Null

[22] The critical points are the links that would not have occurred without the research