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Ex-post Assessment of Impacts of Research on Innovations for Organic Farming: Issues, Methods, Tools and Instruments

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Foreword

I'm very glad to present my thesis, entitled "**Ex-post Assessment of Impacts of Research on Innovations for Organic Farming: Issues, Methods, Tools and Instruments"**.
This thesis was written to comply with the requirements of the school SupAgro and the Doctoral School of Economic and Management (EDEG) from Montpellier (France), in order to obtain the title of Doctor in Economics. The process of research and writing of this thesis started in March of 2014.

This thesis was done in the frame of the EU project IMPRESA[1] (Impacts of Research on EU agriculture) and was accomplished at FiBL (Research Institute of Organic Agriculture) in Switzerland and in the lab Innovation at INRA (National Institute of Agronomic Research) in Montpellier.

The research work has not always been easy, but studying this theme in-depth was very interesting and enriching, personally and academically. Very fortunately, Dominique Barjolle, Jean-Marc Touzard, Matthias Stolze, Agathe Devaux-Spatarakis, and Ludovic Temple, in particular, were always available and able to answer my questions. A specific section will be dedicated to all acknowledgments.

This thesis is presented in the form of articles, with 3 parts corresponding each to the elaboration of one scientific article, encompassed in a set of 8 parts including a general introduction, discussion, and conclusion.

I hope that you will enjoy your reading!

Sylvain Quiédeville,
Montpellier, 01 October 2017

[1] The overall aim of IMPRESA is to « measure, assess and comprehend the impacts of all forms of European SRA [Scientific Research on Agriculture] on key agricultural policy goals, including farm level productivity but also environmental enhancement and the efficiency of agrifood supply chains » (IMPRESA Website, 2017).

(Avant-propos)

Je suis très heureux de vous présenter ma thèse de doctorat, intitulée **« Evaluation Ex-post des Impacts de la Recherche sur les Innovations pour *l'*Agriculture Biologique : Enjeux, Méthodes, Outils et Instruments »**.
Cette thèse a été rédigée selon *les exigences d'obtention du diplôme de doctorat en Economie de l'établissement scolaire SupAgro et de l'Ecole Doctorale Economie et Gestion (EDEG) de* Montpellier (France). Le *processus de recherche et d'écriture de cette thèse a commencé en* mars 2014.

Cette thèse s'est déroulée dans le cadre du projet Européen (UE) IMPRESA[2] (Impacts de la Recherche *sur l'agriculture au sein de l'U*E) et a été réalisée au FiBL (Institut de Recherche *de l'Agriculture Biologique) en Suisse ainsi qu'au sein* de *l'UMR Innovation de l'INRA (Institut* National de la Recherche Agronomique) à Montpellier.

Les travaux de recherche n'ont pas toujours été faciles, mais étudier ce thème en profondeur *s'est avéré* très stimulant et enrichissant sur le plan personnel et académique. Fort heureusement, Dominique Barjolle, Jean-Marc Touzard, Matthias Stolze, Agathe Devaux-Spatarakis et Ludovic Temple, en particulier, se sont toujours montrés disponibles et à même de répondre à mes questions. Une section sera spécifiquement dédiée à tous les remerciements.

Cette thèse se présente sous la forme *d'*articles, avec 3 parties correspondant chacune à *l'élaboration d'un article scientifique, s'insérant dans un ensemble de* 8 parties incluant notamment une introduction, discussion, et conclusion générale.

En vous souhaitant une bonne lecture !

Sylvain Quiédeville,
Montpellier, 01 octobre 2017

[2] *L'objectif général d'IMPRESA est de* « mesurer, évaluer et comprendre les impacts de toutes formes de RSA *européennes [Recherche scientifique sur l'Agriculture] sur les questions clés de politiques agricoles, incluant la productivité au niveau des exploitations agricoles mais aussi l'amélioration environnementale et l'efficience des chaines d'approvisionnement alimentaires* » (IMPRESA Website, 2017).

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Abbreviations

ABM	Agent-Based Model
AKIS	Agricultural Knowledge and Innovation System
AKS	Agricultural Knowledge System
ANT	Actor Network Theory
ASIRPA	Analysis of the Impacts of the Public Agronomic Research
BEM	Bio-Economic Model
CEBIOCA	Organic Cereals in the Camargue
CFR	French Center of Rice
CGIAR	Consultative Group for International Agricultural Research
CIAB	Internal Committee in Organic Farming
CIRAD	French Agricultural Research and International Cooperation Organization
CRP	Crucial Research Point
CSIRO	Commonwealth Scientific and Industrial Research Organization
CUMA	Cooperatives for the use of agricultural equipment
EC	European Commission
EDEG	Doctoral School of Economics and Management
EMBRAPA	Brazilian Corporation of Agricultural Research
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FIBL	Research Institute of Organic Agriculture
IKE	Innovation, Knowledge and Economic Dynamics
ILLIAD	Local or Localized Initiatives, Innovative for Sustainable Foods
IMPRESA	Impacts of Research on EU agriculture
IMPRESS	Impact of Research in the South
INRA	National Institute of Agronomic Research

IPA	Impact Pathway Analysis
IRRI	International Rice Research Institute
ISRIP	Impacts of Science-Based Research and Innovation Program
JOLISAA	Joint Learning in Innovation Systems in African Agriculture
KVC	Knowledge Value Collectives
LINSA	Learning & Innovation Networks for Sustainable Agriculture
LUC	Land Use Change
MLP	Multi-Level Perspective
NIE	New Institutional Economics
NPL	New Public Management
NSI	National Systems of Innovation
OECD	Organization for Economic Co-operation and Development
OH	Outcome Harvesting
OF	Organic Farming
ORPESA	Organic Rice Production in Environmentally Sensitive Areas
PIPA	Participatory Impact Pathway Analysis
PT	Program Theory
PUM	Possible Underlying Mechanism
PVM	Public Value Mapping
R&D	Research and Development
SARL	Private Limited Company
SCAR	Standing Committee on Agricultural Research
SI	Systems of Innovation
SIAMPI	Social Impact Assessment Method
SNA	Social Network Analysis
STS	Sociotechnical Systems
SRA	Scientific Research on Agriculture

TFI	Treatment Frequency Index
TFP	Total Factor Productivity
TS	Technological Systems
TSS	Technological and Sociotechnical System
UMR	Mixed Research Unit
VMPs	Veterinary Medicinal Products
WP	Work Package

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Acknowledgments

First of all, I would like to thank Dominique, Matthias, and Jean-Marc for offering me the opportunity to perform this thesis and to work on the EU IMPRESA[3] (Impact of Research on EU agriculture) project. I would like to thank in particular Dominique as main supervisor of this thesis but also as supervisor of the third Work Package (WP3) of the EU IMPRESA project. This thesis would not have been possible without your knowledge and experience! Dominique was replaced for the latest phases of the EU IMPRESA project by Otto Schmidt (FiBL), whom I also thank very much for our very fruitful collaboration!

I also would like to thank very much all members of the thesis committee, who were volunteer to co-supervise this work – Many thanks to Jean-Marc, Matthias, Ludovic, Egizio and Agathe for your interest and the insightful discussions with you!
I am also very grateful to all partners who were involved in the EU IMPRESA project for the substantial synergies with them, which appeared very useful to complete this thesis. Special thanks to researchers who were involved in WP3, including Dominique, Matthieu, Otto, Matthias, Clémentine, Petya, Simone and Susan.

Still, I would like to thank again all of the respondents from the Camargue territory. Many thanks to farmers, rice traders, respondents from CIRAD (French Agricultural Research and International Cooperation Organization), CFR (French Center of Rice), Tour du Valat, Natural Reserve of the Camargue, Rice-traders Union, as well as researchers from INRA (National Institute of Agronomic Research) with in particular Jean-Claude and Roy who were keys to the success of the Camargue case study! The success of the Camargue case study was also made possible with the particular help of Dominique, Clémentine, Matthias, Heidrun and Hélène – Thank you! I also thank very much the Bulgarian researchers and especially Petya who worked on the Ecostop case study, which is used in the third paper of this thesis (part 6).

As host institutions, my warm gratitude goes to FiBL (Research Institute of Organic Agriculture) and to the joint UMR Innovation INRA/CIRAD – Particular thanks to Dominique,

[3] The overall aim of IMPRESA is to « measure, assess and comprehend the impacts of all forms of European SRA [Scientific Research on Agriculture] on key agricultural policy goals, including farm level productivity but also environmental enhancement and the efficiency of agrifood supply chains » (IMPRESA Website, 2017).

Matthias, and Urs for FiBL; and Jean-Marc, Pascal and Guy for the UMR Innovation. I also thank all of my other colleagues from FiBL, CIRAD and INRA for their insights and friendliness. Moreover, I thank the School SupAgro and the doctoral school EDEG (Doctoral School Economics and Management) for their support. Finally, I would like to thank all of the other persons who supported me during the research and writing process, including my relatives and friends.

(Remerciements)

En premier lieu, j'aimerais dire un grand merci à Dominique, Matthias, et Jean-Marc qui *m'on*t offert la possibilité de réaliser cette thèse ainsi que de travailler sur le projet Européen (UE) IMPRESA[4]. *J'aimerais* remercier tout particulièrement Dominique en tant que directrice de la thèse et du troisième package (WP3) du projet IMPRESA. Cette thèse *n'aurait pas été* possible sans tes connaissances et ton expérience ! Dominique a été remplacée pour les dernières phases du projet IMPRESA par Otto Schmidt (FiBL), lequel je remercie aussi grandement pour notre collaboration très fructueuse !

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Je suis également très reconnaissant envers les partenaires ayant participé au projet IMPRESA pour les synergies importantes avec eux, lesquelles se sont avérées précieuses pour *l'accomplissement de ce*tte thèse. Un merci particulier aux chercheurs ayant été impliqués dans WP3, incluant Dominique, Matthieu, Otto, Matthias, Clémentine, Petya, Simone et Susan.

Aussi, j'aimerais remercier toutes les personnes du territoire camarguais ayant été interrogées. Merci beaucoup à tous les agriculteurs, aux metteurs en marché du riz, aux interlocuteurs du CIRAD (Centre International de la Recherche Agronomique pour le Développement), du CFR (Centre Français du Riz), de la Tour du Valat, du Parc de réserve naturelle de Camargue, du syndicat du riz *; de même qu'aux chercheurs de l'INRA* (Institut National de la Recherche Agronomique), en particulier Jean-Claude et Roy qui ont été les clés du succès du cas *d'étude* camarguais ! Le succès de ce cas *d'étude* a aussi été rendu possible grâce à *l'aide* précieuse de Dominique, Clémentine, Matthias, Heidrun et Hélène – Merci ! Je remercie aussi chaleureusement les chercheurs bulgares et Petya en particulier, qui ont travaillé sur le cas *d'étude Ecostop, lequel* fait partie intégrante du troisième papier de cette thèse (partie 6).

[4] L'objectif général d'IMPRESA est de « mesurer, évaluer et comprendre les impacts de toutes formes de RSA européennes [Recherche scientifique sur l'Agriculture] sur les questions politiques agricoles clés, incluant la productivité au niveau des exploitations agricoles mais aussi l'amélioration environnementale et l'efficience des chaines d'approvisionnement alimentaires » (IMPRESA Website, 2017).

*Comme institutions d'accueil, ma gratitude va au F*iBL *(Institut de Recherche de l'Agriculture* Biologique) et à *l'UMR Innovation* jointe INRA/CIRAD – Un merci tout particulier à Dominique, Matthias et Urs pour le FiBL ; *ainsi qu'à Jean-Marc, Pascal et Guy pour l'UMR* Innovation. Je remercie également tous mes autres collègues du FiBL, du CIRAD et *de l'*INRA pour nos *échanges d'idées et* pour leur *convivialité. Par ailleurs, je tiens à remercier l'école* SupAg*ro et l'école doctorale EDEG* (Ecole Doctorale Economie et Gestion) pour leur soutien. Enfin, je souhaite remercier toutes les autres personnes *m'ayant* aidé au cours du processus de *recherche et d'écriture*, incluant mes proches et amis.

Abstract

This thesis intends to evaluate, develop and test different qualitative methods and ways of ex-post assessing the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic agriculture.

We have conducted two case studies focusing on the transition to organic farming. First is the Camargue case (in France) that encompasses a broad range of technical innovations. Second is on the development of the organic product Ecostop to protect bees against the varroatosis disease in Bulgaria.

We evaluate the potential of a broad approach based on the Participatory Impact Pathway Analysis (PIPA) and adapted & complemented by several other methods (first article, part 4), as well as the potential of the Social Network Analysis (SNA) (second paper, part 5) and of the Actor Network Theory (ANT) (third paper, part 6), in evaluating ex-post the impacts and contribution of the research. We study the impacts of the research in the Camargue and how they were generated. The Bulgarian case is only used to evaluate the potential of ANT (together with the Camargue case).

The approach based on PIPA allows assessing successfully the impacts and contribution of the research. We could show that the research contributed to change in the Camargue by developing co-learning interactions with farmers although this was not critical to the success of the innovation as a whole. The agricultural policies, economic factors, the testing conducted independently by farmers, and the institutional framework, were the most important and influential factors. With respect to SNA, it was of interest to validate stakeholders' views on actors' relationships and their implications on the transition to organic farming. For example, the growing role played by INRA (National Research Agronomic Institute) within the actor network was confirmed as well as its contribution to the transition. As to ANT, it allows highlighting interpersonal actors' relationships and their effects on the innovation development. We particularly underline the importance of opinion leaders in the phases of implementation and diffusion; and also show the importance of problematizing the issues to be tackled in order to increase the success of research programs.

Key words – Evaluation; Program Theory; Innovation Process; Ex-post Participatory Impact Pathway Analysis; Social Network Analysis; Actor Network Theory.

(Résumé)

Cette thèse *a pour objet d'évaluer,* de développer et de tester différentes méthodes qualitatives *et manières d'évaluer ex*-post les impacts et la contribution de la recherche sur les processus *d'*innovations et la société, par rapport à *la transition à l'agriculture biologique.*

Nous avons réalis*é deux cas d'études traitant de la transition à l'agriculture biologique. L*e premier est le cas camarguais (en France) englobant *un ensemble d'innovation*s techniques. Le second concerne le développement du produit biologique Ecostop pour protéger les abeilles contre la maladie de la varroatose en Bulgarie.

Nous évaluons le potentiel d'une approche globale *basée sur l'analyse participative du chemin de l'im*pact (PIPA) mais adaptée et complémentée par de nombreuses autres méthodes (premier article, partie 4), ainsi que le potentiel de *l'analyse du réseau social (SNA) (deuxième article,* partie 5) et de *la théorie de l'acteur réseau (ANT) (troisième article,* partie 6) *pour l'évaluation* ex-post des impacts et de la contribution de la recherche. Nous étudions les impacts de la recherche en Camargue et la manière dont ils ont été générés. Le cas Bulgare est seulement utilisé pour évaluer le potentiel *d'*ANT (avec le cas camarguais).

L'approche basée sur PIPA permet d'évaluer avec succès les impacts et la contribution de la recherche. Nous avons pu mettre en évidence que la recherche a contribué au changement en Camargue à travers le *développement d'interactions* de co-apprentissage avec les producteurs bien que cela ne se soit *pas avéré crucial pour le succès de l'innovation* dans son ensemble. Les politiques agricoles, facteurs économiques, tests conduits indépendamment par les agriculteurs, et le cadre institutionnel, ont été les facteurs les plus importants et ayant eu le *plus d'effets*. En ce qui concerne SNA, il est apparu utile pour valider les dires des parties prenantes sur les relations entre acteurs ainsi que leurs implications sur la transition à *l'agricultur*e biologique. Par exemple, le rôle grandissant joué par *l'*INRA (Institut National *de la Recherche Agronomique) au sein du réseau d'acteur*s a été confirmé de même que sa *contribution à la transition vers l'agriculture biologique. Quant à l'approche* ANT, elle permet *de mettre en avant les relations interpersonnelles d'acteurs et leurs effets sur le développement de l'innovation. Nous soulignons en particulier l'importance des leaders d'opinion* au cours *des phases d'implémentation et de diffusion* ; et montron*s également l'importance de*

problématiser les questions devant être traitées afin *d'améliorer* le succès des programmes de recherche.

Mots clés – Evaluation ; Théorie du Programme ; Processus *d'Innovation ;* Analyse Ex-post et Participative du Chemin de *l'Impact ;* Analyse du Réseau Social ; *Théorie de l'Acteur Réseau*.

Extended Summary

General introduction and state of the art (part 1 & 2)

The rationale of evaluating ex-post innovation processes and research programs is mainly to report to stakeholders on the profitability and/or the social utility of the investments, as well as to increase the impacts of the research. But the question of how innovation processes and the contribution of the research should be assessed remains a complex and highly debated issue. Available methods for evaluating impacts of research are often of quantitative nature and fail at highlighting the complex mechanisms involved in innovation processes.

This thesis intends to evaluate, develop and test different qualitative methods and ways of ex-post assessing the impacts and contribution of the research on innovation processes and the society, concerning the transition to organic agriculture. The general objectives of the thesis are as follows:

(1) To assess ex-post the impacts of the research program as well as the role and contribution of this research on innovation processes and the society, in relation to the transition to organic farming in the Camargue. A qualitative mixed-method is developed for this purpose. This objective is addressed in the first article in part 4.

(2) To study the interest of performing a Social Network Analysis (SNA) in ex-post evaluating the impacts of the research on innovation processes and the society, regarding the transition to organic farming in the Camargue. This objective is addressed in the second article in part 5.

(3) To evaluate the interest of the Actor Network Theory (ANT), used as theoretical framework, in orienting evaluative questions for assessing ex-post the impacts and contribution of the research on innovation processes linked to the transition to organic farming. This objective is addressed in the third article in part 6.

(4) To question the global relevance and contribution of the different methodological developments (resulting from the objectives 1, 2, and 3) in understanding ex-post the impacts and contribution of the research on innovation processes and the society, with respect to the transition to organic agriculture. This objective is addressed in the discussion part (part 7).

A state of the art on the evaluation of the research based innovation and on impact assessment is made in part 2. We take account of a "dynamic" view to innovation, which focuses us on qualitative impact evaluation approaches. Two case studies are explored in this thesis. First is the Camargue case which is about the transition to organic rice farming systems in the Camargue territory in France. Second is the Bulgarian case study that deals with a specific and radical innovation, i.e. the Ecostop product to treat bees organically against the varroatosis disease.

Methodology (part 3)

The objectives of the thesis are discussed in more details together with the research questions and hypothesis. We also specify the conceptual and theoretical framework, which is based on the observation that innovations are increasingly complex and on the fact that we focus on the transition to organic farming. In order to better understand the "black box" of the innovation and how research outputs do generate outcomes and impacts, we take an interactive view and, more importantly, an evolutionary perspective to innovation, considering the latter as a "system". Furthermore, a short description of the two case studies is made (French Camargue and Bulgaria) and the rationale of selecting them is specified. The Camargue case is about the transition to organic rice farming systems. It was primarily chosen as it tackles a radical innovation and also because of the availability of numerous publicly documents on the research program as well as of the presence of a key informant from INRA (National Institute of Agronomic Research). As to the Bulgarian case, it was mainly chosen as it deals with a specific radical innovation, i.e. the Ecostop product, which has become one of the most important product against the varroatosis disease in Bulgaria. Finally, the structure of the thesis on the following parts is specified: the three articles (part 4, 5 and 6), the general discussion (part 7), and the general conclusion (part 8).

First article (part 4)

The first paper assesses the contribution, role, and impacts of the Science-Based Research and Innovation Program (ISRIP) on farmers' transition to organic production in the Camargue. The Participatory Impact Pathway Analysis (PIPA) approach is used to enlighten complex mechanisms in the innovation process; the Outcome Harvesting (OH) method to adapt PIPA to the requirements of an ex-post evaluation; and SNA to emphasize actors' relationships in

relation to the development process. Other methods are also used in combination to deepen the analysis. We demonstrate that the research contributed to change by developing co-learning interactions with farmers, although this was not critical to the success of the innovation. Rather, we highlight that agricultural policies, economic factors, testing conducted independently by farmers, and the institutional framework, are the most important and influential factors.

Second paper (part 5)

The second paper evaluates the relevance of undertaking a SNA in deepening the understanding on the network of actors and the role it plays during the innovation process. Most importantly is the analysis of stakeholders' views, by taking the Camargue case study (in France) on the transition to organic farming as example. The analysis confirms the growing role played by INRA over the actor network as well as its contribution to the transition to organic agriculture. The study also corroborates the importance of the institutionalization of the supply chain (creation of the specialized firm BIOSUD) that took place in 2003. SNA is able to validate stakeholders' views on actors' relationships and their implications on the transition to organic farming.

Third paper (part 6)

The third paper explores the potential of ANT in understanding the contribution of the actors and how they interact during the different phases of innovations linked to the transition to organic farming. The study relies on the French Camargue and Bulgarian case. We show that ANT is able to identify the role played by human actors and objects. Key actors are identified while highlighting interpersonal actors' relationships and their effects on the innovation development. We underline the importance of opinion leaders in the phases of implementation and diffusion; and also show the importance of problematizing the issues to be tackled in order to increase the success of research programs. We advocate that the role played by opinion leaders and individual actors should be further questioned when planning and implementing research programs.

General discussion and conclusion (part 7 & 8)

We show that the approach developed successfully adapts existing methods and especially the PIPA approach to the requirements of an ex-post evaluation. Also, the reconstruction of the network of actors at different periods in the innovation pathway is of interest for identifying the most important actors as well as the research activities that have had the most important impacts. Other major elements are the table of links to identify underlying mechanisms to pathway links and what that this entails; the "scoring system" for identifying the key pathway components; the counterfactual instrument to establish causal inferences; and the ANT for highlighting the role of interpersonal relationships and negotiation processes.

We also show the strong interest of the approach for evaluating the effects of the research intervention in the Camargue case and subsequently for improving the pathway of the transition to organic farming. The research program on the transition to organic farming in the Camargue played an important role in developing and structuring the network of actors. The adoption of the technical incremental innovations is however principally derived from the "tests" set individually by farmers (refinement and optimization of the rice production system).

Based on the knowledge generated on how to assess research impacts of and on the way the transition to organic farming occurs, 13 recommendations for policy makers, researchers, and stakeholders are made. 8 main recommendations are as follows:

- To **problematize the challenges to be tackled** before implementing a research program as such, and refine this problematic all along the process;
- The **interests of the different actors from research should primarily be aligned** around goals that are beneficial for everybody;
- To **enable farmers to conduct experimentations on their farms**, preferably in close collaboration with the research;
- To **enroll opinion leaders** to make a closer link between research and the farmer community;
- To **enable a favorable economic and institutional environment** to make the research intervention more successful;
- To **allow flexibility into research programs** to adapt to unexpected developments during innovation processes;

- To **regularly monitor research outputs and outcome**s during the time span of the research program;
- To **conduct an ex-post participatory impact pathway evaluation.**

We conclude that PIPA can be successfully combined with other methods from social sciences. This allows informing the impacts and contribution of the research in the impact pathway. We also emphasize that the different methodological developments allow to reduce the size of the "black box" of the innovation process in relation to the transition to organic farming. It was recognized (1) the importance of the problematizing phase, (2) the importance of a few key persons that play a role of initiator, (3) the decisive role of the trust among actors to disseminate the knowledge with success, (4) the importance of the "trialability" (conduct of experimentations / testing), of the "objectivity" (direct visualization of testing / experimentations' results), and of the opinion leaders in the implementation and diffusion, and finally (5) the essential function of the economic environment and markets.

(Résumé approfondi)

Introduction générale et état de l'art (partie 1 & 2)

*L'intérêt d'évaluer ex-post les processus d'innovation*s et programmes de recherche est principalement de faire part aux parties prenantes de la rentabilité *et/ou de l'utilité sociale des* investissements, ainsi que *d'améliorer les impacts de la recherche. Mais la question de comment les processus d'innovation*s et la contribution de la recherche pourrait être évalués reste un sujet complexe et très débattu. Les méthodes disponibles pour évaluer les impacts de la recherche sont souvent de nature quantitative et ne permettent pas de faire la lumière sur les *mécanismes complexes opérant au cours du processus d'innovation.*

Cette thèse a pour objet d'évaluer, de développer et de tester différentes méthodes qualitatives *et façons d'évaluer ex*-post les impacts et la contribution de la recherche sur les processus *d'*innovations et impacts sociétaux liés, *concernant la transition à l'agriculture biologique. Les* objectifs généraux de la thèse sont les suivants :

(1) Evaluer ex-post les impacts du programme de recherche ainsi que le rôle et la contribution de cette recherche sur les *processus d'innovation*s et la société, en rapport *avec la transition à l'agriculture biologique en Camargue. Une méthode qualitative* mixte est développée à cette fin. Cet objectif est traité dans le premier article à la partie 4.

(2) Etudier *l'intérêt de réaliser une Analyse du Réseau Social* (SNA) pour évaluer ex-post les impacts de la recherche sur les *processus d'innovation*s et la société, vis-à-vis de la *transition à l'agriculture biologique en Camargue.* Cet objectif est traité dans le deuxième article à la partie 5.

(3) *Evaluer l'intérêt de la théor*ie de *l'acteur réseau (ANT), utilisée comme* cadre théorique, *dans l'orientation des questions évaluatives pour analyser ex*-post les impacts et la *contribution de la recherche sur les processus d'innovations lies à la transition à l'agriculture biologique.* Cet objectif est traité dans le troisième article à la partie 6.

(4) *Interroger la pertinence globale et l'apport des différents développements* méthodologiques (résultant des objectifs 1, 2 et 3) dans la compréhension, ex-post, des *impacts et de la contribution de la recherche sur les processus d'inno*vations et impacts sociétaux liés*, en ce qui concerne la transition à l'agriculture biologique.* Cet objectif est traité dans la partie discussion (partie 7).

U*n état de l'art sur l'évaluation de la recherche en matière d'innovation et* d'évaluation de *l'impact est réalisé dans la deuxième partie. Nous retenons une vision «* dynamique » de *l'innovation, nous amenant à* nous *focaliser sur des approches qualitatives de l'évaluation de l'impact. Deux cas d'études sont explorés dans cette thèse.* Le premier est le cas de la Camargue concernant la transition vers des systèmes rizicoles biologiques (en France). Le deuxième est le cas Bulgare, *traitant d'une innovation radicale* et spécifique, à savoir le produit Ecostop pour protéger biologiquement les abeilles contre la maladie de la varroatose.

Méthodologie (part 3)

Les objectifs de la thèse sont discutés plus en détails avec les questions de recherche et hypothèses. Nous précisons également le cadre conceptuel et théorique, qui se base sur *l'observation que les innovations sont de plus en plus complexes et sur le fai*t que nous nous *focalisons sur la transition à l'agriculture biologique. Afin de mieux comprendre la* « boite noire » *de l'innovation et comment les «* outputs » de la recherche génèrent des « outcomes » et impacts, nous nous basons sur une vision interactive, et plus important encore, sur une *perspective évolutionniste de l'innovation, considérant cette dernière comme un «* système ». *De plus, une courte description des deux cas d'études est réalisée (la Camargue en France et* le cas Bulgare), et la raison de leur sélection spécifiée. Le cas de la Camargue concerne la transition à des systèmes rizicoles biologiques. Il a notamment *été choisi car il traite d'une* innovation radicale, mais aussi du fait de la disponibilité de nombreux documents sur le programme de *recherche et de la présence d'un informateur clé de l'INRA* (Institut National de la Recherche Agronomique). Quant au cas Bulgare, les raisons principales de sa sélection *ont trait à l'accent mis* sur une *innovation radicale, c'est*-à-dire sur le produit Ecostop, qui est *devenu l'un des produits les plus importants contre l*a maladie de la varroatose en Bulgarie. Enfin, la structure de la thèse pour les parties subséquentes est spécifiée : les trois articles (partie 4, 5 et 6), la discussion générale (partie 7), et la conclusion générale (partie 8).

Premier article (partie 4)

Le premier article évalue la contribution, le rôle, et les impacts de la recherche scientifique & programmes *d'innovation*s liés, *sur la transition à l'agriculture biologique en Camargue. L'approche de l'analyse participative du chemin de l'impact (PIPA) est* adoptée afin de faire *la lumière sur les mécanismes complexes dans le processus d'innovation* ; la méthode « Outcome Harvesting » (OH) *pour adapter PIPA aux conditions d'une évaluation ex*-post ; et *l'analyse du réseau social* (SNA) *pour souligner les relations d'acteurs en relation avec le* processus de développement. *D'autres méthodes sont également utilisées en combinaison afin d'approfondir l'analyse.* Nous montrons que la recherche a contribué au changement en développant des interactions de co-apprentissage avec les agriculteurs même si cela *n'a pas* été primordial pour le *succès de l'innovation. Nous montrons* en revanche que les politiques agricoles, les facteurs économiques, les « tests » conduit indépendamment par les producteurs, et le cadre institutionnel, sont les facteurs les plus influençant et importants.

Deuxième article (partie 5)

Le deuxième article évalue *la pertinence d'effectuer une analyse du réseau social* (SNA) pour *approfondir la compréhension du réseau d'acteur et du rôle qu'il joue au cours du processus d'innovation. Le plus important est l'analyse des opinions* des parties prenantes, en prenant le *cas de la transition à l'agriculture biologique en Camargue (en* France) pour exemple. *L'analyse confirme le rôle grandissant joué par l'INRA* au cours du temps au sein du réseau *d'acteur*s *ainsi que sa contribution à la transition vers l'agriculture biologique. L'étude corrobore également l'importance de l'institutionnalisation de la chaîne de valeur (création* de la firme spécialisée BIOSUD) ayant eu lieu *en 2003. L'analyse du réseau social* est à même *de valider les opinions des parties prenantes sur les relations d'acteurs et leurs implications sur la transition à l'agriculture biologique.*

Troisième article (partie 6)

Le troisième article explore le potentiel de la théorie de l'acteur réseau dans la compréhension de la contribution des acteurs et comment ils interagissent durant les différentes phases de *l'innovation,* en rapport avec *la transition à l'agriculture biologique. L'étude se base sur le* cas de la Camargue en France et sur *le cas Bulgare. Nous montrons que la théorie de l'acteur réseau est à même d'identifier le rôle joué par les acteurs humains et les objets. Les acteurs*

clés sont identifiés tout en soulignant *les relations interpersonnelles d'acteurs et leurs effets sur le développement de l'innovation. Nous mettons en avant l'importance des leaders d'opinion au cours des phases d'implémentation et de diffusion* ; et montrons également *l'importance de problématiser les sujets à traiter afin d'augmenter les chances de succès des programmes de recherche. Nous suggérons que le rôle joué par les leaders d'opinion et acteurs individuels devraient être davantage questionné lors de la planification et la mise en œuvre* des programmes de recherche.

Discussion et conclusion générale (partie 7 & 8)

Nous montrons que l'approche développée permet d'adapter avec succès les méthodes existantes, et particulièrement PIPA, aux *conditions d'une évaluation ex*-post. Aussi, la *reconstruction du réseau d'acteur*s à différentes périodes du *chemin de l'innovation* est utile à *l'identification des acteurs le*s plus importants ainsi que des activités de recherche ayant eu le *plus d'impacts. D'a*utres éléments majeurs sont la table des liens pour identifier les mécanismes sous-jacents des liens du chemin et ce que cela implique ; le « système de points » pour identifier les composantes clés du chemin *; l'instrument contrefactuel pour é*tablir les relations de causes à effets *; et la théorie de l'acteur réseau pour mettre en avant le rôle des relations* interpersonnelles et des processus de négociation.

*Nous montrons aussi le fort intérêt de l'approche pour évaluer les effets de l'interve*ntion de la recherche dans le cas camarguais et ainsi pour améliorer le chemin de la transition vers *l'agriculture biologique. Le programme de recherche sur la transition à l'agriculture* biologique en Camargue a joué un rôle important dans le développement et la structuration du *réseau d'acteurs. L'adoption des innovations techniques incrémentales est cependant* principalement dérivée des « tests » menés individuellement par les producteurs (amélioration et optimisation du système de production rizicole).

Sur la base des connaissances développées *par rapport à l'évaluation de l'impact et à* la *manière dont la transition vers l'agriculture biologique opère, nous préconisons* 13 recommandations pour les décideurs politiques, les chercheurs, et les parties prenantes. 8 recommandations principales sont:

- **Problématiser les challenges à considérer** *avant de mettre en œuvre un programme de* recherche en tant que tel, et réviser cette problématique tout au long du processus ;

- Les **intérêts des différents acteurs de la recherche devraient en première instance être alignés** autour *d'objectifs s'avérant bé*néfiques pour tout le monde ;
- **Permettre aux agriculteurs de mener des expérimentations sur leurs fermes**, de préférence en étroite collaboration avec la recherche ;
- **Enrôler *les leaders d'opinion*** pour établir un lien étroit entre la recherche et la communauté des agriculteurs ;
- **Permettre un environnement économique et institutionnel favorable** pour que *l'intervention de la recherche* ait plus de chances de succès ;
- **Accorder de la flexibilité aux programmes de recherche** pour *s'*adapter aux évènements imprévus *au cours des processus d'*innovations;
- **Suivre régulièrement les « outputs » et « outcomes »** au cours du programme de recherche;
- **Réaliser une évaluation participative ex-post *du chemin de l'impact***.

Nous concluons que l'approche PIPA peut être combinée avec succès avec d'autres méthodes venant des sciences sociales. Cela permet de renseigner les impacts et la contribution de la *recherche dans le chemin de l'impact.* Nous soulignons aussi que les différents développements méthodologiques permettent de réduire sensiblement la taille de la « boite noire » du processus *d'innovation en rapport avec la transition à l'agriculture biologique. Il a été reconnu (1) l'importance* de la phase de problématisation, *(2) l'importance de quelques personnes clés jouant un rôle d'initiateur*, (3) le rôle décisif de la confiance entre acteurs pour diffuser la connaissance avec succès, *(4) l'importance de la «* trialabilité *» (conduite d'expé*rimentations / tests), de « *l'objectivité* » (visualisation directe des résultats des tests / expérimentations), et *des leaders d'opinion* dans les phases *de mise en œuvre et de diffusion*, et finalement (5) la fonction essentielle *de l'environnement économiq*ue et des marchés.

Part 1: General introduction

The agricultural sector is facing important and growing challenges, particularly to answer the increased food demand and to tackle environmental and climatic issues. The agricultural sector accounts for biodiversity erosion, health problems, and pollution issues. It contributes to around 24% to greenhouse gas emissions worldwide (IPCC, 2014), mainly due to emissions of nitrous oxide and methane. It is generally recognized that the more intensive the farming production system is, the highest the greenhouse gas emissions are (e.g. Küstermann and Hülsbergen, 2008; Crosson et al. 2011). That is the reason the call for developing alternative agricultural modes of production is of upmost importance, especially concerning the transition to organic farming systems.

These observations lead to a growing public awareness on the main challenges to be tackled in relation to agriculture and in order to preserve life on the planet, which calls for more accountability of firms and research organizations. The role of agricultural research in supporting innovations towards a more sustainable world thus becomes more important (Fischer, 2000). Further agricultural research efforts are needed to achieving more sustainable farming systems and in turn to preserve life on the planet. Research on organic farming appears especially central as this production system is less intensive. Furthermore, several challenges in terms of scientific research still need to be solved regarding the transition to organic farming since no synthetic chemical inputs can be used according to regulations on organic agriculture.

As the agricultural sector presents market failures due to the relative inelasticity of the demand and offer and to the numerous number of economic agents, the non-perfect circulation of information and the presence of social and ecological externalities; economic markets cannot be sufficient by themselves to drive agriculture in a way that fulfills sustainable economic, social, and environmental goals. In absence of clear economic incentives, the private research within the agricultural sector is thereby insufficient. Public research is intended to fill that gap, including for sustainability and organic driven research.

However, public expenditures into agricultural research are called into question in the context of repeated financial and economic crisis and of the diminishing role of the states. Such expenditures have to be increasingly justified through scientific evidences. That is the reason

evaluation issues, including ex-post assessments (evaluation taking place once the project / research program is terminated) have gained importance during the last decades. The development of evaluation studies is a response to a demand of transparency and accountability expressed by citizens and the society as a whole. The European Commission (EC) and international organizations have led this movement and required provision of evidences for the effects of research and development programs. Two main objectives of evaluating impacts[5] of research are to measure the efficiency of interventions for accounting (CGIAR, 2000) and to bring out improvements in research policies and programs (Mackay and Horton, 2003).

In the case of the conversion to organic farming, Lamine et al. (2009) underlined the importance of extension services, collective actions and learning processes to impulse changes of farmers' practices. Social and technical innovations towards sustainable farming are complex and figure out a "black box" where research and innovation are supporting processes of change at individual, collective and institutional levels. Therefore, evaluating impacts of research programs on innovations linked to the transition to organic farming is even more complex as for other types of innovations.

Several approaches have been developed in the literature to ex-post evaluate impacts of research programs. But the question of how innovation processes driven by research should be assessed remains unanswered. Methods in the literature often fail at disentangling the "black box", that is, the complex process taking place between research investments on the one hand and the adoption of innovations and achievement of related impacts on the other (Penfield et al. 2013). Such quantitative approaches include econometric models, non-monetary approaches, as well as multi-criteria and cost-benefit analysis.

Quantitative approaches are in fact not very suitable because of the non-exploration of the complex pathway by which results are obtained. This type of practice, based on a linear view of innovation, is still dominant in evaluation studies (Cozzens and Snoek, 2010). It relies on two hypothesis (Matt et al. 2017): (1) a straightforward relation from investments leading to an increased stock of knowledge, which in turn leads to an increased productivity, and (2) the postulate that economic expansion necessarily implies social improvement. These hypotheses are no longer valid due to the shift from AKS (Agricultural Knowledge System) to AKIS

[5] The OECD (2002) defines impacts as the effects produced by outcomes in a long-term perspective, and that can be either intended or unintended.

(Agricultural Knowledge and Innovation System) and from the Mode 1 to the Mode 2 of knowledge production by Gibbons et al (1994). AKS and the Mode 1 do not recognize the role of complex interactive relationships nor intend to support sweeping changes (EU SCAR, 2012; Gibbons et al, 1994). Therefore, evaluation methods based on a linear framework do not allow complex and dynamic underlying mechanisms to be taken into account, nor to recognize systems of reflexive, learning and network interactions (Knickel et al. 2009a).

Furthermore, the computation of internal rates of return in the agricultural sector has been central for research impact evaluation for many years (Alston et al. 2009). This situation has somewhat caused an oversimplification of the understanding of the process of innovation and to a misleading or incomplete interpretation of its drivers. Additionally, quantitative approaches using the Total Factor Productivity (TFP) as outcome of research projects are often called into questions as regard to the consistency of the results obtained. The TFP growth calculation is faced with methodological issues in relation to its level and in understanding the sources of productivity (Byerlee and Murgai, 2001; Midmore, 2017). The TFP is actually not sufficient to capture all the complexity of the dynamics involved in agricultural innovation processes, especially when it comes to sustainability issues (Byerlee and Murgai, 2001).

The movement of privatization of agricultural extension services and the growing complexity of the agricultural innovation system, in the frame of a knowledge economy, calls for the development of another type of approach than the use of rates of return for evaluating the impacts of research. There is in particular a need to take better account of the role of co-production and exchange of knowledge among an increasing diversity of stakeholders driving innovation at local level. This also implies that local stakeholders should be further involved in decision-making on agricultural research and projects related in order to increase their knowledge on innovation development and adoption behaviors & drivers, as well as for empowering them towards a more sustainable agriculture. Furthermore, the increasing complexity of agricultural innovations makes it difficult to conduct an attribution analysis by undertaking a quantitative method. The focus should rather be on a contribution analysis, for which qualitative approaches, theory-driven, appear more suitable. The idea is thereby to look for the contribution of the research on both the innovation process and achievement of impacts.

Qualitative theory-driven approaches also seem more suitable for the purpose of understanding the pathway to impacts in that they are more operating in reflecting the complex learning interactions as well as the composite and causal underlying mechanisms (Hall et al. 2003, Colinet et al. 2014). These methods include for example the SIAMPI approach (Spaapen et al. 2013) and the Participatory Impact Pathway Analysis (PIPA) (Alvarez et al. 2010). That said, these approaches need to be significantly adapted and combined with others to be able to (1) evaluate impacts of research on agricultural innovation processes and by extension on the society, in an ex-post manner, while involving stakeholders into the process, and (2) to evaluate the contribution of the research in driving agricultural innovations and in achieving impacts. We therefore identified the need to develop a new approach to ex-post evaluate the impacts and contribution of research programs on innovation processes and the society, in relation to the transition to organic farming; and to go a step further towards developing non-traditional ways of evaluating impacts that take account of the new knowledge production paradigm.

This thesis intends to evaluate, develop and test different qualitative methods and ways of ex-post assessing the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic agriculture. As already said, this implies focusing on complex innovations characterized in particular by dynamic processes of knowledge co-creation. This is why a strong emphasis needs to be put on the role played by the network of actors on innovation processes and in achieving economic, social, and environmental impacts.

This thesis contains four objectives, which are further discussed in part 3 together with the specific research questions and hypothesis. The first three objectives are each tackled in a scientific article (part 4, 5, and 6), whilst the last objective is addressed in a general discussion part (part 7). The general objectives of the thesis are as follows:

(1) To assess ex-post the impacts of the research program as well as the role and contribution of this research on innovation processes and the society, in relation to the transition to organic farming in the Camargue. A qualitative mixed-method is developed for this purpose. This objective is addressed in the first article in part 4.

(2) To study the interest of performing a Social Network Analysis (SNA) in ex-post evaluating the impacts of the research on innovation processes and the society, in relation to the transition to organic farming in the Camargue. This objective is addressed in the second article in part 5.

(3) To evaluate the interest of the Actor Network Theory (ANT), used as theoretical framework, in orienting evaluative questions for assessing ex-post the impacts and contribution of the research on innovation processes linked to the transition to organic farming. This objective is addressed in the third article in part 6.

(4) To question the global relevance and contribution of the different methodological developments (resulting from the objectives 1, 2, and 3) in understanding ex-post the impacts and contribution of the research on innovation processes and the society, with respect to the transition to organic agriculture. This objective is addressed in the discussion part (part 7).

(Partie 1 : Introduction générale)

Le secteur agricole fait face *à d'importants et* croissants défis, en particulier pour répondre à la demande alimentaire grandissante et pour tenir compte des questions environnementales et climatiques. *Le secteur agricole a une responsabilité en matière d'érosion de la biodiversité,* de problèmes de santé, et de *pollution. Il contribue d'environ 24% au*x émissions de gaz à effet de serres au niveau mondial (IPCC, 2014), principalement à cause des émissions de méthane *et d'oxyde d'azote. Il est généralement reconnu que*, plus le système de production agricole est intensif, plus les émissions de gaz à effet de serre sont élevées (p.ex. Küstermann and Hülsbergen, 2008; Crosson et al. 2011). *C'est pourquoi il est d'autant plus important de* développer des modes de productions agricoles alternatifs, comme la transition vers des systèmes agricoles biologiques.

Ces observations amènent à une plus grande prise de conscience publique des principaux challenges à relever *dans le domaine de l'agriculture afin* de préserver la vie sur la planète, ce qui appelle à davantage de responsabilité des entreprises et des organismes de recherche. Le *rôle de la recherche agricole dans le développement d'innovation*s pour un monde plus durable apparait de plus en plus important (Fischer, 2000). Des efforts supplémentaires en matière de recherche agricole sont nécessaires pour la mise au point de systèmes agricoles plus durables et en corolaire pour préserver la vie sur la planète. *La recherche sur l'agriculture biologique* semble particulièrement décisive dans la mesure où ce système de production est moins intensif. De plus, de nombreux défis en matière de recherche scientifique doivent encore être résolus en *ce qui concerne la transition à l'agriculture biologique* puisque les produits chimiques de synthèse ne peuvent y être utilisés selon les régulations en la matière.

Dans la mesure où le secteur agricole présente des imperfections de marché du fait de la *relative inélasticité de la demande et de l'offre ainsi que de l'atomicité des agents économiques,* de *l'imparfaite circulation de l'information ou encore de* la présence *d'externalités sociales et* écologiques ; les marchés ne suffisent pas à amener *l'agriculture dans une voie qui puisse* répondre aux défis de la durabilité en termes économique, social et environnemental. En *l'absence d'incitations économiques* claires, la recherche agricole privée apparait insuffisante.

La recherche publique est appelée à remplir ce vide, notamment en ce qui concerne *l'agriculture* durable et biologique.

Cependant, les dépenses publiques dédiées à la recherche agricole sont remises en question dans un contexte de crises économiques et financières répétées et de diminution du rôle des *états. Ces dépenses doivent de plus en plus faire l'objet de* justifications scientifiques. *C'est pourquoi le sujet de l'évaluation, notamm*ent de type ex-post (réalisée une fois que la recherche / le programme de recherche est terminé), a gagné en importance au cours des dernières décennies. *Le développement d'études d'évaluation*s est une réponse à la demande de transparence et de redevabilité exprimée par les citoyens et la société dans son ensemble. La Commission Européenne (EC) et les organisations internationales ont poussé ce mouvement et demandent des éléments de preuves scientifiques quant aux effets de la recherche et des pr*ogrammes de développement. Deux objectifs principaux de l'évaluation de l'impact de la recherche sont de mesurer l'efficience des interventions pour rendre des comptes* (CGIAR, 2000) ainsi que *d'*apporter des améliorations aux politiques et programmes de recherche (Mackay and Horton, 2003).

Dans le cas de la conversion *à l'agriculture biologique*, Lamine et al. (2009) ont souligné *l'*importance des activités de vulgarisation, des actions collectives et des processus *d'apprentissage pour impulser des changements de pratiques* auprès des agriculteurs. Les innovations sociales et techniques vers une agriculture durable sont complexes et représentent une « boite noire *» où la recherche et l'innovation supportent les processus de changement au niveau individuel, collectif et institutionnel. Ainsi, l'évaluation des impacts des programmes de* recherche sur des innovations en lien avec la transition à *l'agr*iculture biologique parait encore *plus complexe que pour d'autres types d'innovations.*

De nombreuses approches ont été développées dans la littérature pour évaluer ex-post les *impacts de la recherche. Néanmoins, la question de comment les processus d'innovations* soutenus par la recherche devraient être évalués reste en suspens. Les méthodes exposées dans la littérature faillissent souvent à faire la lumière sur la « boite noire *», c'est à dire sur le processus complexe opérant entre les dépenses de recherche d'un côté et l'adoption des innovations et l'obtention d'impacts d'un autre côté* (Penfield et al. 2013). De telles approches quantitatives comprennent les modèles économétriques, les approches non-monétaires, de même que les analyses multicritères et de coûts-bénéfices.

Les approches quantitatives sont en fait peu appropriées du fait *de l'absence d'exploration du* chemin complexe par lequel les résultats ont été atteints. Ce type de pratique, basé sur une *compréhension linéaire de l'innovation, est encore dominant dans les études d'évaluations* (Cozzens and Snoek, 2010). Cela repose sur deux croyances de causalité (Matt et al. 2017): (1) *d'abord* que les investissements amèneraient à une augmentation du stock de connaissances qui à son tour entraînerait une augmentation de la productivité, et (2) que la croissance économique implique nécessairement un meilleur environnement social. Ces hypothèses ne sont plus valides du fait du passage du cadre AKS (*"*Agricultural Knowledge System*"*) vers le cadre AKIS (*"*Agricultural Knowledge and Innovation System*"*) et du Mode 1 vers le Mode 2 de la production de connaissances de Gibbons et al (1994). AKS et le Mode 1 ne reconnaissent pas le rôle des *relations complexes d'interactions et ne permettent pas* la réalisation de changements substantiels (EU SCAR, 2012; Gibbons et al, 1994). *Les méthodes d'évaluation*s basées sur ce cadre linéaire ne permettent pas de prendre en considération les mécanismes sous-jacents et complexes, ni ne reconnaissent les systèmes de réflexion et les interactions *d'apprentissages et de réseau* (Knickel et al. 2009a).

De plus, le calcul de taux de rentabilité interne dans le secteur agricole a longtemps été central dans les évaluations des impacts de la recherche (Alston et al. 2009). *D'une certaine manière,* cette situation a conduit à une simplification excessive de la compréhension des processus *d'innovations et à une* interprétation erronée ou incomplète de ses déterminants. Aussi, les approches quantitatives utilisant la productivité totale des facteurs (TFP), comme impact des programmes de recherche, sont souvent remises en question eu égard à la consistance des résultats obtenus. Le calcul du taux de croissance du TFP fait face à des difficultés méthodologiques par rapport à son niveau et à la compréhension des sources de productivité (Byerlee and Murgai, 2001; Midmore, 2017). Le TFP est en fait insuffisant pour capturer toute la complexité des dynamiques évoluant au cours des *processus d'innovations agricoles*, en particulier lorsque ces derniers *traitent d'enjeux de durabilité* (Byerlee and Murgai, 2001).

Le mouvement de privatisation des activités de vulgarisation agricole de même que la *complexité croissante du système d'innovation agricole, dans le cadre d'une économie de la* connaissance, *appellent au développement d'un autre type d'approche que les taux de retour* pour évaluer les impacts de la recherche. Il y a en particulier un besoin de mieux prendre en

compte le rôle de la co-production et des échanges de connaissances *au sein d'une diversité* croissante de parties prenantes qui soutiennent les innovations au niveau local. Cela signifie également que les parties prenantes locales devraient être plus impliquées dans les prises de décision sur la recherche agricole et des *projets relatifs afin d'accroître leurs connaissances* sur le développement des innovations, s*ur les comportements d'adoption* et les leviers, ainsi que pour les responsabiliser à une agriculture plus durable. De plus, la complexité croissante des innovations agricoles rend difficile la réalisation *d'une analyse d'attribution via l'emploi d'*une méthode quantitative. *L'accent* devrait plutôt être mis sur une analyse de contribution, pour laquelle les approches qualitatives, basées sur la théorie, semblent plus appropriées. *L'idée est ainsi d'étudier la contribution de la recherche à la fois sur le*s processus *d'innovation*s *et à la fois sur l'obtention d'impacts.*

Les approches qualitatives, basées sur la théorie, paraissent également plus adaptées pour comprendre le chemin emprunté vers *l'obtention d'*impacts en ce sens qu*'elles sont plus à même* de *faire la lumière sur les interactions complexes d'apprentissage et les mécanismes causaux* sous-jacents (Hall et al. 2003, Colinet et al. 2014). Ces méthodes comprennent par exemple *l'approche SIAMPI* (Spaapen et al. 2013) et *l'analyse participative du chemin de l'impact* (PIPA) (Alvarez et al. 2010). Cela dit, ces approches doivent être significativement adaptées et *combinées avec d'autres pour être à même* (1) *d'évaluer les impacts de la recherche sur les processus d'innovations agricoles*, de façon ex-post, en y impliquant les parties prenantes dans le processus, et (2) pour évaluer la contribution de la recherche au développement des innovations agricoles et à la génération *d'impacts.* Il a donc été identifié le besoin de développer une nouvelle approche pour évaluer ex-post les impacts et la contribution des *programmes de recherche sur les processus d'innovations* et la société, en relation avec la *transition à l'agriculture biologique* ; *et d'aller pl*us loin vers le développement de façons non *traditionnelles d'évaluer l'impact,* tenant compte du nouveau paradigme de la production de connaissances.

Cette thèse a pour objet d'évaluer, de développer, et de tester différentes méthodes qualitatives et man*ières d'évaluer ex*-post les impacts et la contribution de la recherche sur les processus *d'innovation*s et par extension sur la société, *en lien avec la transition à l'agriculture* biologique. Comme déjà évoqué, ceci signifie que *l'accent* est mis sur des innovations

complexes, caractérisées notamment par des processus dynamiques de co-création de *connaissances. C'*est pourquoi il apparait nécessaire de *mettre l'accent* sur le rôle joué par le *réseau d'acteurs sur les processus d'innovation*s et dans la production des impacts économiques, sociaux et environnementaux.

Cette thèse comprend quatre objectifs, lesquels sont davantage discutés à la partie 3 avec les questions de recherche spécifiques et les hypothèses. Les trois premiers objectifs sont chacun traités dans un article scientifique (partie 4, 5 et 6), tandis que le dernier objectif est adressé dans une discussion générale (partie 7). Les objectifs généraux de la thèse sont les suivants :

(1) Evaluer de manière ex-post les impacts du programme de recherche ainsi que le rôle et la contribution de cette recherche sur les *processus d'innovation*s et la société, en *rapport avec la transition à l'agriculture biologique en Camargue. Une méthode* qualitative est développée à cette fin. Cet objectif est traité dans le premier article à la partie 4.

(2) Etudier *l'intérêt de réaliser une* analyse du réseau social (SNA) pour évaluer ex-post les impacts de la recherche sur les *processus d'innovation*s et la société, vis-à-vis de la *transition à l'agriculture biologique en Camargue*. Cet objectif est traité dans le deuxième article à la partie 5.

(3) *Evaluer l'intérêt de la théorie de l'acteur réseau* (ANT), utilisée comme cadre *théorique, dans l'orientation des questions évaluatives pour analyser ex*-post les impacts et la contribution de la recherche sur les *processus d'innovations liés* à la *transition à l'agriculture biologique.* Cet objectif est traité dans le troisième article à la partie 6.

(4) *Interroger la pertinence globale et l'apport des différents développements* méthodologiques (résultant des objectifs 1, 2 et 3) dans la compréhension ex-post des impacts et de la contribution de la recherch*e sur les processus d'innovation*s et la société, *en ce qui concerne la transition à l'agriculture biologique.* Cet objectif est traité dans la discussion générale à la partie 7.

Part 2: State of the art

Abstract

In this part, we make a state of the art on the evaluation of the research based innovation and on impact assessment. We first show how the concept of innovation has evolved from a linear to a more interactive and then to an evolutionary perspective. This shift towards a "dynamic" conceptualization of innovation occurs in parallel to the shift from the classical economic paradigm to the evolutionary economic paradigm. We take account of a "dynamic" perspective to innovation, which focuses us on qualitative impact evaluation approaches. We show how the concept of evaluation has emerged and developed, before we present the most relevant qualitative impact assessment approaches. The Participatory Impact Pathway Analysis (PIPA) is seen as one of the most suitable one to evaluate the impacts and contribution of the research on innovation processes and the society.

(Partie 2 : Etat de l'art)

(Résumé)

Dans cette partie, nous faisons *un état de l'art sur l'évaluation de la recherche en* matière *d'innovation* ainsi que *sur l'évaluation de l'*impact. Nous montrons en premier lieu comment *le concept d'innovation a évolué d'une vision linéaire à une perspective plus interactive* puis évolutionniste. Ce mouvement vers une conceptualisation « dynamique *» de l'innovation a* évolué en parallèle du mouvement allant *du paradigme de l'*économie classique à une vision *évolutionniste de l'*économie. Nous tenons *compte d'une* perspective « dynamique » de *l'innovation,* ce qui nous amène à considérer l*es approches qualitatives de l'évaluation de l'impact.* Nous montrons *comment le concept d'évaluation a émergé* puis *s'est développé, avant* que nous ne présentions les approches qualitatives les plus pertinentes *pour l'*évaluation de *l'impact. L'*analyse participative du c*hemin de l'*impact (PIPA) est regardée comme *l'une des* plus pertinentes pour évaluer les impacts et la contribution de la recherche sur les processus *d'innovations et la société.*

2.1 Outline

In this part, we first make a literature review on innovation theories by presenting the main paradigms, especially on aspects of socioeconomics transition. The investigated theories are intended to help comprehend the concept of innovation and its evolution over time, in order to focus on the most suitable approaches for evaluating the impacts and contribution of the research on agricultural innovation processes and by extension on the society. In a subsequent section, we trace back the historical development of programs evaluation, from the emergence of the concept of measure & evaluation to the most recent evolutions, e.g. in terms of impact evaluation. Existing types of programs evaluation are then outlined before focusing on the most relevant qualitative methods for evaluating research programs based innovation.

2.2 Rationale for evaluating research programs

The rationale of evaluating research programs is as follows: (1) to report to stakeholders (public or private) on the return to their investments and whether the intended effects have been achieved or not, (2) to prove the achievement of impacts on populations, (3) to encourage accountability on allocation of resources across research programs, (4) to bring out improvements in policies and programs, and (5) to assess likely future impacts of the programs (CGIAR, 2000; Mackay and Horton, 2003; OECD, 2008).

Furthermore, agricultural research based innovation appears to be of high interest to foster innovation development in the agricultural sector. Three main reasons are identified. Firstly, agricultural farms are relatively small enterprises and have limited capacities to engage in financial investments. A second reason is linked to the "homogeneous nature" of agricultural products, which makes it difficult to differentiate products on market and thus to obtain a substantial return on investment through higher prices or additional sales. A third reason is that the agricultural sector is relatively well protected compared to others. This may limit inducements to invest as farmers are a priori more guaranteed to remain in the agricultural economic sector.

Furthermore, because of market failures (e.g. ecological externalities), economic markets cannot be sufficient by themselves to drive agriculture in a way that fulfills sustainable economic, social and environmental goals. In absence of sufficient economic incentives, the

private research within the agricultural sector is thereby insufficient. Public research is intended to fill that gap, including for sustainability and organic driven research.

In summary, agricultural research, including the public one, is of great importance for developing wide-ranging and sustainable innovations in agriculture, but until now no clear evidences have been described in the literature on how research contributes to the development of agricultural innovations and in turn to the achievement of outcomes (changes in behaviors, adoptions and actions undertaken) and impacts (mid and long-term effects), including for the transition to a more sustainable and/or organic agriculture.

2.3 Economic theories

2.3.1 Definition of innovation

We call innovation the first commercialization of an invention, which is the first occurrence of an idea for a new product or process. Progress from invention to innovation requires different types of knowledge, competences, resources and capabilities to be combined (Fagerberg, 2006). An innovation occurs within the market, companies or societies when new routines are emerging while current habits start losing ground (Bianchi and Miller, 1996). The notion of innovation has evolved over time in the way it is understood as a global concept. This issue is discussed after presenting in the subsequent section the main economic paradigms.

2.3.2 Main paradigms

Neoclassical perspective

It is not a long time ago that agricultural innovations were viewed as linear processes of public research and extension organizations leading to new goods and services. This view is in line with the neo-classical economy, which is based on the perfect rationality (Arrow and Debreu, 1954). This means that the decision to adopt innovations is driven by the meeting of the supply and demand (prices) within the framework of a perfect market (Romer, 1986). In effect, market prices implicitly contain all the information needed to allow economic agents making the most efficient choices. In other words, this allows agents to adequately use the resources at their disposal to obtaining the highest possible profit. Mode1 by Gibbons (1994) reflects this intellectual current by considering innovation as a linear and relatively uncomplicated process. In that model, the stakeholders involved in the knowledge transfer do not actively interact with

the research system nor influence the creation of knowledge. Later, a deep revisiting of the linear model of innovation occurred. This paradigm shift is well enlightened by Gibbons et al. (1994) with the shift from the Mode1 to the Mode2.

New Institutional Economics

The New Institutional Economics (NIE) is a set of schools of economic thought that emerged in the 70s. The development of NIE was based on pioneering work done by American institutionalists until 1945. The NIE questions the role of the institutions in the economy, that is, how they emerge and develop and what their objectives are. An institution can be defined as a set of norms and rules that frames and regulates behaviors.

The article "The Nature of the Firm" by Coase (1937) has been a crucial milestone in the development history of NIE, where the notion of transaction cost was introduced. Coase explained the existence of firms by the presence of transaction costs in exchanges between companies. The presence of a firm, as an intermediary and specialist actor, allows reducing the transaction costs through decreasing the number of transactions and/or improving their efficiency. Other economists' work contributed to this movement: Hayek and his work on the "knowledge" (Hayek, 1937, 1945); but also the research efforts made by North (1971) and Williamson (1981, 1984), among others.

Williamson makes the hypothesis that economic agents are opportunists: they endeavor to ameliorate their personal situations by all possible means. However, this type of behavior increases transaction costs as there is a need of negotiating ex-ante and controlling the respect of the contracts. Furthermore, Williamson puts special emphasis on the specificity of assets, which implies changes in economic actors' relationships as well as modifications and more uncertainty in the transaction frequency (unique, occasional or sustained). An asset is supposed to be specific when a long-term investment is required and when investments cannot be redeployed to another activity.

Moreover, North argues that contrary to what the neoclassical perspective suggests, the capital and technical progress factors cannot be described as economic growth determinants but as simple manifestations of it. North advocates that exchanges can only occur when there are both limited transaction costs and a low uncertainty.

To sum up, NIE places enterprises and firms at the core of the economic system, recognizes the presence of transaction costs, and thus underscores how complex economic agents' relationships are as well as the difficulty of finding the most efficient form of governance (market, firm, or hybrid).

Evolutionary economics

The neo-classical economy has left room for a more complex intellectual current, the evolutionary theory. Innovation processes are non-linear and characterized by the presence of feedback-loops. They can even be described as learning or cognitive processes implying incremental improvements. This perspective is based on the bounded rationality considering individuals' capabilities are limited by their restricted access to information (the market is not perfect) and by their partial cognitive abilities due to unpredictable risk (uncertainty). This view is opposite to the neo-classical economic thought, which considers the risk as predictable. These elements imply that individuals fail at making full use of the resources at their disposal and do not maximize profits accordingly.

Furthermore, while Schumpeter viewed innovation as a linear process, from invention leading to innovation and in turn to diffusion (Guellec, 2009), he also advocated that economic agents are not "cold and calculating" and may have irrational behaviors through adventurer and pride considerations. This brings more complexity into innovation processes, which become unforeseeable, with speeding up, slowing down and crisis (Leeuwis, 2004). Contrary to the proponents of the neoclassic economic thought, Schumpeter argued that the economic stationarity cannot exist because economic agents are not fully rational and also because the entrepreneur breaks out the "routine" of the Walras' general equilibrium (Schumpeter, 1934; Marty, 1955). From a neo-classical perspective, the stationary equilibrium can only deviate very temporarily from its gravity center when an innovation emerges. However, according to Schumpeter, the entrepreneur follows a strategy of imperfect competition, as it needs to be protected from competitors by filling patents or creating monopolies (Schumpeter, 1934).

2.3.3 Towards an interactionist and evolutionary view of innovation

Towards an interactionist view of innovation

The model of the Technology push (or Research push) was developed in the 50s and constituted the most common innovation model during the 20th century. The Technology push is a linear model, which considers innovation as directly arising from industry and scientific discoveries. This model is made of four different and successive phases: invention, study, implementation, and marketing. The Demand-pull model was later developed by Jacob Schmookler (1966). Contrary to the Technology push that emphasizes the role played by science, the Demand-pull underlines the "sovereignty" of the consumer on innovation development. In other words, the innovation is triggered by the demand that affects the speed of the technological diffusion. The Technology-push and Demand-pull models are still dominant in the way innovations are conceptualized and understood. These straightforward models were elaborated following Schumpeter's ideas, which focused on technological aspects of innovation. However, these models are of linear nature, where all the complexity involved in innovation processes is excluded. Kline and Rosenberg (1986) enounced four important critics in that respect: (1) innovation processes start in the field of science, but Kline and Rosenberg stated that they result from successive development objectives of new products and processes, (2) the role of technology for science is omitted, (3) a direct link is established between innovation development and new scientific knowledge whereas most of the innovations are initiated by available scientific knowledge, and (4) process innovations are not evaluated accurately.

To answer critics on the very linear conception of innovation processes, Kline and Rosenberg (1986) have developed the so-called Chain-linked model. Under this model, both the demand and technology are expected to play an important role in fostering innovations, which are hence understood as dynamic processes and not only as a set of multiple independent and successive phases. The different phases of the Chain-linked model are as follows: (1) identification of a market opportunity or of new relevant scientific and technological data, (2) the invention, detailed conception, and trials, (3) the final conception and production, and (4) the distribution and commercialization. This model is characterized by the presence of feedback loops and interactions by the means of systemic linkages between phases but also through recognizing interconnections between market, science, and technology. The Actor Network Theory (ANT)

emerged later (together with managerial approaches) as a more complex type of innovation stressing the importance of knowledge and information sharing.

ANT, also known as sociology of associations or translations, was developed in the 80s in the field of sociology of sciences and technics (Matos and Ipiranga, 2017). It is an interdisciplinary approach, seeing the world as composed by essence of networks (Law, 1992). ANT gained recently in popularity in the area of innovation research (Hoholm and Araujo, 2011; Ramírez et al. 2011; du Preez, 2012). It aims at investigating the way networks of actors and social effects come into being and develop, the process of actors' enrollment, the mechanisms of persuasion and influence acting over these networks (Mouritsen et al. 2001), as well as how technology favors the organization of the actions undertaken (Chen and Hung, 2016). ANT examines how actors are seen by their peers and themselves, what they obtain or abandon to get involved, and what their objectives and motivations are (Lockie, 2007). Economic agents' interactions stabilize the knowledge network by the means of "boundary objects" e.g. codes of practice (Šūmane, 2010). This process of stabilization is not simple given the different actors' interests that need to align with each other. This process is known as process of translation (Callon, 1986). The designers of ANT share the view that innovation is no longer triggered by an isolated actor; rather ANT sees innovation as a novel combination of knowledge and as a non-linear and interactive process in which actors are transformed during translations (Callon, 1986; Latour, 1988; Law, 1987). Moreover, it should be emphasized that ANT is based on the principle of "symmetry", by giving to human and non-human actors, also referred as "actants", equal analytical priority (Law 1992, Walsham 1997, Akrich et al. 2006).

Towards an evolutionary perspective of innovation

The evolutionist perspective of economics then developed, considering the economy in terms of disequilibrium. Innovation is hence seen as a system. According to Bergek et al. (2007), this system presents seven functions: (1) knowledge development and diffusion, (2) influence on direction of search and identification of opportunities, (3) entrepreneurial experimentation and management of risk and uncertainty, (4) market function, (5) resource mobilization, (6) legitimation, and (7) development of positive externalities. Nelson and Winton are two crucial contributors to the evolutionary economics. These authors underline the important role played by organizational routines, drawing on the idea that firms permanently recombine routines

depending on existing dynamics (Nelson and Winter, 2009). This highlights the need to consider firms on different temporal steps and selection processes that depend on the technical regime as well as on organizational and institutional changes in progress (Dosi, 1982; Lazaric, 2010).

An innovation system can be defined as "all important economic, social, political, organizational, and other factors that influence the development, diffusion, and use of innovations." (Edquist, 1997, p14). It is composed of institutions and actors' network which foster, diffuse and utilize innovations (e.g. Malerba, 2002). The approach of innovation system takes its roots in the work of Freeman. In the 80s, the collaboration between Freeman and the IKE group (Innovation, Knowledge and Economic dynamics) from the department of business studies at the Aalborg University was considered important to combining the different work other scholars previously made on this topic (Freeman, 1982; Lundvall, 1985). According to Carlsson et al. (2002), this concept aims at understanding how a set of various organizations, institutions and actors (embedded in networks) interact with each other for developing innovations (national, regional or sectoral level). This development was based on the observation that the success of innovations can be due to networks and institutions that facilitate learning processes and information sharing.

The concept of innovation system has been broadly used so far, not only by research actors but also by international development organizations like the World Bank and the EU. Yet, this concept is not unidimensional but encompasses different approaches. These include Systems of Innovation (SI) as well as Technological and Sociotechnical Systems (TSS).

- Systems of Innovation

The approach of SI was widely used in the 90s (Edquist, 2001), following the pioneering explorations of Freeman (1987), Lundvall (1992) and Nelson (1993). SI has been inspired from the evolutionary theory, and views innovation process as evolutionary. National Systems of Innovation (NSI) emerged first, before sectoral and regional declinations were developed.

- ✓ National Systems of Innovation

The objective of NSI is to help comprehend innovation and process of learning as well as to address political recommendations. The chain-linked model we presented earlier also acted as a bridge towards the development of NSI since it further elaborated linear models like the Demand Pull. Furthermore, it was increasingly recognized that markets do not only rely on prices and quantities but also on actors' connections as well as on knowledge and interactive learning processes. These interactions are seen as organized markets shaped by elements of trust, power and loyalty (Lundvall, 1985). Another element that gave impetus to the development of NSI is the significant differences between nations e.g. in terms of habits, routines and rules ("simple" SI are not suitable for all countries).

- ✓ Sectoral and Regional Systems of Innovation

During the last decades, new models highlighting the systemic nature of innovation were developed, focusing at other geographical scales. These new models are alternative sectoral and regional SI, which concentrate on diverse local products or technologies (Mowery and Nelson, 1999). It was observed an increasing importance of more sectoral systems like technological districts, local clusters and production systems. Porter (1990), a well-known author, has shown that international competitiveness relies on specialized clusters or districts. The opening of commercial and financial borders in the 80s and 90s has been giving increasing importance to product quality (the "differentiation"). Furthermore, Krugman (1991) and Audretsch & Feldman (1994), have described four advantages regarding such local organizations: (1) shared labor market composed of qualified employees with specific competencies, (2) increased information flow and knowledge spillovers due to the internalization of the tacit knowledge within the localized technological system, (3) possible expansion of specific intermediate good industries, and (4) less expensive provision of non-exchangeable inputs exclusive to the industry.

Actually, all SI approaches, either national or sectoral / regional, are complementary, considering learning as interactive amongst organizations (formal structures like private firms, governmental and non-governmental agencies, associations, with clear goals) (Edquist, 1997; Markard and Truffer, 2008). Still, institutions (set of routines, habits, rules, technical and

sociocultural norms, regulations and laws, etc.) are seen as fundamental components, shaping organizations' activities and the way they interact with each other (Edquist, 1997; Markard and Truffer, 2008). Organizations develop under the umbrella of institutions. Institutions can also be influenced by organizations insofar as they sometimes arise within organizations like firms. Institutions and organizations are strongly connected together in a complex and interactive way, which in turn influences SI (Edquist and Johnson, 1997).

- Technological and Sociotechnical Systems

A Technological System (TS) can be defined as: "networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse and utilize technology" (Carlsson and Stankiewicz, 1991, p94). TS are defined in terms of knowledge or competence flow rather than flow of ordinary goods and services. As for NSI, the approach of TS refers to an evolutionary view of economics and takes a system perspective while attempting to explicate innovation processes and economic growth. An important critic addressed to earlier models is the omission of the "technical" parameter as an endogenous factor to the production function and therefore to innovation and economic growth. The nation level recognized in NSI is in fact not necessarily the right level of delimitation to analyze innovations. Sectoral and regional models were developed to focus on particular products and technologies. The rationale of taking a TS perspective is in line with this; the boundaries of a TS are not necessarily those of a nation. Therefore, there is a need to focus on TS as such, without considering the geographical level. "TS involve market and non-market interaction in three types of networks: buyer-supplier relationships, problem-solving networks, and informal networks. [TS] capture and enhance technological spill-overs [and] create favorable conditions for market exchange" (Carlsson, 1997, p5).

Technologies play a key role within sociotechnical systems. Technologies can improve the efficiency of a given production system by reducing the use of natural, capital and labor inputs (OECD, 2005). Sectoral SI focus considerably on knowledge development but much less on technological diffusion and wide changes. The latter rely not only on technological innovations but more generally on new sociotechnical systems. This is due to the strong embeddedness of technologies into sociotechnical systems. Technologies themselves are not able to develop and

diffuse without appropriate social functions in terms of communication, housing, transport and so on (Geels, 2004).

- The Quintuple Helix Model

The Quintuple Helix Model represents a cooperation and knowledge system composed of social interactions and highlighting the role of the know-how in developing innovations for a sustainable development. It highlights the perspective of social ecology of the society, and considers the natural environment as a system of knowledge creation by itself.

This model was developed from previous models of knowledge creation and innovation creativity, following a continuous development series:

- ✓ a) The Mode1 by Gibbons et al (1994) focused on the role of university research in the frame of a linear view of innovation;
- ✓ b) The Mode2 by Gibbons et al (1994) started to recognize the role of complex interactive relationships. The Mode2 is characterized by "(1) knowledge produced in the context of application, (2) transdisciplinarity, (3) heterogeneity and organizational diversity, (4) social accountability and reflexivity, (5) and quality control" (Carayannis et al. 2012, p3);
- ✓ c) The Triple Helix combined the perspectives of knowledge creation from the Mode1 and Mode2 – reflexive communications and user-producer interactions – as sub-dynamics of the whole system. It emphases on university-industry-government relations and on the knowledge economy, and is "a model of "trilateral networks and hybrid organizations" of "university-industry-government relations" " (Carayannis et al. 2012, p3);
- ✓ d) The Quadruple Helix is similar to the Triple one but add an additional Helix, the "media-based and culture-based public".

In mode details, the Quintuple Helix Model is "interdisciplinary and transdisciplinary at the same time: the complexity of the five-helix structure implies that a full analytical understanding of all helices requires the continuous involvement of the whole disciplinary spectrum, ranging from the natural sciences (because of the natural environment) to the social sciences and

humanities (because of society, democracy and the economy)" (Carayannis and Campbell, 2010, p30).

This model is useful in solving problems in relation to sustainable development and to the socio-ecologic transition. This transition is made possible by the means of knowledge co-production for the "natural". The latter is conceptualized by the new Helix, called "the natural environment". The five helix of the model are as follows:

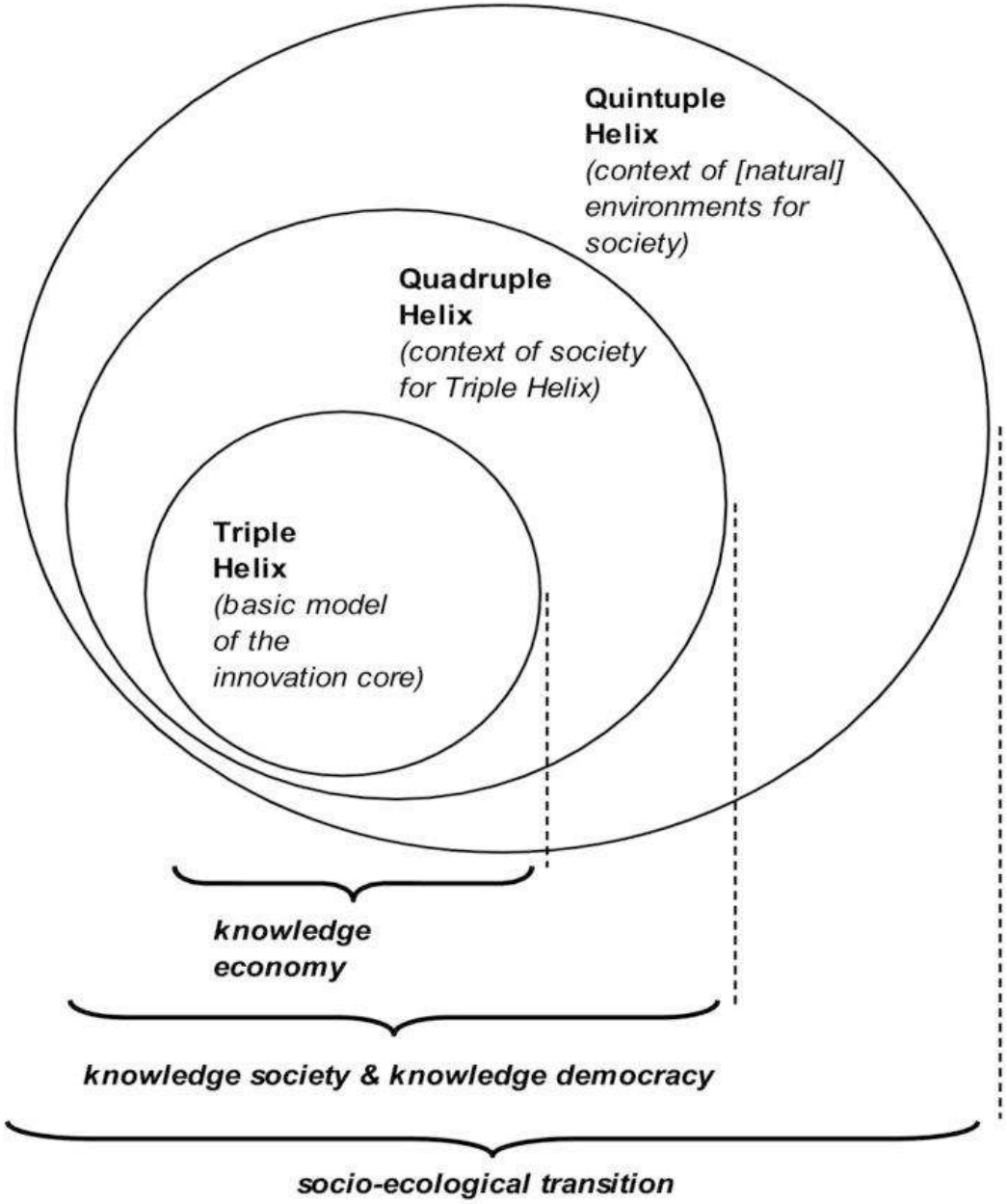
(1) Political system: this helix refers to the "political and legal capital", e.g. ideas and laws;

(2) Education system: this helix comprises academia, universities, higher education systems, and schools. It refers to the "human capital";

(3) Economic system: this helix is composed of industry / industries, firms, services and banks. It refers to the "economic capital";

(4) Natural environment: this helix is relevant to promote a more sustainable development. It refers to the notion of "natural capital";

(5) Media-based and culture-based public: this helix comprises and associate together two forms of capital: "social capital" and "capital of information".



Source : Carayannis et al (2012, p4)

FIGURE 1: KNOWLEDGE PRODUCTION AND INNOVATION IN THE CONTEXT OF THE KNOWLEGE ECONOMY, KNOWLEDGE SOCIETY, AND THE NATURAL ENVIRONMENTS OF SOCIETY

2.3.4 Transition theories

The notion of transition has often been used in the literature to characterize the shift from communist to capitalistic regimes in the 90s. This paradigm shift towards capitalist regimes gave rise to the emergence of this notion of transition (Dobry, 2000).

a) Socio-Technical Transitions

The theory of transitions encompasses different approaches aiming at assessing how Socio-Technical Transitions (STT) are being developed. STT represents changes in technological and social relationships dynamics towards a new system. Four approaches of STT are as follows: (1) the Multi-Level Perspective (MLP) by Geels (2005), (2) the IS (Jacobsson and Bergek, 2011), (3) the complex systems (Loorbach, 2010), and (4) the evolutionary systems (Safarzyńska and Van den Bergh 2010). The paradigm shift from communist to capitalistic regime is a good illustration of a radical innovation that is able to destabilize the pre-existing regime.

The regime or the "deep structure" accounts for the stability of an existing STT (Geels, 2004). This system is sheltered by the presence of lock-in mechanisms, anchored institutions, established technologies, social networks, routines, etc. These elements, that constitute the regime, should evolve to facilitate the emergence and development of radical changes. Only incremental innovations can develop without much hindrances (Kemp et al. 2001; Schot and Geels, 2008). "Niches" can destabilize a regime. A "niche" can be defined as a "discrete application domain (habitat) where actors are prepared to work with specific functionalities, accept such teething problems at higher costs, and are willing to invest in improvements of new technology and the development of new markets" (Hoogma et al. 2005, p4). In other words, a niche refers to a protected space (with its own rules, institutions, habits, etc.), where new technologies and socio-technical practices emerge from the selection pressures of "normal" markets of regimes (Geels, 2005) and which could replace the existing regime (Schot and Geels, 2008). At a higher level, we observe the "landscape", which represents the general structuration of the socio-economic system with its own laws, robust principles, and so on (Markard and Truffer, 2008; Geels, 2004). Changes in the regime are supposed to bring incremental modifications in the "landscape", which can in turn open windows of opportunity for the development of "niches". Yet, the development of these "niches" is likely to alter the regime.

b) Sustainability transitions

STT can be framed towards achieving sustainable objectives ("sustainability transition"). According to Raven et al (2010), this process is made of four steps: (1) problematization, (2) development of a vision of sustainability, (3) mobilization of actors, and (4) monitoring, evaluating, and learning.

Moreover, the transition towards a more sustainable agriculture aims at achieving general sustainability goals rather than only exploring new technologies, innovations, and so on (Smith et al. 2005). This implies that farmers may not have direct financial benefits and therefore incentives to adopt "sustainable" innovations. The improvement of the sustainability at a global level does not necessarily affects positively farms' profitability. As a result, public intervention is fundamental for internalizing externalities such as environmental damages as well as for creating "artificial" incentives to increase farmers' adoption of sustainable innovations. However, this implies revisiting the global economic conditions (subsidies, taxes, etc). The sustainability transition is a complex process, which is situated at the interface between innovations, new technologies, policy goals, and the economic environment. Results are highly dependent from institutions and public authorities' will, and on how they perceive the notion of sustainability.

c) Actor Network Theory

The Actor Network Theory (ANT) is an approach that emerged in the 90s in the field of sociology. This approach was first discussed in section 2.3.3. Here we highlight the process of translation of ANT. This process is understood as "a vague initial idea [that] is shaped, diverted and consolidated, to build up a network of allies who believe in, test, and carry forward the development of the innovation" (Arnaboldi and Spiller, 2011, p642). The transition process is made of 4 stages:

(1) Problematization: it allows interested actors to delineate the problem and to become essential in solving it. These actors then raise awareness in the network as to the importance of the problem to be tackled in order to convince other actors to take part in the process;

(2) Interessement: this phase aims at enrolling additional actors, either humans or objects, by the means of discourses and negotiation processes. The more the number of enrolled actors, the more the network is potentially viable;
(3) Enrollment: this can be defined as the strategies and set of tactics used for creating a stable network of alliances. That said, this stability depends on the process of negotiation taking place in the network;
(4) Mobilization of allies: the level of mobilization of allies is linked to their degree of acceptance on the innovation development.

Throughout this part on economic theories, it was recalled that innovation processes shifted from a linear perspective, e.g. with the Technology push model, to a more interactive and systemic approach. The Quintuple Helix Model is of particular interest since it takes a system perspective and shows how a socio-ecological transition is being materialized. We also reminded how complex this transition is.

2.4 Historical development of programs evaluation

This section aims to better comprehend why and how programs evaluation have emerged, in general and within the agricultural sector.

2.4.1 Until the year 2000

The notion of the measure goes back to the antiquity period. It steadily developed with the implementation of academic tests, which were the first attempts of evaluating programs in the history. The 19th century was also that of evaluation development, with in particular the development of an empirical approach of programs evaluation (Madaus et al. 1983). This evolution was encouraged by the development of social associations that were created in the second half of the 19th century (Madaus et al. 1983).

The effectiveness and testing were the major features of the first third of the 20th (Madaus et al. 1983), in which the concept of evaluation arised (in the 30s). The period from 60s to 80s was that of the "Science-Driven Wave", which saw the "triumph" of the so-called "radical rationalism" (Vedung, 2010). There was a demand for public policy to be more functional and scientific (Hajer and Wagenaar, 2003). "To become more rational, public decision-making

bodies should exploit the full arsenal of methods for program budgeting, zero-based budgeting, multi-annual planning, future studies, systems analysis and cost-benefit analysis, which are sometimes jointly called 'policy analysis' " (Vedung, 2010, p265). The radical rationalism implied that any public intervention should not occur before scientific evidences on the problem to be tackled are found (description of the problem, goals and likely impacts, diverse costs, etc).

From the 70s, the field of evaluation has increasingly become a specialty, and several methodologies, training materials, and so on, have developed. The 70s were those of the "Dialogue-Oriented Wave", being materialized by an increasing involvement of various stakeholders (not only politicians) into evaluation procedures (Vedung, 2010). This type of evaluation is also named as "stakeholder evaluation" and sometimes as "democratic evaluation" since the process was "supposed to be conducted by discussion dialogue and communication among equals, even deliberation avant la lettre" (Vedung, 2010, p268). During the "Dialogue-Oriented wave", Guba and Lincoln (1989) have pushed forward the constructivist paradigm, which has dissimilarities compared to the positivist approach at ontological level (the objective reality is refuted as realities are socially built) but also at epistemological level (subjectivity of evidences: the inquirer cannot be separated from the inquired person) and methodological level (the way the objective reality occurs cannot be determined because this reality is denied).

The 80s were those of a formalist type of approach with the development of several standards to assess evaluation (Rossi, 1982). This period was also that of the "Neo-Liberal Wave" (Vedung, 2010), with a shift from public intervention to a more market and customer oriented economic system. "What was novel was not that goal achievement, effectiveness, efficiency and productivity became catch phrases but that these objectives were to be achieved by government marketization instead of stakeholder involvement or scientification from the top down" (Vedung, 2010, p270). The neo-liberal movement is known as New Public Management (NPM) and has led to new evaluation practices in relation to three elements:

(1) the "victory" of the leadership concept, with the conviction that giving more freedom to managers fosters the development of more efficient companies; leaders should thus be evaluated for their performance, competence, and so on;
(2) the development of a more indirect control of enterprises by the state due to the movement of privatization; and the increasing use of outsourcing created a new relation

of principal-agents, which requires these agents to be supervised by the principal for their reliability and performance (with the help of accountability tools);

(3) The reform of organizations that calls for a better consideration of customers' needs and preferences; the evaluation helping to assess the degree of satisfaction of these customers (with consumers' surveys).

Several evaluation approaches were developed, e.g. the transactional model (Rippey, 1973), the case study (Stake, 1978) and the responsive model of evaluation (Guba and Lincoln, 1981). The latter aims at evaluating the usefulness of local programs and to formulate recommendations for their improvements. As to the transaction model, it focuses at changes in the way people are affecting with each other (Wallis et al. 2008).

Fischer (1980) also has contributed to the development of evaluation, based on critics of the so-called "positivist approach" in the domain of public policy evaluation. Fischer developed a more comprehensive approach, the "levels model", focusing on the way of tackling questions related to policy evaluation. This model contains 4 levels (with sub-questions at each level): (1) technical verification of program's objectives (intentions, empirical consequences, unanticipated effects, alternative means), (2) situational validation of policy goals (relevance, context, multiple goals, and precedence), (3) vindication of political choice (system consequences, equity, ideological conflicts), and (4) choice of social order (alternative social orders). From the point of view of Fischer, this model allows broadening the "narrow technocratic orientation of conventional policy evaluation" (Fischer, 1996, p17) by involving in particular a sufficient diversity of actors in the evaluation process.

2.4.2 After the year 2000

Since early in the 21th century, a considerable and growing attention is paid to program evaluation and impact assessment. This change finds its roots in two events: (1) the failure of the Washington consensus, and (2) the Lisbon Strategy (2001). The Washington consensus aimed at finding solutions to the important debt problems encountered in several developing countries during the 80s. The Latin America was particularly affected by this problem, which was due to the important rise of their external debt in dollar caused by an important decline of their domestic currencies' exchange rate. Several measures were programmed in order to solve this situation. They were promoted by the World Bank, the International Monetary Fund, and

were largely inspired by the economist John Williamson in 1989. The ideas coined by Williamson were strongly in line with the economic liberalism, especially concerning the abolishment of economic borders and the liberalization of the domestic economic market. But the Washington consensus did not produce the expected results. The international funding institutions have recognized this failure. It followed a contentious debate on the success of liberal prescriptions on the one hand and on the effectiveness of international supports on the other. As an example, Easterly (2001) advocated that the policies conducted in 80s and 90s did lead to economic stagnation in developing countries. Significant methodological issues were posed regarding the way Washington consensus' impacts should be evaluated. Furthermore, the funding institutions did not plan evaluating the impacts of the program, whether in an in-itinere or ex-post manner. The publication "When will we ever learn? Improving lives through impact evaluation" lies in this frame of reproaches (Evaluation Gap Working Group, 2006). As to the Lisbon Strategy, the main goals were to make the EU the most competitive and dynamic knowledge based economy before the year 2010, with a view to generating a sustainable economic growth together with a continued improvement in the job market and a greater societal cohesion. Innovation and research were seen as the main strategic drivers for reaching this objective. A clear focus was put on the improvement of the socio-economic impacts of the EU research.

The European Commission has developed a long-term research strategy in order to enhance impacts of the European agricultural research and innovation (European Commission, 2015a). The Commission is devoting an increasing budget for this purpose since the dramatic surge in food prices in 2008 and following FAO's prospective scenarios regarding nutrition and food security issues (European Commission, 2015a). These issues are raising more awareness on the need to support agriculture and develop innovations. At the same time, a growing attention is paid to the effectiveness and efficiency of research programs in a context of scarce financial resources. Results need to be evidence-based and therefore indicators of performance and impacts are being developed. This is the "evidence movement", also known as the "evidence wave". The task of developing "Horizon 2020 indicators" highlights this process (European Commission, 2015b), as it intends assessing results and impacts of the EU Horizon 2020

program[6]. At Member State level and in France in particular, INRA (French National Institute of Research Agriculture) and CIRAD (French Agricultural Research and International Cooperation Organization) started to develop indicators of impacts to assess innovation from their own research programs. More generally, INRA and CIRAD are looking with growing importance at scientific evidences of results of their research programs.

The movement around the failure of the Washington Consensus as well as the implementation of the Lisbon Strategy have been encouraging the conduct of numerous impact assessment studies and the development of several methodologies. Examples of methods are the Public Value Mapping (Bozeman and Rogers, 2002), the SIAMPI i.e. Social Impact Assessment Method (Spaapen et al. 2013), and the Payback Framework (Donovan and Hanney, 2011). In the agricultural sector, three important organizations are involved in this movement: the CGIAR (Consultative Group for International Agricultural Research) (Walker et al. 2008), the CSIRO (Commonwealth Scientific and Industrial Research Organization) (Acil Tasman, 2010), and the EMBRAPA (Brazilian Corporation of Agricultural Research) (Avila et al. 2016).

2.5 Existing programs and evaluation approaches

2.5.1 Current concept of evaluation

According to the OECD (2002), the term of evaluation can be defined as "the systemic and objective assessment of an on-going or completed project, program or policy, its design, implementation and results. The aim is to determine the degree of relevance and fulfillment of the objectives, as well as the development efficiency, the effectiveness, the impacts and the sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision-making process of both recipients and donors". Moreover, the concept of evaluation is generally well distinguished from the concept of research (Weiss, 1997), and from that of monitoring. Research is a systemic investigation, with the objective to set up principles and laws. The research aims at identifying scientific explanations on how variables interact with each other. The objective is to draw conclusions upon these findings, to allow researchers generalizing results and making hypothesis, principles and laws. Monitoring specifically aims at collecting data during on-going programs in order to

[6] "Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness" (European Commission, 2016).

bring improvements directly in the process advancement, and to help achieve the expected results. Furthermore, monitoring is not intended to determine whether impacts are attributable to the program but only if they are attained and why. TABLE 1 summarizes the most important differences between the concept of monitoring and evaluation.

Monitoring	Evaluation
To clarify the objectives of the program.	To analyze whether the expected objectives have been reached.
To link inputs and activities to the objectives.	To assess specific causal contributions of activities to results.
To set performance indicators and targets, based on the objectives.	To investigate the implementation process.
To regularly gather data on these indicators and evaluate whether the targets have been reached or not.	To identify the unexpected results.
To report advancements to leaders and warm them in case of a problem.	To draw conclusions on the success or potential of the program, identify the main lessons learned and provide avenues for improvements.

Source: Kusek et Rist (2004).

TABLE 1: MONITORING VS. EVALUATION

Furthermore, according to the OECD (2008), the concept of evaluation presents five important criteria:

(1) Relevance: to estimate the pertinence of the program with respect to the local or national objectives and priorities;

(2) Effectiveness: to identify whether the objectives have been achieved and to what extent results answer the expected goals;

(3) Efficiency: to assess whether the objectives were efficiently achieved. The ratio spending / results can inform this;

(4) Impact: to evaluate the impacts being attributable to the program;

(5) Sustainability: to evaluate the sustainability or permanence of the intervention.

2.5.2 Time period of the evaluation

The evaluation can be carried out at different periods: ex-ante; in-itinere; ex-post; or a combination between ex-ante, in-itinere, and ex-post.

Ex-ante evaluation (Dufumier, 1996; OECD, 2008; Gertler et al. 2011; Joly et al. 2016): an ex-ante evaluation mainly aims at measuring the expected impacts of a future intervention as well as understanding the mechanisms by which the program will or could achieve the desired impacts. It can also serve to build scenarios, anticipate potential risks and particular needs, and therefore to adapt a future intervention. In general, such an evaluation is conducted via economic modelling, scenario development, or structural models. Structural models describe the different "elements" constituting a system and how they are interrelated. Examples of such "elements" are a package, an interface, and an object.

In-itinere evaluation (OECD, 2008; Gertler et al. 2011; Joly et al. 2016): the objective of an in-itinere evaluation is to adjust the innovation, when on-going, to increase its chances of success and reach the expected impacts. To do so, the evaluation sheds light on the first effects of the program by identifying its actual weaknesses and strengths. Moreover, an in-itinere evaluation can only be performed when the evaluator has sufficient knowledge on the innovation and related mechanisms, as well as on the different actors being involved in the program.

Ex-post evaluation (Maredia et al. 2000; Boardman et al. 2006; OECD, 2008; Walker et al. 2008; Gertler et al. 2011): an ex-post evaluation takes place after the program is completed. It assesses the observed effects and impacts of the intervention, positive or negative and expected or not, while seeking to understand the underlying mechanisms. Depending on the delay between the end of the program and the evaluation; short, mid or long-term impacts may be considered. Such an analysis requires the innovation to be at an advanced stage. An ex-post evaluation may require significantly more financial resources than an ex-ante evaluation, as numerous data have to be collected on all changes caused by the intervention. Also, the identification and assessment of the full set of impacts can be very time-consuming.

Both ex-ante and ex-post evaluation (OECD, 2008; Gertler et al. 2011): the aim is to compare the results of an ex-ante or in-itinere analysis with an ex-post evaluation, with a

view to better understand the route the innovation is being undertaken, as well as for improving current or future programs. The comparison is intended to generate a wealth of knowledge, which can be used to adjust the way programs are implemented.

2.5.3 Categories of evaluation

a) Positivist approach

The positivist approach is a scientific method that can be used when quantitative evidences are available. In other words, the effects of the program should be quantifiable (Potter, 2006). The evaluator uses observable information instead of gathering data through interviewing actors. The positivist approach can take many forms: Program-Theory (PT) assessment, efficiency or impact assessment, and needs assessment (Rossi et al. 2004).

b) Interpretive approach

The interpretive approach analyzes how humans interpret activities. The researcher studies and interprets varied lived experiences and their subjective evidences. The evaluator seeks to understand the needs and experiences of the different stakeholders to better evaluate the effects of the program (Potter, 2006). Qualitative data are collected by undertaking focus groups, in-depth interviews, and through observations.

c) Critical and emancipatory approaches

Critical and emancipatory approaches have to be differentiated from positive and interpretive research approaches. The two latter approaches usually seek to solve a particular problem or to improve the way of tackling it, as well as proposing the best practices with a view to transform social relationships (Potter, 2006). The critical and emancipatory approaches are focused on participation, empowerment, and social power structures (Potter, 2006). They can be described as participatory methods since stakeholders are actively involved in the process. The critical approach specifically focuses on social issues and relies on assumptions on human interests and knowledge. This approach is opposed to the positivist science. The positivist thinking was strongly criticized by researchers from the “critical” school of thought, arguing the positivist science is undemocratic, too narrow, and non-humanist. These researchers also criticize the interpretive approach which should concentrate more on social issues from their viewpoint.

d) Empowerment approach

Empowerment approaches aim at improving programs or policies as well as training the different stakeholders and communities involved so that they may monitor, evaluate, and improve their own existing and future programs by themselves or with the assistance of the evaluator (Fetterman, 1996). Empowerment is "a construct that links individual strengths and competencies, natural helping systems, and proactive behaviors to social policy and social change" (Perkins and Zimmerman, 1995, p569). With respect to empowerment evaluation, it can be defined as an approach that aims "to increase the probability of achieving program success by (a) providing stakeholders with tools for assessing the planning, implementation, and self-evaluation of their program, and (b) mainstreaming evaluation as part of the planning and management of the program / organization" (Wandersman et al. 2005, p28). Empowerment evaluation can also be defined as a democratic approach (Fetterman, 1996) contrary to positivist approaches.

e) Operational evaluation

An operational evaluation (Khandker et al. 2010) aims at identifying if the program unfolded as planned, that is, to evaluate whether the results delivered are in line with the objectives defined before the program started. Another objective is to draw conclusions and to identify the main lessons learned to better implement future programs. Operational evaluation is part of project implementation. Even though a difference is made between operational and impact evaluation, these methods are complementary rather than substitutes.

f) Impact evaluation

In the literature, the term "impact" often refers to long-term effects of a program. The OECD bears witness to this, and defines an impact as "positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended" (OECD, 2002). As to "impact evaluation", it can be defined as "an assessment of how the intervention being evaluated affects outcomes (changes) in the actions, relationships, and behaviors of enterprises, individuals or communities, whether these effects are intended or unintended" (OECD, 2002). Impact evaluation assesses impacts in relation to the objectives set

before the research activities were launched. Its originality is to focus on causal mechanisms of the impacts generated by the intervention.

The evaluation of impacts is applied in several sectors like energy, transportation, education, development projects, health, or agriculture. By the way, the existence of the international association for impact assessment is no mere coincidence. It organizes an annual conference on this topic. This association distinguishes "impact assessment" into 5 main disciplinary lines: environmental impact assessment, social impact assessment, health impact assessment, risk assessment and strategic impact evaluation (CGIAR, 2000).

Two types of impact evaluation can be conducted: a contribution analysis and an attribution analysis (Mayne, 2001). The latter refers to a counterfactual situation to investigate the causality. As to the contribution analysis, it attempts to decompose the different causal steps of the process under study.

Counterfactual scenario:

A comparison is made between the situation studied and a situation with no intervention. The question posed is what the outcomes (changes) and impacts would have been in absence of the intervention. This comparison allows establishing causalities between variables by attributing changes to the program intervention. However this type of evaluation requires the innovation to be relatively simple, stable over time, and that the potential beneficiaries are easily identifiable (Devaux-Spatarakis, 2014). Those characteristics fit into the frame of a classical or neo-classical economy.

Contribution analysis:

By contrast, a contribution analysis decomposes the whole process of change, from intervention to impacts, while highlighting the complex and underpinning causal mechanisms. Under this concept, we seek to determine the **set of factors** which have led to changes **instead of attributing** the effects of separate variables to the observed results. Although this is not a requirement, the innovation investigated is generally of a complex nature, non-linear, and potential beneficiaries are more difficult to predict.

2.5.4 Qualitative methods for evaluating research programs

a) Public Value Mapping

The Public Value Mapping (PVM) is a conceptual tool that aims to comprehend causes of social outcomes (Bozeman and Sarewitz, 2005). Outcomes stand for changes in the behavior, relationships, activities and/or actions of the stakeholders (Earl et al. 2001). PVM also endeavors to estimate the contribution of the research to reaching social outcomes; and looks at the underlying causal logic of programs through applying a "churn" model of knowledge value and innovation (Bozeman and Rogers, 2002). This model specifically focuses on "Knowledge Value Collectives (KVC) and "Knowledge value alliances" which are used and/or developed by actors from a network for enhancing and using scientific knowledge. PVM makes the assumption that science is only part of the process leading to social outcomes and is not necessarily the most important factor. That is the reason PVM explores alternative explanations to the underlying causal logic of programs. Also, PVM assumes that complex relationships occurring between research and social outcomes cannot be understood without examining the way KVC are operationalized. However, a weakness of PVM in relation to our objective is that it only explores the public (social) value, which is generated by science as well as the set of actors and institutions that together transform knowledge into social changes.

b) SIAMPI approach

The SIAMPI approach (Spaapen et al. 2013) aims at evaluating the social impacts of research by overcoming limitations regarding suitable instruments of measure as well as attribution problems (multi causal impacts, long time span). Impacts are the effects produced by the outcomes in a long-term perspective and can be intended or unintended (OECD, 2002). SIAMPI stands for Social Impact Assessment for research and funding instruments through the study of productive interactions between science and society. The method focuses on learning instead of judging and accounting, as it concentrates on productive interactions (direct, indirect and financial interactions between researchers and other involved actors) which helps understand the "black box" between research and impacts. The good understanding of the process generating impacts, in turn, allows defining more relevant indicators of measurement. Nonetheless, the SIAMPI approach is not of participatory nature and does not provide a clear template or stepwise approach for ex-post reconstructing ISRIP. Furthermore, factors linked to

the research are not distinctly distinguished from external causes; thus, contribution of research remains unclear. Finally, SIAMPI does not tackle economic and environmental impacts.

c) Outcome Mapping

Outcome Mapping (OM) is a method that was developed by Earl et al (2001) and aiming at designing projects in an ex-ante manner. Projects designers are involved in a participatory workshop in order to define the way it should or will be undertaken to reach the expected goals. Boundary partners, that is, actors with whom the project has direct contacts or on which it may have influences, should also participate to the meeting. It must be emphasized that the frontier between boundary partners and final beneficiaries is not very strong. A boundary partner can also be a final beneficiary.

All of the attendants are asked to draw the expected chain of progress from inputs and activities to outputs and outcomes. Impacts are omitted in this method and replaced by the concept of "Vision". The Vision represents changes in terms of human, social and environmental development that a project intends to encourage and to which it aims to contribute. Furthermore, the "Mission" describes how the project is expected to contribute to the Vision through activities, outputs, and outcomes. In other words, the Mission describes how the project fulfills its role in relation to the Vision, how it encourages boundary partners to reach their objectives, and how it attains the effectiveness, efficiency, relevance and viability. The Mission is supposed to encourage potential beneficiaries to adopt new innovation(s) arising from the project. The approach advocate conducting monitoring activities, but it is not designed to perform an ex-post evaluation of the project. That is the reason the Outcome Harvesting (OH) approach was developed to overcome the shortfalls of OM.

d) Outcome Harvesting

OH was developed by Wilson Grau and Britt (2002) to overcome the shortcomings of the OM approach (Earl et al. 2001) in terms of ex-post evaluating programs. OM aims to implement projects by constructing expected pathways. OH presents the major interest to be designed for ex-post analysis and is an "evaluation approach in which evaluators, grant makers, and/or program managers and staff identify, formulate, verify, analyze and interpret 'outcomes' in programming contexts where relations of cause and effect are not fully understood" (Wilson-Grau, 2015). Under OH, changes (outcomes) related to the intervention are identified before going further back to outputs and research activities. However, OH does not propose organizing

workshops as primary option and can hardly be described as a participatory approach. Rather, OH recommends to collect data through publicly available documents, surveys, questionnaires, and in-depth interviews.

e) Payback Framework

The payback framework (Donovan and Hanney, 2011) is a logic model representing the different elements operating from research to impacts and composed of two interfaces: project specification and selection on the one hand and dissemination on the other. The model allows exploring a research program from the idea or invention developed within the research process to the dissemination phase. The research process is non-linear and characterized by the presence of several feedback loops occurring between the different phases, and the role of intermediaries and beneficiaries in the interface of dissemination is emphasized. Research programs are explored by collecting information through surveys, analysis of various documents, and interviews. The method is therefore not of participatory nature.

f) Participatory Impact Pathway Analysis

The Participatory Impact Pathway Analysis (PIPA) (Douthwaite et al. 2007) is derived from the approach of Impact Pathway Analysis (IPA). PIPA looks at the detailed process generating impacts from activities, outputs and outcomes. This approach is inspired from the Program-Theory (PT), which is often referred as theory of change, theory-based evaluation (Weiss, 1997), intervention logic (Nigel and Vanheukelen, 1997). PT refers to a set of possibilities for developing a comprehensive impact logic model (from activities to outputs leading to outcomes and then to impacts) of the program with the aim to guide evaluation of an intervention (Rogers et al. 2000). Logic model development is the centerpiece of rebuilding PT, which intends to link investments in projects' inputs with observed or intended direct results or outputs, indirect effects or outcomes, and impacts.

However, PIPA is not very participatory. The workshops are guided by a draft problem tree, previously prepared by a few project designers with the purpose of tackling current problems and related causes and thus clarify the program's logic model (Renger, 2002; Douthwaite et al. 2007). Moreover, only the designers i.e. the actors who imagined the program before it started are usually involved (Douthwaite et al. 2007; Alvarez et al. 2010); thus, diversity in group discussions is not sufficient. We advocate diversity is important for two main reasons (Mathie

and Greene, 1997): (1) to balance power with the different types of stakeholders (researchers, knowledge brokers, beneficiaries), and (2) to take all experiences and views into account. Furthermore, we face the problem that PIPA is not designed for ex-post reconstructing the impact pathway. No template is provided in that respect. Additionally, ex-post reconstructing the pathway story requires participants to remember how events occurred and necessitates doing an exhaustive reflection exercise. However, several crucial elements are not considered by PIPA: (1) stakeholders can have a lack of memories on innovation story components, (2) the available time in workshops is restrained, as stakeholders are usually not willing to participate for a long time, (3) a power game may occur among participants (Mathie and Greene, 1997), which means that the discussions can be dominated by important actors or even influenced merely by their presence, (4) the actor network is not very well studied (scarcity of time in workshops), and (5) causes with little or no link to the research projects are not tackled by PIPA although a PT usually offers this possibility to avoid attributing the whole impact to projects' investments (Rogers et al. 2000).

The PIPA method appears to be the most suitable existing one for evaluating research programs while focusing on the underlying and complex mechanisms along innovation processes.

Part 3: Methodology

Abstract

The objectives of the thesis we mentioned in the general introduction are discussed in more details together with the research questions and hypothesis. We also specify the conceptual and theoretical framework, which is based on the observation that innovations are increasingly complex and on the fact that we focus on the transition to organic farming. In order to better understand the "black box" of the innovation and how research outputs do generate outcomes (changes) and impacts, we take an interactive view and, more importantly, an evolutionary perspective of innovation, considering the latter as a "system". Furthermore, a short description of the two case studies is provided (the French Camargue and Bulgarian case) and the rationale of selecting them specified. The Camargue case is about the transition to organic rice farming systems. It was primarily chosen for the reason that it tackles a radical innovation and also because of the availability of numerous publicly documents on the research program as well as of the presence of a key informant from INRA (National Institute of Agronomic Research). As to the Bulgarian case, it was mainly selected as it deals with a specific radical innovation, i.e. the Ecostop product, which has become one of the most important product against the varroatosis disease in Bulgaria. Finally, the structure of the remaining parts of the thesis is indicated: the three articles (part 4, 5 and 6), the general discussion (part 7), and the general conclusion (part 8).

(Partie 3 : Méthodologie)

(Résumé)

Les objectifs de la thèse que nous avons cités *dans l'introduction générale sont discutés plus* en détails avec les questions de recherche et hypothèses. Nous précisons également le cadre *conceptuel et théorique, qui se base sur l'observation que les innovations sont de plus en plus* complexes et sur le *fait que nous nous focalisons sur la transition à l'agriculture biologique.* Afin de mieux comprendre la « boite noire » *de l'innovation et comment les «* outputs » (éléments tangibles) de la recherche génèrent des « outcomes » (changements) et impacts, nous nous basons sur une vision interactive, et plus important encore, sur une perspective *évolutionniste de l'innovation, considérant cette dernière comme un «* système ». De plus, une *courte description des deux cas d'études est réalisée (la Camargue en Fran*ce et le cas Bulgare), et la raison de leur sélection spécifiée. Le cas de la Camargue concerne la transition *à des systèmes rizicoles biologiques. Il a été principalement choisi car il traite d'une innovation* radicale, mais aussi du fait de la disponibilité de nombreux documents sur le programme de *recherche et de la présence d'un informateur clé de l'INRA* (Institut National de la Recherche Agronomique). Quant au cas Bulgare, les raisons principales de sa sélection reposent sur le caractère radical de *l'innovation considérée, le produit Ecostop, qui est devenu l'un des* produits les plus importants contre la maladie de la varroatose en Bulgarie. Enfin, la structure de la thèse sur les parties restantes de la thèse est indiquée : les trois articles (partie 4, 5 et 6), la discussion générale (partie 7), et la conclusion générale (partie 8).

3.1 Context

This thesis falls into the EU IMPRESA project, which stands for "Impacts of Research on EU agriculture". "The overall aim of IMPRESA is to measure, assess and comprehend the impact of all forms of European SRA (Scientific Research on Agriculture) on key agricultural policy goals, including farm level productivity but also environmental enhancement and the efficiency of agro-food supply chains" (IMPRESA Website, 2017). Furthermore, IMPRESA undertakes "a broad qualitative meta-analysis of the volume and categorization of current research, including recent trends, exploring specific quantitative and qualitative means of assessment of its impact in specific cases, and engaging with relevant interest networks through multiple channels and throughout the project" (IMPRESA Website, 2017). Synergies were therefore generated and helped, under the Work Package 3 (WP3), in developing a qualitative method to assess the impacts and contribution of the research on innovation processes and the society.

In IMPRESA WP3, case studies were conducted to test and refine the developed qualitative method. The rationale of taking a case study approach was to analyze innovations and research programs in-depth by shedding light on the complex process stirring the impact pathway. Six cases were selected with a view to covering a distinct range of agro-climatic, socio-economic and sectoral conditions. I had an important involvement in IMPRESA WP3. Furthermore, many questions and demands of supports were inquired by partners, which was very time consuming but at the same time highly interesting and fruitful.

In this thesis, we analyze two cases that were selected in IMPRESA WP3: the Camargue and Bulgarian case. The Camargue case concerns a process of transition towards organic rice farming systems in the French Camargue (South-East of France). It covers a broad range of technical and managerial innovations (more details in part 3.4). The Bulgarian case is about the development of a technical innovation, the product Ecostop, which has been developed in Bulgaria to combat the varroatosis (pest) in organic beekeeping (more details in part 3.4). We use case studies, which are increasingly popular in the literature to draw lessons. They allow exploring specific situations in a thorough manner (Eisenhardt and Graebner, 2007). The conduct of these case studies is intended to answer the different research questions and to test the hypothesis in relation to the different objectives set.

3.2 Objectives, research questions, and hypothesis of the thesis

The different research questions as well as the hypothesis in relation to the four objectives are specified in TABLE 2. The first and third objectives comprise each two sub-objectives.

Objectives	Sub-objectives	Research questions	Hypothesis	Where?
1) To ex-post assess the impacts of the research program as well as the role and contribution of this research on innovation processes and the society, in relation to the transition to organic farming in the Camargue.	1.1) To develop a qualitative method to ex-post evaluate the impacts and contribution of the agricultural research on innovation processes and the society, in relation to the transition to organic farming. 1.2) To ex-post assess the impacts and contribution of the research program on innovation processes and the society, linked to the transition to organic farming in the Camargue.	a) What are the limits of existing qualitative methods in ex-post evaluating science-based innovation processes in agriculture? b) Can the Participatory Impact Pathway Analysis approach (PIPA) be successfully combined with other methods from social sciences and ex-post analyze well the impacts and contribution of the research on innovation processes and the society, with respect to the transition to organic farming in the Camargue?	a) PIPA can be successfully combined with other methods from social sciences and therefore tell ex-post what the impacts and contribution of the research on innovation processes and the society are, in relation to the transition to organic farming. b) The impacts and contribution of the research in Camargue on the development of innovation processes and related societal impacts, concerning the transition to organic farming, are important. The research is the most important factor in the process.	- Part 4, in the form of an article. - Part 7 (general discussion) in which all main results are summarized and further discussed.
2) To study the interest of performing a Social Network Analysis (SNA) in ex-post evaluating the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming in the Camargue.		(a) Is SNA suitable in validating stakeholders' statements on relationships issues in order to better evaluate ex-post the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic agriculture? (b) Can SNA deepen ex-post the understanding of the impacts and contribution of the research actors on innovation processes and the society, in relation to the transition to organic farming in the Camargue?	(a) SNA is able to ex-post validate stakeholders' statements on relationships by the help of indicators of centrality and of the characterization of the intensities of relationships in the innovation network. (b) SNA can help to understand ex-post how new techniques or products are spreaded and thus to help draw conclusions on the role the research actors have played during the innovation process.	- Part 5, in the form of an article. - Part 7 (general discussion) in which all main results are summarized and further discussed.

Objectives	Sub-objectives	Research questions	Hypothesis	Where?
3) To evaluate the interest of the Actor Network Theory (ANT), used as theoretical framework, in orienting evaluative questions for assessing ex-post the impacts and contribution of the research on innovation processes linked to the transition to organic farming.	3.1) To evaluate what brings ANT, used as theoretical framework, in orienting evaluating research questions for understanding ex-post negotiation processes among researchers and the other types of actors during the transition pathway to organic farming in the Camargue and in Bulgaria. 3.2) To assess what brings ANT, used as theoretical framework, in orienting evaluative questions for assessing ex-post the contribution of the research in that pathway towards the conversion to organic farming in the Camargue and in Bulgaria.	a) Can ANT deepen ex-post the understanding of the impacts and contribution of the research actors and "boundary objects" during innovation processes associated with the transition to organic farming in the Camargue and in Bulgaria? b) Can ANT reinforce the methodological developments arising from the completeness of the first and second objective of this thesis?	a) ANT allows deepening ex-post the understanding of and role of interpersonal relationships between actors in innovation networks associated with the transition to organic farming in Camargue and in Bulgaria. b) ANT reinforces the approach for evaluating the impacts and contribution of the research on innovation processes linked to the transition to organic farming, through the identification of additional specific milestones.	- Part 6, in the form of an article. - Part 7 (general discussion) in which all main results are summarized and further discussed.
4) To question the global relevance and contribution of the different methodological developments (resulting from the objectives 1, 2, and 3) in understanding ex-post the impacts and contribution of the research on innovation processes and the society, with respect to the transition to organic agriculture.		a) Are social sciences able to identify the impacts and contribution of the research on innovation processes and the society, concerning the transition to organic farming? (b) Can social sciences deepen the understanding, ex-post, of innovation processes for the transition to organic farming as well as the role played by the research in such processes?	a) The methodological developments shed light on the complex process by which outcomes and impacts are generated and therefore reduce the size of the "black box" of innovation processes linked to the transition to organic farming. (b) Social sciences have weaknesses in identifying the exact contribution of the research in achieving outcomes and impacts during innovation processes linked to the transition to organic farming.	- Part 7 (general discussion) in which all main results are summarized and further discussed.

TABLE 2: OBJECTIVES, RESEARCH QUESTIONS, AND HYPOTHESIS

3.2.1 First objective (in article)

The first objective is primary to develop a qualitative method for ex-post evaluating the impacts and contribution of agricultural research on innovation processes and the society, in relation to the transition to organic farming, while uncovering the different mechanisms that lead to these impacts. In a second step, the impacts and contribution of the research on innovation processes and the society, linked to the transition to organic farming in the Camargue territory, are evaluated.

Although qualitative methods for evaluating research impacts are available in the literature they are not well suited for ex-post assessment, nor do sufficiently studying the complex mechanisms along innovation processes and identifying the contribution of the research (see part 4). We develop a methods-mix, revolving around the Participatory Impact Pathway Analysis (PIPA). This method is tested in the Camargue case study that focuses on the transition to organic rice farming from 1999 to 2014. Our first hypothesis is that PIPA can be successfully combined with other methods from social sciences and thus identify ex-post the impacts and contribution of the research on innovation processes and the society, concerning the transition to organic farming. A second hypothesis is that the impacts and contribution of the research on innovation processes and the society, regarding the transition to organic farming in the Camargue, are important. The rationale is that the research program launched by INRA (National Institute of Agronomic research) in 1999 has a clear and ambitious focus on organic rice farming systems and comprised a set of several projects from 1999 to 2014 in investigating crucial issues on that topic. Also, the research program has been driving by a very motivated and skilled researcher from INRA, and also in close contacts with a few farmers from Camargue and important local organizations like the Rice Farmers Union.

This objective is addressed in the form of an article in part 4. This article is entitled "Ex-post evaluation of the impacts of the Science-Based Research and Innovation Program: A new *method applied in the case of farmers' transition to organic production in the Camargue*".

3.2.2 Second objective (in article)

The objective is to study the relevance of undertaking a Social Network Analysis (SNA) in ex-post evaluating the impacts and contribution of the research on innovation processes and the society, concerning the transition to organic farming in the Camargue. Particularly, it will be

explored whether SNA can validate stakeholders' statements on relationships issues in order to better evaluate ex-post the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming. The rationale of this is that participatory approaches, including the PIPA approach, are faced with limitations calling into question their scientific robustness (see part 5 and 7). By extension, it will be evaluated whether SNA can deepen ex-post the understanding of the impacts and contribution of the research actors on innovation processes and related societal impacts, in relation to the transition to organic farming in the Camargue.

We make the hypothesis that SNA allows validating ex-post stakeholders' statements by the help of indicators of centrality and intensity of relationships between actors in the innovation network. We also hypothesize that SNA permits a deepening ex-post of the understanding of the role played by the different research actors in the innovation process.

This objective is addressed in the form of an article in part 5. This article is entitled "Using Social Network Analysis to evaluate the Impact of the Research: On the transition to organic farming in the Camargue".

3.2.3 Third objective (in article)

The objective is first to evaluate the interest of the Actor Network Theory (ANT), used as theoretical framework, in orienting evaluative questions for understanding ex-post negotiation processes among researchers and the other types of actors during the transition pathway to organic farming in the Camargue and in Bulgaria. We also evaluate what brings ANT in orienting evaluative questions for assessing ex-post the contribution of the research in that transition pathway towards organic farming in the Camargue and in Bulgaria.

Our first hypothesis is that ANT is able to deepen ex-post the understanding on the role of interpersonal relationships between actors within innovation networks linked to the transition to organic farming in Camargue and in Bulgaria. We also hypothesize that ANT allows reinforcing the methodological developments, addressed by the first two objectives, to evaluating the impacts and contribution of the research on innovation processes and the society, regarding the transition to organic farming.

This objective is addressed in the form of an article in part 6. This article is entitled "Role of the research in the transition to organic farming using the Actor Network Theory".

3.2.4 Fourth objective (in a general discussion part)

The objective is to question the global relevance and contribution of the different methodological developments (resulting from the objectives 1, 2, and 3) in understanding ex-post the impacts and contribution of the research on innovation processes and the society, with respect to the transition to organic agriculture.

A step back is taken on the usefulness of the different methodological developments made, in enlightening ex-post the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming in the Camargue. It is also questioned in what the different methodological developments made in the three articles inform us on the transition process towards organic farming in terms of the diverse drivers on stake.

We hypothesize that the methodological developments proposed in this thesis to evaluate the impacts and contribution of the research on innovation processes and the society, regarding the transition to organic farming, allow highlighting the complex process by which outcomes and impacts are generated and thus to reduce the size of the "black box" of such innovation processes. We also make the hypothesis that social sciences have weaknesses in identifying the exact contribution of the research in achieving outcomes and impacts during innovation processes linked to the transition to organic farming. The rationale of this is linked to the high and increasing complexity of innovation processes, as it was recalled in part 2 (state of the art). Innovation processes imply involving several factors and complex dynamics.

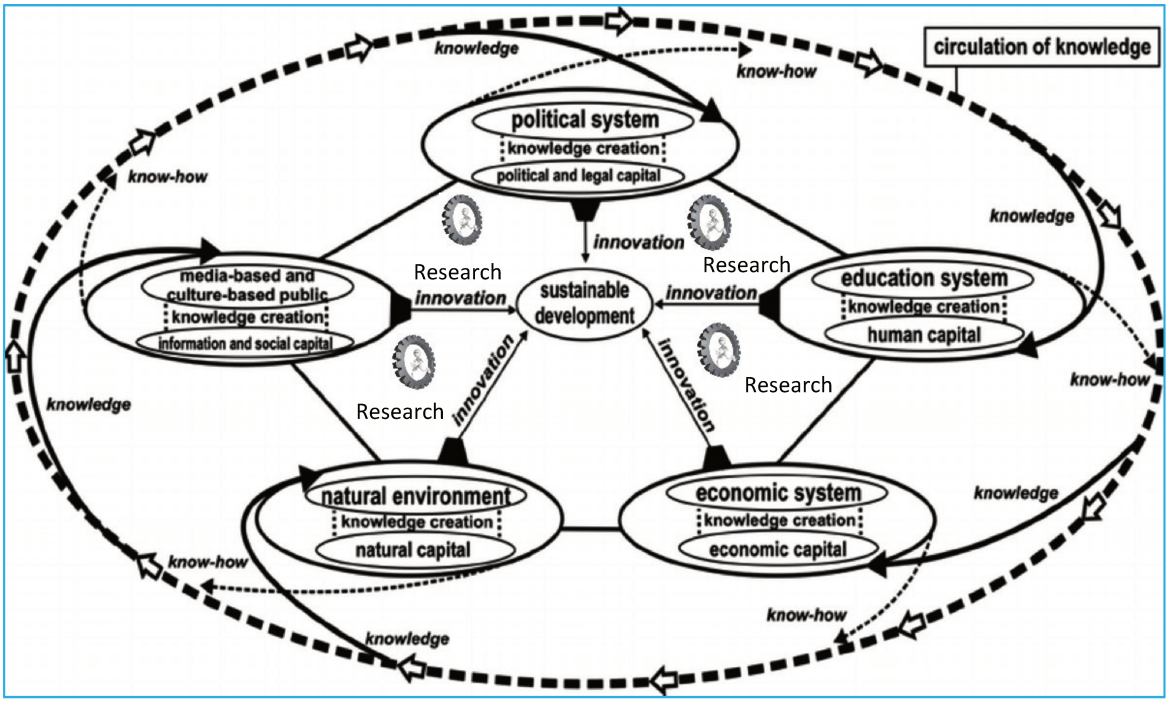
This objective is addressed in the form of a general discussion part (part 7). This part is called "General discussion and lessons learned".

3.3 Theoretical and conceptual framework

It was recalled in the part on the state of the art that innovations are increasingly complex. They rely on several aspects such as interactive knowledge, actors' behaviors, and the economic and institutional environment. This increasing complexity implies that changes are less and less attributable to research. In other words, there is an increasing attribution gap between research on the one hand and social, economic, and environmental changes on the other (Springer-Heinze et al. 2003). In order to better understand the "black box" of the innovation and how research outputs do generate outcomes and impacts, we take an interactive view and, more importantly, an evolutionary perspective to innovation, considering the latter as a "system". This perspective is also considered given the relatively complex nature of the agricultural sector compared to others. That is because the development and adoption of agricultural innovations rely not only on research outputs but also on numerous and further other aspects like interactive knowledge (farmers have usually not the capacity to make research on their own), trust (limited number of advisers and extension services), risk aversion (dependence on meteorological conditions, etc.), system of values, and so on.

Quintuple Helix Model

The quintuple Helix Model represents a cooperation and knowledge system composed of social interactions and highlighting the role of the know-how in developing innovations for a sustainable development. "The Quintuple Helix Model is interdisciplinary and transdisciplinary at the same time: the complexity of the five-helix structure implies that a full analytical understanding of all helices requires the continuous involvement of the whole disciplinary spectrum, ranging from the natural sciences (because of the natural environment) to the social sciences and humanities (because of society, democracy and the economy)" (Carayannis and Campbell, 2010, p30). In the adapted FIGURE 2, the research interacts with all the different helices (political system, education system, economic system, natural environment as well as media-based and culture-based public). For the purpose of this thesis, we consider explicitly all public and private research as part of the global system and not only from the education system. Still, in the adapted FIGURE 2, the research contributes into developing innovation processes and in enhancing agricultural sustainability.



Source: Adapted from Carayannis and Campbell (2010).

FIGURE 2: QUINTUPLE HELIX MODEL AND ROLE OF THE KNOWLEDGE & RESEARCH FOR SUSTAINABLE INNOVATIONS

The above adapted quintuple Helix Model highlights the role of the know-how in developing innovations for sustainable goals. However, this theoretical framework needs to be operationalized to tackle the problematic of this thesis, i.e. to be able to ex-post evaluate the impacts and contribution of the research on innovation processes and the society, regarding the transition to organic farming in the Camargue (France) and in Bulgaria. To do so, we make use of the so-called "theory of change". A theory of change is a conceptual model linking the activities, all changes, and the context of the initiative (Connell and Kubisch, 1998).

Theory of change

To tackle the problematic, we first refer to the Impact Pathway Analysis (IPA), Theory-Driven, which seeks to make explicit the theory of change of a R&D program and that investigates the mechanisms along the pathway in order to evaluate the impacts of the investigated program.

The rationale for focusing on impact pathways was recently motivated by Douthwaite et al (2003) and Springer-Heinze et al (2003) by a criticism of the mainstream monitoring and evaluation tools that prevail for project management: the logical framework, where the underlying causal model is relatively straightforward (inputs → activities → outputs → outcomes → impacts). IPA is interesting for understanding the way research programs generate,

in an interactive way, outputs (first and tangible results), outcomes (changes related to adoption) and impacts (long-term effects of the research). IPA recognizes the occurrence of possible feedback loops as well as the dynamic role of the actor network along the impact pathway.

IPA is inspired from the theory of change or Program-Theory (PT). In general, this approach is used ex-ante, i.e. before the research program is implemented, in order to develop a causal model summarizing the way the innovation pathway is intended to or should occur. This causal model can be constructed by the researcher who is in charge of conducting the evaluation; or in a participatory way, i.e. together with the different actors who have been involved in the research program. These actors, also referred as stakeholders, can be funders, researchers, institutions either public or private, extension services, and beneficiaries (e.g. farmers).

A participatory approach is followed with a view to get stakeholders more involved and active in the evaluation process as well as making results more helpful for future use. The Participatory Impact Pathway Analysis (PIPA) (Douthwaite et al. 2007), which is similar to IPA, fits with this thinking and will form the basis of our approach (further details in part 4).

Furthermore, the Outcome Harvesting[7] (OH) is seen as a method of interest (further details in part 4) in that it provides a framework for ex-post reconstructing the innovation pathway. It suggests to reconstruct it backwards, i.e. in identifying outcomes before going further back to outputs and activities. Also, it suggests not only getting information from stakeholders' workshops (as PIPA) but also in the course of semi-structured interviews or based on the project's documentation.

Complementary approaches are used (developed in-depth in the next parts): the process tracing, the counterfactual approach, and the Social Network Analysis (SNA) and Actor Network Theory (ANT). The process tracing approach has the interest of both triangulating and valuing the information collected by evaluating whether the diverse components of the hypothesized links (e.g. event "A" leading to event "B") was actually present. The counterfactual approach seems interesting to eliminate inaccurate pathway links. Finally, the network is studied in-depth to better understand the role played by actors over time during innovation processes linked to the transition to organic farming.

[7] The Outcome Harvesting approach has been developed by Wilson, Grau and Britt (2002) in order to overcome the limitations of the « Outcome Mapping » (Earl et al, 2001) for ex-post evaluating programs.

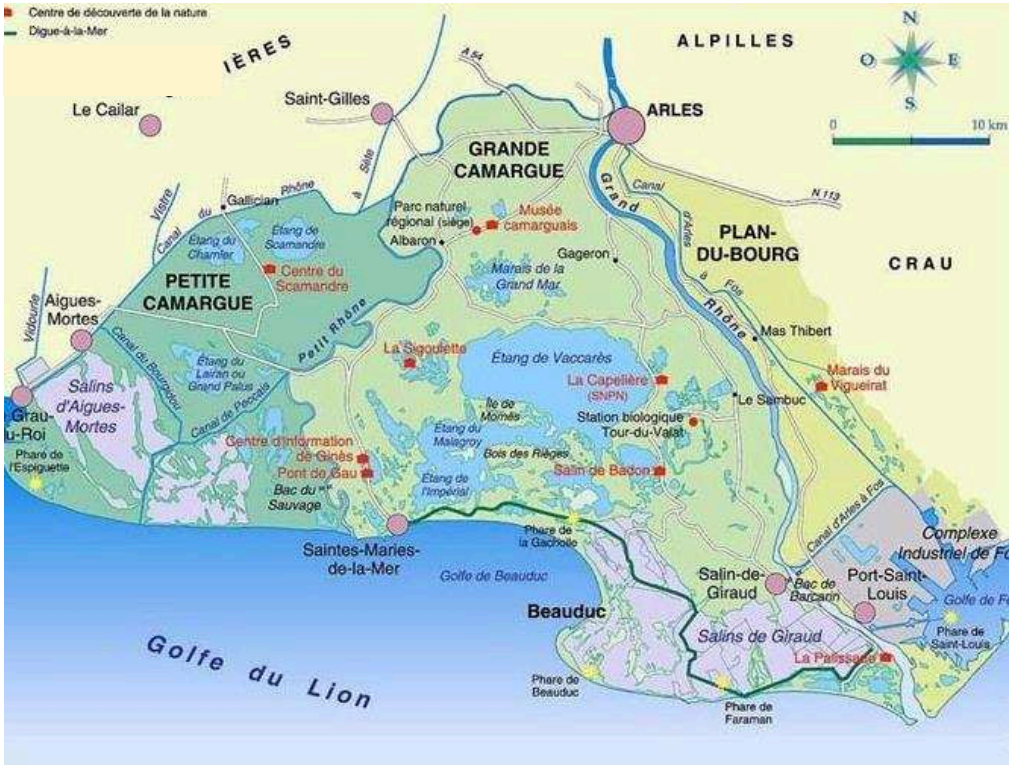
3.4 Case studies and data collection

As this thesis falls into the EU IMPRESA project, we should first emphasize how the case studies were selected in that project. Six case studies were selected in five different countries in order to provide scope for detailed and in-depth comparison. They cover a wide range of agro-climatic, socio-economic and sectoral conditions. To achieve this diversity, each team produced an initial shortlist of three cases. These proposed cases were tabulated for their different characteristics (agricultural sector, geographical level, type of innovation and research program, advantages and disadvantages) for review and discussion. In addition to variations across the final set, other considerations included the availability of data, the length of the innovation cycle, and the scope for collaborating with stakeholders from the case studies (at territory, regional or country level). The case studies selected are as follows: the dairy sector in the United Kingdom (fertility index), crop production in Germany (precision farming), sustainable olive production and on-farm biogas in Italy, organic production in the Camargue in France, and organic beekeeping in Bulgaria.

For the purpose of this thesis, we selected two case studies focusing on the transition to organic farming, that is, the Camargue case concerning the conversion to organic of a whole crop production system with rice as main crop; and the Bulgarian case on the development of the Ecostop product to protect bees against the varroatosis disease in an organic way. The Camargue case is the main one utilized in this thesis, while the Bulgarian case is essentially used for comparison and differentiation of results in the third paper (part 6) and questions the interest of ANT in evaluating the impacts and contribution of the research.

3.4.1 The Camargue case study

The Camargue territory is located in the south east of France and extending to 145,300 ha. In the frame of this thesis, we mainly focus on rice production for three key reasons: (1) rice is the main crop production in the Camargue, (2) cultivation of rice significantly contributes to the pollution of the Rhône River, and (3) rice helps to diminish the rate of salt (paddy fields are flooded) in the soil and thus allows crop productions to develop in the territory.



Source: reflectim.fr.

FIGURE 3 : OVERVIEW OF THE CAMARGUE TERRITORY IN FRANCE

Organic rice production has increased in the 1980s through the initiative of pioneer producers. In 2014, it accounted for 10% of the total rice farming area and for 16% of the rice producers in Camargue (35 out of total of 215). The main rice trader is the SARL Thomas, which processes around 5000t of organic rice per annum. We must also emphasize the creation of the firm BIOSUD in 2003, which is specialized in marketing organic rice coming from both the cooperative SudCéréales and the trader SARL Thomas. This company was created with a view to improving the organization and thus the performance of the Camargue organic value chain.

In the year 2000, a research program made for organic rice production was launched by the French National Institute of Agronomic Research (INRA) together with boundary partners

(CIRAD, CFR, FranceAgriMer), in order to develop new technics for organic production and increase the share of organic farming in the Camargue territory.

Rationale of selecting this case study

The Camargue case study was selected since it shows a typical situation where agriculture and natural areas have to coexist. The question of achieving environmentally sustainable innovations is tackled by the IAASTD (International Assessment of Agricultural Knowledge and Technology for Development). In particular the importance of developing innovative technologies is advocated to answer specific consumers' wishes, including environmental concerns, within the context of more globalized and complex agro-food systems (IAASTD, 2009). The Camargue territory is subject to protective measures aiming at preserving the flora and fauna. Furthermore, the cumulative effect of the severe winds (the Mistral), the insolation and the temperature causes a strong evaporation, leading to salinity from the groundwater, which in turn sterilizes agricultural lands (Chataigner, 1997). The cultivation of rice is therefore very important in that it allows this phenomenon to be reduced: the flooding of the paddy fields reduces the salinity, but rice production in the Camargue has to be undertaken with sensitivity due to environmental issues in the territory (e.g. pollution of the Rhône).

Furthermore, this case concerns a radical innovation towards better sustainability, which requires significant supports from the whole AKIS (Agricultural Knowledge and Innovation System). In fact, AKIS is intended to promote radical innovations contrary to the former AKS (Agricultural Knowledge system) which did not recognize the role of complex interactive relationships nor intend to support sweeping changes (EU SCAR, 2012). Furthermore, it was demonstrated that LINSA[8], representing a "network of producers, customers, experts, NGOs, SMEs, local administrations and components of the formal Agricultural knowledge System [(AKS)]", can actually facilitate the achievement of sustainable agricultural goals (Moschitz et al. 2015).

Still, the specific subject of the conversion to organic farming was considered because it represents a paradigm shift (Wynen, 1996; Pretty, 1997; Edwards, 2005), which typically implies developing various innovations including different technical advancements. Consequently, the role of AKIS appears to be even more important to reflect, especially as technical agricultural innovations are faced with numerous potential barriers (Kouplevatskaya-

[8] LINSA stands for "Learning and Innovation Network for Sustainable Agriculture".

Buttoud et al. 2011; Long et al. 2015) that the actor network system may prevent of limit. An example of barriers is the strong presence of routines (Argyris, 1993; Faber and Hoppe, 2013). The actor network may play a positive role through the presence of knowledge brokers (Klerkx et al. 2009b), cluster organizations (Omta and Fortuin, 2013), collective actions e.g. to foster leadership capacity (Devaux et al. 2009), and so on.

Data collection

Interviews/workshops	Purpose
In-depth interviews with respondents from INRA, CFR, Natural Park of Camargue, private traders (the SARL Thomas, the Comptoir Agricole du Languedoc and Biocamargue) and 15 farmers (4 organic, 7 partially-organic, and 4 conventional).	Identification of general enabling and disabling factors on the impact pathway.
	To collect data for the Social Network Analysis (SNA) (conventional farmers were not interviewed).
A group discussion was organized (11 persons attended).	To undertake a review concerning general factors that positively or negatively influenced farmers' transition to organic rice production.
We organized one workshop (20 persons attended).	To reconstruct the theory of change of the program and to draw the related impact pathway.
In depth interviews with 12 organic farmers and 1 researcher from INRA.	To further understand the pathway links for which the necessary conditions (including the identification of a relevant underlying mechanism) were not satisfied.
	To ask counterfactual questions.
	To estimate the importance of the validated pathway routes output-outcome, outcome-outcome, external factor-outcome, and activity 6 (experimentations made by farmers) – outcome.
	To measure impact pathway indicators.
Final feedback-round with stakeholders (9 persons attended).	To present findings, secure the agreement from stakeholders and acknowledge their contribution to the study.

TABLE 3: DATA COLLECTION IN THE CAMARGUE CASE STUDY

3.4.2 The Bulgarian case-study

The Bulgarian case study focuses on the development of the Ecostop product in Bulgaria (country level). Ecostop is an organic product that aims at treating bees against the varroatosis disease. Numerous products have been developed since the year 1973 where the disease was officially recognized. But they appeared to be ineffective a couple of years after their first use. In fact, the regular use of the same products made them non-operational due to the appearance of resistance. Ecostop was developed in the company Primavet that was created in 1994. The product was developed between 1998 and 2006 and was available on the market in 2007.

Ecostop is made of natural substances contrary to the vast majority of the medicines presently commercialized. In the year 2014, the product Ecostop was already adopted by around 20 to 25% of the population of beekeepers in Bulgaria.

Source: Primavet.com.

FIGURE 4: ECOSTOP PLATES

Rationale of selecting this case study

The Bulgarian case is only used in the third article of this thesis (part 6). This case was mainly chosen as it deals with a specific radical innovation, i.e. the Ecostop product, which has become one of the most important product against the varroatosis disease in Bulgaria. Also, the Ecostop product represents an important medicine, allowing the transition from the use of chemical products to organic ones. This is all the more important in that chemical molecules develop resistance to the varroa mite. Still, the development of the innovation (the product Ecostop) was funded privately contrary to the Camargue case, and key researchers were available and willing to share information with the evaluators. It was also selected because it presents a different network configuration, as well as a different context from the Camargue case study. The French case is characterized by a relatively complex actor network (more details in part 5 and 6). The Bulgarian case seems of less complexity at first glance i.e. with fewer challenges in terms of cooperation building and conflicts.

Data collection

Interviews/workshops	Purpose
Key stakeholders interviewed (4 interviews): researchers and first organic beekeepers in the country (Bulgaria).	Initial screening. Identification of general enabling and disabling factors on the impact pathway.
Key stakeholders involved in a first workshop (10 attendants): researchers, beekeepers, representatives of organic beekeeping associations.	Initial in-depth discussions on the innovation pathway.
	To undertake a review concerning general factors that positively or negatively influenced farmers' transition to organic.
Semi-structured interviews with beekeepers, researchers, owners of veterinarian pharmacies or agro-drug stores (10 interviews).	Further in-depth discussions on the innovation pathway. To clarify questions arising from the analysis of the discussions in focus group.
	To reconstruct the theory of change of the program.
Survey with beekeepers (116 structured interviews).	Further in-depth discussions on the innovation pathway.
Final feedback-round with stakeholders (20 attendants).	To present findings, secure the agreement from stakeholders and acknowledge their contribution to the study.

TABLE 4: DATA COLLECTION IN THE BULGARIAN CASE STUDY

3.5 Structure

The following parts are constructed by the form of three scientific articles (part 4, 5 and 6), complemented by a general discussion and conclusion (part 7 & 8). FIGURE 5 thereafter shows the different steps accomplished and the way they are interrelated with each other. The articles respectively address the first, second and third objective of the thesis (see section 3.2). A short transition is made between each article and before the general discussion part (part 7).

The first article (part 4) endeavors to develop and presents a mixed-qualitative method to assess the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming. The method developed is presented through the example of the Camargue case study. The impacts and contribution of the research on innovation processes and the society, with respect to the transition to organic farming in the Camargue case, are also evaluated. This article is entitled "Ex-post evaluation of the impacts of the Science-Based Research and Innovation Program: A new method applied in the case of *farmers'* transition to organic production in the Camargue" and was published in the "Journal of Innovation Economics and Management" in January 2017.

The second and third article articles (respectively in part 5 and 6) are more specific, addressing respectively the interest of SNA and ANT in assessing ex-post the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming. The second article is called "Using Social Network Analysis to evaluate the Impact of the Research: On the transition to organic farming in the Camargue" and has been submitted in "Cahier *d'*agriculture" in April 2017. As to the third article, it is named "Role of the research in the transition to organic farming using the Actor Network Theory" and has been submitted in the journal "Economics of Innovation and New Technology" in October 2017.

The general discussion part (part 7) will then question the global relevance and contribution of the different methodological developments (resulting from the objectives 1, 2, and 3) in understanding ex-post the impacts and contribution of the research on innovation processes and the society, with respect to the transition to organic agriculture. We then give specific recommendations to researchers and policy makers for evaluating and for increasing the impacts of the agricultural research on innovation processes and the society, concerning the transition to organic farming. Finally, we will draw the general conclusions of the thesis (part 8).

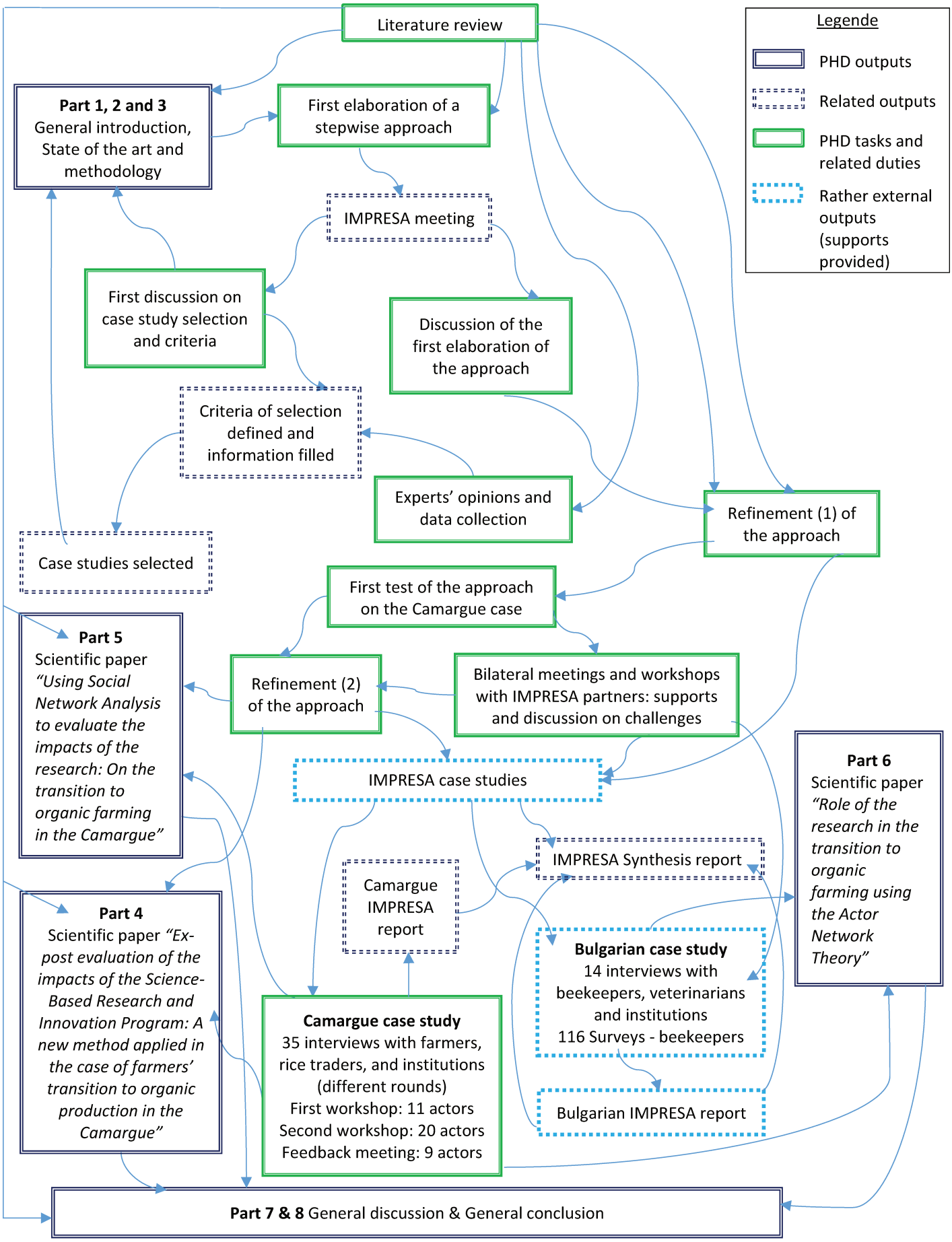


FIGURE 5: STRUCTURE AND DIFFERENT STEPS COMPLETED

Part 4 - Article: Ex-post evaluation of the impacts of the Science-Based Research and Innovation Program: A new method applied in the case of farmers' transition to organic production in the Camargue

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Article published in the "Journal of Innovation Economics and Management" in January 2017

Abstract

This paper aims to assess the contribution, role, and impacts of the Science-Based Research and Innovation Program (ISRIP) on farmers' transition to organic production in the Camargue. Focusing on how, and to what extent, the research actors have contributed to the innovation pathway, we applied a methods-mix. The Participatory Impact Pathway Analysis (PIPA) was used to uncover complex mechanisms in the innovation process; the Outcome Harvesting method to adapt PIPA to the requirements of an ex-post evaluation; and the Social Network Analysis (SNA) to emphasize actors' relationships in relation to the development process. We demonstrate that the research has contributed to change by developing co-learning interactions with farmers, although this was not critical to the success of the innovation. Rather, we highlight the fact that agricultural policies, economic factors, testing conducted independently by farmers, and the institutional framework, are the most important and influential factors.

Key words – Evaluation; Science-based research; Program theory; Innovation process; Ex-post Participatory Impact Pathway Analysis; Camargue rice systems.

(Partie 4 - Article : Evaluation ex-post des impacts de la recherche scientifique et programmes d'innovations liés : Une nouvelle méthode appliquée dans le cas de la transition à l'agriculture biologique en Camargue)

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Article publiée dans le "Journal of Innovation Economics and Management" en Janvier 2017

(Résumé)

Cet article *a pour objectif d'évaluer la* contribution, le rôle et les impacts de la recherche *scientifique et programmes d'*innovations liés (ISRIP) par rapport à la transition vers *l'agriculture biologique en Camargue.* Nous avons appliqué une méthode mixte en se focalisant sur la manière dont *les acteurs de la recherche ont contribué au chemin de l'innovation* et dans quelle mesure. Une a*nalyse participative du chemin de l'impact* (PIPA) a été réalisée afin de faire la lumière sur les mécanismes complexes dans le processus *d'innovation ;* la méthode *"Outcome Harvesting"* pour adapter PIPA aux conditions *d'une* évaluation ex-post, et *l'analyse de*s réseaux sociaux (SNA) *pour mettre en avant les relations d'a*cteurs en parallèle du processus de développent. Nous démontrons que la recherche a contribué au changement *par le développement d'interactions* de co-apprentissage avec les producteurs, bien que ceci *n'ait* pas été décisif *pour le succès de l'innovation.* Nous soulignons plutôt le fait que les politiques agricoles, les facteurs économiques, les essais conduits de manière indépendantes pas les agriculteurs, et le cadre institutionnel, sont les facteurs les plus importants et influents.

Mots clés – Evaluation ; Recherche scientifique ; Théorie du programme ; Processus *d'innovation ;* Analyse Ex-post et participative *du chemin de l'impact ;* Systèmes rizicoles camarguais.

Transition words: From the first to the second article

In the first article a mixed qualitative method was developed to evaluate the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming. The impacts of the research as such in the Camargue were also evaluated.

The Participatory Impact Pathway Analysis (PIPA) was identified as the most relevant existing method to assess the impacts and contribution of the research. However, we also identified shortcomings with respect to this approach, especially in relation to its participatory nature. As it was said, a participatory approach can help to enhance impacts of the research by mobilizing actors and intermediate changes, however there is a debate in the scientific community on whether the use of participatory instruments for evaluation is scientifically robust or not. To overcome limitations of this participatory approach we complemented it with other methods, tools and instruments, e.g. the process tracing and the use of counterfactual questions, and the Social Network Analysis (SNA). The interest of SNA in exploring and validating stakeholders' statements was examined to a very little extent. Furthermore, the contribution of SNA in informing the influence of the different research activities on the structure of the actor network and in turn on the adoption process and generation of impacts has not yet been discussed. Lastly but not least, the relevance of SNA in telling what the most important actors are, and their influence on the network during the innovation process, should be further discussed.

We therefore identified the need to reexamine the interest of using SNA, in a second article. Our goal is to reassess the capacity of SNA to validate impact pathway links on actors' relationships issues and to better understand the impacts and contribution of the different research actors over time on innovation processes linked to the transition to organic farming in Camargue. Still, SNA is quite a comprehensive approach by itself; its characteristics, rationale and usefulness, could not be explored and discussed in-depth in the first article. Moreover, the second article offers the possibility to show how the table of links, which classify all the information collected on the different pathway links, is used in practice (here by focusing only on links describing actors' relationships).

(Mots de transition : Du premier au deuxième article)

Une méthode qualitative mixte a été développée dans le premier article pour évaluer les impacts et la contribution de la recherche *sur les processus d'innovation*s et la société, en rapport *avec la transition à l'agriculture biologique.* Les impacts de la recherche en tant que tels, en Camargue, ont aussi été évalués.

L'analyse participative du chemin de l'impact (PIPA) a été identifiée comme la méthode la plus pertinente pour évaluer les impacts et la contribution de la recherche. Cependant, nous avons identifié des limites par rapport à cette approche, en particulier vis à vis de sa nature participative. Comme il a été dit, une approche participative peut aider à améliorer les impacts de la recherche en mobilisant les acteurs et changements intermédiaires, cependant il y a un débat dans la communauté scientifique quant à la robustesse ou non, *scientifiquement parlant, de l'utilisation d'*instruments *participatifs pour l'évaluation.* Afin de dépasser les limites de cette approche participative, elle a été complétée *par d'autres* méthodes, outils et instruments comme le « process tracing », *l'utilisation de questions contrefactuelles, et l'analyse du réseau social* (SNA). L*'intérêt de l'analyse* du réseau social, *pour étudier et valider les dires d'acteurs*, *n'a été explor*é que dans une mesure très limitée. De plus, la contribution de SNA *pour renseigner sur l'influence des différentes activités de recherche sur la structure du réseau d'acteur*s, *et par extension sur le processus d'adoption* et la génération *d'impacts, n'a pas* encore été évoquée. Dernier point, mais non moins important, la capacité de SNA à informer quels sont les acteurs les plus importants et leur influence sur le réseau au cours du processus *d'innovation*, devrait être davantage discutée. Nous avons donc identifié le besoin de réexaminer *l'intérêt de faire une analyse du réseau social, dans le cadre d'un second article. Notre but est de réévaluer la capacité de SNA* à *valider les liens du chemin de l'impact sur les relations d'acteurs,* et de mieux comprendre les impacts et la contribution des différents acteurs de la recherche au cours du temps. Aussi SNA est une approche globale en elle-même ; ses caractéristiques, son intérêt, et son utilité ne pouvaient être explorés et discutés en profondeur dans le cadre du premier article. Par ailleurs, le deuxième article offre la possibilité de montrer comment la table des liens, qui classifie toutes les informations collectées, est utilisée en pratique (ici on se focalise uniquement sur les liens décrivant les relations entre acteurs).

Part 5 - Article: Using Social Network Analysis to evaluate the Impact of the Research: On the transition to organic farming in the Camargue

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Abstract

This paper evaluates the relevance of undertaking a Social Network Analysis (SNA) in deepening the understanding on the network of actors and the role it plays during the innovation process. Most importantly is the analysis of stakeholders' views, taking as example the Camargue case study (in France) tackling the transition to organic farming. The method SNA, whose we evaluate the interest, is part of a set of methods that form a comprehensive participatory approach that was developed to evaluate ex-post the impacts of the research based innovation in the frame of the European research project IMPRESA. The analysis particularly confirms the growing role played by INRA (National Research Agronomic Institute) over time within the actor network and its contribution to the transition towards organic agriculture. The study also corroborates the importance of the institutionalization of the supply chain, which happened in 2003. SNA is able to validate stakeholders' views with respect to actors' relationships and their implications on the transition to organic farming. SNA could be used more broadly in evaluating research impacts for all types of innovations, especially when participatory procedures are mobilized.

KEY WORDS – Ex-post impact assessment; Innovation; Research networks; Information flow; Rice

(Partie 5 - Article : L'analyse des Réseaux Sociaux pour évaluer les Impacts de la Recherche : Sur la transition à l'agriculture biologique en Camargue)

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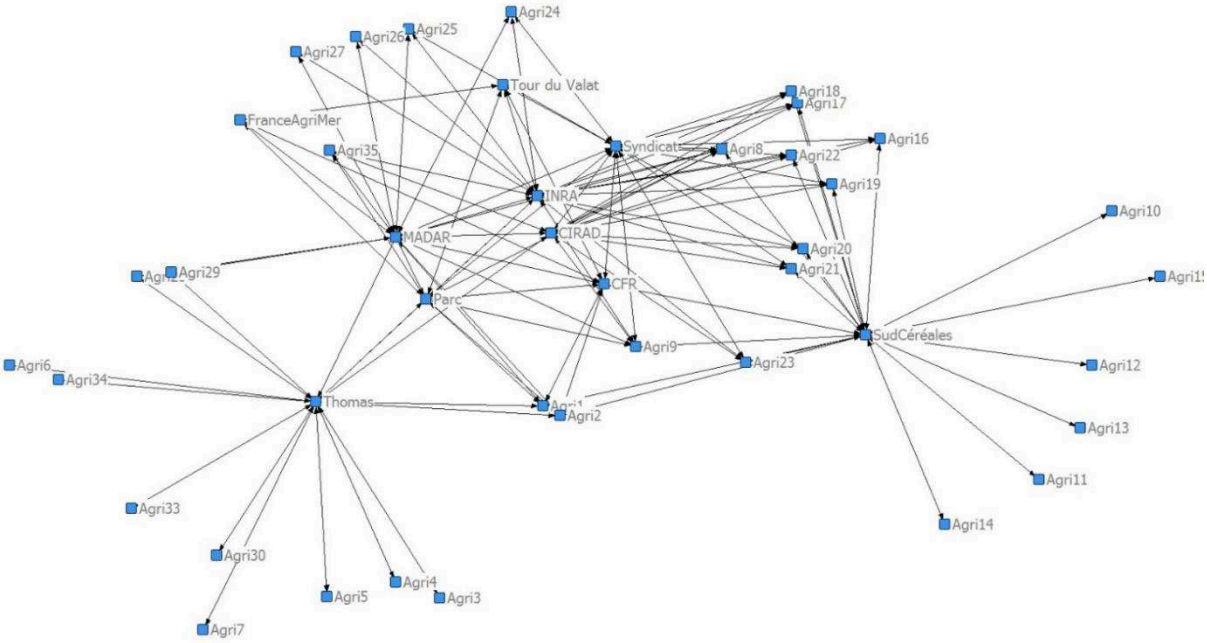
Article soumis dans « *Cahier d'agriculture* » en Avril 2017

(Résumé)

Cet article évalue la pertinence de réaliser une analyse du réseau social (SNA) afin *d'approfondir la compréhension du réseau d'acteurs et du rôle qu'il joue au cours du processus d'innovation. Le plus important est l'analyse de l'opinion des parties prenantes, en prenant comme exemple le cas d'étude de la Camargue (en France) traitant* de la transition à *l'agriculture biologique. La méthode* SNA*, dont nous évaluons l'intérêt, fait partie d'un* ensemble de méthodes formant une approche participative globale laquelle a été développée pour évaluer ex-post les impacts de la recherche axée sur *l'innovation dans le cadre du* projet de recherche E*uropéen IMPRESA. L'analyse confirme en particulier le rôle croissant joué par l'INRA (Institut National de la Recherche Agronomique) au cours du temps au sein du réseau d'acteur et sa contribution à la transition vers l'agriculture biologique. L'étude corrobore également l'importance de l'institutionnalisation de la chaine d'approvisionnement, qui s'est* réalisée en 2003. SNA est à même de valider les opinions des parties prenantes par rapport aux relation*s d'acteurs et leurs implications sur la transition à l'agriculture biologique.* SNA pourrait être utilisée plus largement pour évaluer les impacts de la recherche de tous types *d'innovations, particulièrement lorsque des procédures participatives sont mobi*lisées.

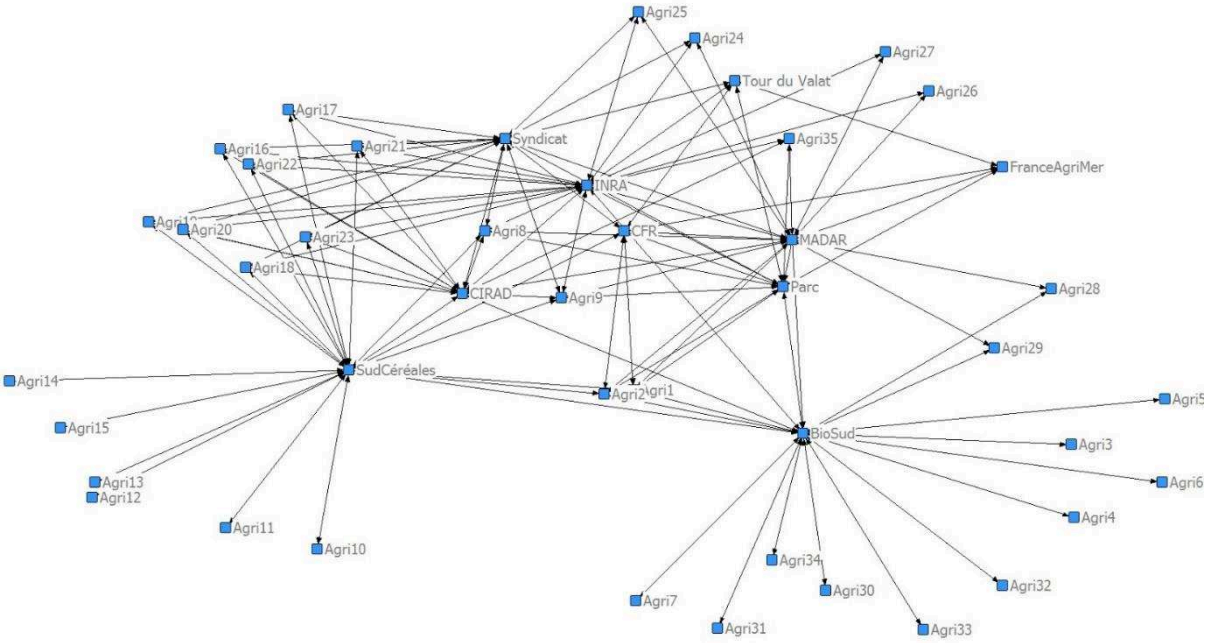
MOTS CLES – *Evaluation de l'impact ex*-post ; Innovation ; Réseau de recherche ; Flux *d'information* ; Riz

5.8.2 Maps of actors



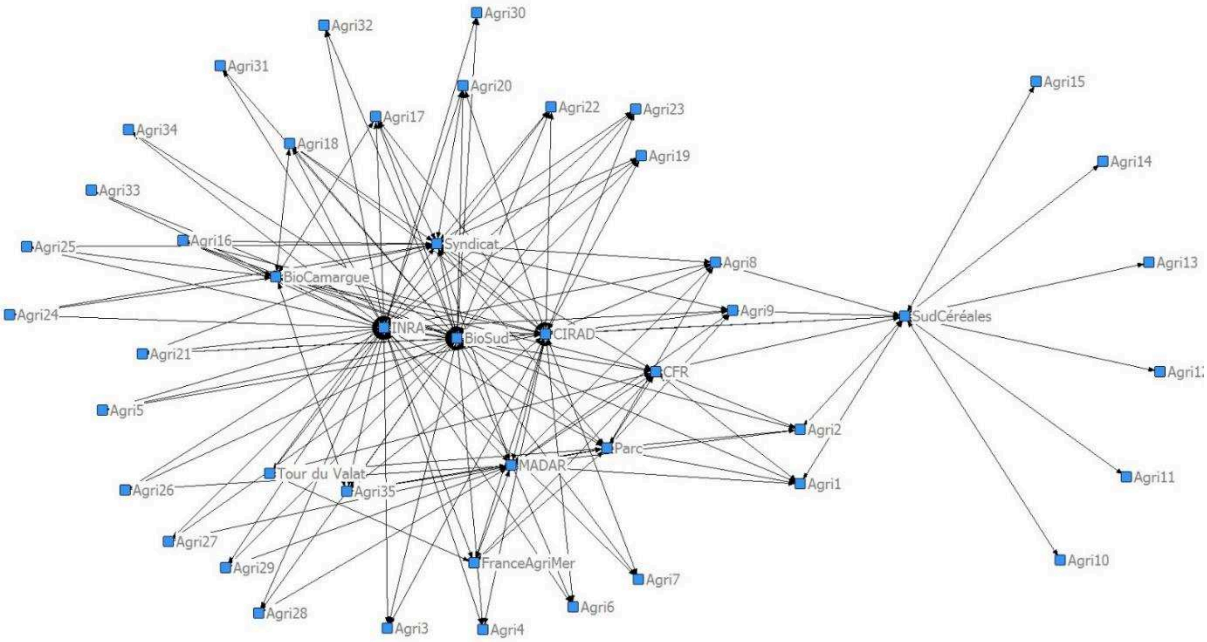
NB: "Agri" means "farmer".

FIGURE 7: MAP OF ACTORS IN 1999



NB: "Agri" means "farmer".

FIGURE 8: MAP OF ACTORS IN 2003



NB: "Agri" means "farmer".

FIGURE 9: MAP OF ACTORS IN 2014

5.9 Appendix to the second article (not submitted in the scientific journal)

5.9.1 Introduction

This second paper was aiming at re-examining the rationale of conducting a SNA to evaluate ISRIP. The objectives were to assess:

(1) The interest of SNA in exploring in-depth stakeholders' statements on actors' relationships and understanding the role played by economic agents;

(2) What the limitations of SNA are in evaluating the impacts and related contribution of the research and whether SNA can be generalized for this purpose.

Here we question a third objective, which is as follows:

(3) The relevance of performing a SNA to ex-post evaluate ISRIP on the resilience of the innovation system.

5.9.2 Rationale for focusing on the resilience

The degree of resilience of a system can determine the maintenance of innovations over time and therefore be considered as an impact of the research program. The concept of resilience has been broadly debated in the last 50 years since it can refer to different fields and be interpreted from different perspectives i.e. human-environment system and natural hazards, social science, and ecological science (Zhou et al. 2010; Norris et al. 2008; Walker et al. 2004). Walker et al. (2004), in the context of socio-ecological systems, defined the resilience as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks—in other words, stay in the same basin of attraction". The authors defined four critical attributes of the resilience: the latitude (the maximum level to which a system can be modified while remaining able to recover), the resistance (degree of facility to change the system), the precariousness (referring

to the trajectory of the system i.e. good or critical) and the Panarchy. The latter refers to how the other three attributes mentioned "are influenced by the states and dynamics of the (sub) systems at scales above and below the scale of interest" (Walker et al. 2004). According to Tyler et al. (2016), an actor network should continuously adapt itself to external uncertainties or risks in order to quickly react and take strategic decisions accordingly, as well as being able to cope with internal difficulties such as the bankruptcy of a commercial actor.

5.9.3 Methods to evaluate the resilience

The resilience of the innovation network can be estimated by survivability indicators such as the Robustness (the larger the structure's central core, the more robust the whole actor network is), and the Responsiveness (Talamini and Ferreira, 2010). The latter allows for the diffusion speed of information within the network and thus for its resilience (the more the actors are reactive to the vagaries of their environment, the more viable the innovation network is). These can be estimated by measuring factors of network quality:

Responsiveness: it can be estimated by calculating the distance between actors, as a little distance is likely to increase the flow of relevant information within the innovation network (Suire and Vicente, 2008) and consequently leads to a higher responsiveness (Talamini and Ferreira, 2010).

Robustness: the Clustering coefficient can be used for identifying the "central core" of the network structure, whose the size can be estimated[40] by dividing the aggregate Degrees of the involved actors to the sum total of Degrees from the overall network (Bassenne et al. 2014).

[40] The formula calculation has been developed by the author.

Talamini & Ferreira (2010) have developed other indicators of resilience: the Flexibility and the Adaptability. However, they were not considered here because SNA is not appropriate to their estimation. We consider that the Responsiveness and Robustness offer an acceptable estimation of the degree of resilience of a system.

It should however be emphasized the limitations of considering the strength of relationships between actors to inform the resilience of the innovation system. An increase in social links among actors may lead to a certain homogeneity within the network in terms of knowledge, norms and behaviors, and at the same time diminish the interactions with individuals from outside of that network (Barnes-Mauthe et al. 2015). Also, an increased intensity of relationships in the network could only benefit to actors who are already well connected to the rest of the network in qualitative terms (Maertens and Barrett, 2013). Still, the information theory discusses the link between the quality of the actor network on the one hand and the resilience of the innovation system on the other. This theory advocates that overdeveloped relationships among actors could lessen the resilience of an innovation system as maintaining high quality relationships may require significant resources to be mobilized, thus limiting the capacity to face disturbances (Ulanowicz et al. 2009).

5.9.4 Data collection

In order to estimate the resilience of the network with the indicators of Responsiveness and Robustness, we utilized data from the ILLIAD (local or localized initiatives, innovative for sustainable foods) project (Bassenne et al. 2014). Ten levels of intensity of relationships (from 0 to 10) were set and the different types of relationships (information flow, cooperation and financial links) were not considered. Sixteen farmers (four organic, three partially-organic[41],

[41] The partially-organic farmers were only included in the organic network.

and nine conventional), all research and advisory institutes including INRA (French National Institute of Agronomic Research), the Rice-Farmers Union, the Natural Reserve of the Camargue, and five rice traders (all of them) were interviewed[42].

5.9.5 Result

The Camargue organic network appears to have a better resilience than the conventional one, as the Responsiveness and Robustness indicators are higher for the organic network compared to the conventional one. The distance between the different actors, which we took into account for estimating the Responsiveness, was 15% lower in the organic network (1.8 compared to 2.1). With respect to the Robustness, no clear focal organization could be found within the conventional network, whereas the organic one is strongly organized around the pole "BIOSUD-SudCéréales-Thomas". A Clustering coefficient of 8.14 was found for this pole compared to 4.14 for the entire organic network. We estimated the theoretical Robustness of the organic network to be 76% in 2013. As a result, the organic network is likely to sustain over time but also to support a better resilience of the whole agricultural system.

5.9.6 Conclusion

We could demonstrate, by using SNA indicators, that the organic network is a priori more resilient than the conventional one and that the organic agricultural system is more likely to sustain over time. The organic network is strongly organized around the pole "BIOSUD-SudCéréales-Thomas", characterized by close links between actors. This enhances the capacity of these actors to quickly react and adapt to face disturbances, risks or uncertainties. The concept of resilience thus reflects an important mid and long-term impact of a research program.

[42] The samples of the two actor networks (organic and conventional) were generalized to their population.

We advocate this concept should be considered for future studies on impact evaluation of agricultural programs based innovation.

That said, this estimation of the Resilience of the innovation system could be overestimated. In effect, the innovation system could be very resilient now but at the same time be highly dependent on one actor. The innovation system could collapse in case this actor leaves the network. To avoid this problem, the indicators of Flexibility and Adaptability that quantify the number of alternative pathways, and that were developed by Talamini and Ferreira (2010), could be of high interest. They were not considered here because SNA is not appropriate to their estimation.

Transition words: From the first & second article (with its appendix) to the third paper

In the first article, an original qualitative and comprehensive approach was proposed to evaluate the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming. The impacts and contribution of the research as such in the Camargue were also evaluated. Using the Participatory Impact Pathway Analysis (PIPA) with complementary methods, tools, and instruments, the different mechanisms occurring along the innovation pathway could be detailed well in the Camargue case study. Still, the contribution of the research was studied with a certain degree of success. Furthermore, diverse types of indicators of change, covering the three dimensions of the sustainability, could be identified, measured, and linked to the research activities and outputs.

The Social Network Analysis (SNA) was further explored in the second article and appeared very beneficial. It could validate impact pathway links on actors' relationships, better identify the role and contribution of the different research actors over time, as well as deepening our understanding as to the influence of the different research activities on the structure of the network and in turn on the adoption process. However, the microeconomic mechanisms by which for example research activities have impacted the structure of the network, were underexplored. If we could tell the extent to which a research activity X was affecting the network and what the general underlying mechanisms were (e.g. strengthened relationships between farmers and researchers); the question of why and how the latter have developed was mostly unconsidered.

The third paper further addresses the role of interpersonal links, power relationships, influence and negotiation processes, in their capacity to trigger innovation processes related to the transition to organic farming. We test the relevance of the Actor Network Theory (ANT) in informing these elements. It is applied in two case studies which were selected in order to cover two different types of innovation, and for their diversity in terms of network configurations and local contexts. The first case is a broad range of different technical and social innovations which are leading the transition to organic rice farming systems in the French Camargue. The second case is a technical innovation, i.e. the development of a new organic product (Ecostop) in Bulgaria to protect bees from the varroatosis disease.

(Mots de transition : Du premier & deuxième article (avec son annexe) au troisième papier)

Nous avons proposé dans le premier article une approche originale, globale et qualitative pour évaluer les impacts et la contribution de la recherche *sur les processus d'innovation*s et la société, *en rapport avec la transition à l'agriculture biologique*. Les impacts et la contribution de la recherche en tant que tels en Camargue ont également été évalués. À travers *la conduite d'une analyse participative du chemin de l'impact* (PIPA), associée à *d'autres méthodes,* outils, et instruments, les différents mécanismes opérant au long du *chemin de l'innovation* ont pu être bien *détaillés dans le cas d'étude de la Camargue.* De même, la contribution de la recherche a été étudiée avec une certaine réussite. De plus, *divers types d'indicateurs de cha*ngement, couvrant les trois dimensions de la durabilité, ont pu être identifiés, mesurés, et reliés aux activités de recherche et « outputs ».

L'analyse du réseau social (SNA) a été davantage explorée dans le deuxième article et est apparue très *bénéfique. Elle a pu valider les liens du chemin de l'impact sur les relations d'acteurs*, de mieux identifier le rôle et la contribution des différents acteurs de la recherche au cours du temps, et *d'approfondir notre compréhension de l'influence des différentes* activités de recherche sur la structure du réseau et ainsi *sur le processus d'adoption.* Cependant, les mécanismes microéconomiques par lesquels les activités de recherche ont impacté la structure du réseau *n'ont pas été suffisamment explorés. S'il* a été possible de dire dans quelle mesure une activité de recherche X a pu affecter le réseau et quels ont été les mécanismes globaux sous-jacents (ex : relations renforcées entre producteurs et chercheurs) ; la question de pourquoi et comment ces dernières se sont développées a été insuffisamment considérée.

Le troisième article interroge le rôle des liens interpersonnels, des relations de pouvoir, *d'influence*, et des processus de négociation, dans leur capacité à « piloter » le chemin de *l'innovation. Nous testons la pertinence de la théorie de l'acteur réseau* (ANT) pour informer ces éléments. Celle-ci est appliquée dans les *deux cas d'études* sélectionnés dans cette thèse, pour couvrir deux *types d'innovation* et avoir une diversité en termes de configurations de réseau et de contextes locaux. Le premier cas est un ensemble de diverses techniques et innovations sociales ayant accompagné *la transition à l'agriculture biologique* en Camargue en France. Le second cas est une innovation technique, *c'est à dire* le *développement d'un nouveau produit biologique en Bulgarie* (Ecostop) pour protéger les abeilles contre la maladie de la varroatose.

Part 6 - Article: Role of the research in the transition to organic farming using the Actor Network Theory

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Abstract

This paper explores the potential of Actor Network Theory (ANT) in understanding how the process of interaction and translation between human and non-human actors contribute to the development, adoption and diffusion of science-based innovations linked to the transition to organic farming. The study relies on two case studies, the French Camargue case covering a range of technical and social innovations, and the case from Bulgaria focusing on the development of a technical and product innovation, i.e. a veterinary product for organic beekeeping. The paper shows the limitations of classical approaches in studying innovations since they underestimate the role of heterogeneous actors, their status, and how they interact with each other. We argue that focusing on actors' interactions helps to better understand the so-called "uncertainties" and "turning points" in the innovation development, as well as to interpret them as essential elements of the innovation process. Moreover we argue that challenges to tackle should be problematized to increase the success of research programs. We also stress the importance of opinion leaders during the implementation and diffusion phase of the innovation.

KEY WORDS – Actor Network Theory; Research Evaluation; Innovation Process; Bulgaria; Camargue.

(Partie 6 - Article : Rôle de la recherche dans la transition à l'agriculture biologique selon la Théorie de l'Acteur Réseau)

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(Résumé)

Ce papier explore le potentiel de la t*héorie de l'*acteur réseau (ANT) pour comprendre comment *le processus d'interaction et de translation entre* acteurs humains et non-humains contribue au développement, *à l'*adoption et à la *diffusion d'innovations* fondées sur la science et axées sur *la transition à l'agriculture biologique. L'étude se base sur deux cas d'*études, avec le cas de la Camargue couvrant *un ensemble d'innovations te*chniques et sociales, et le cas Bulgare axé sur le développement *d'une innovation technique et de produit, c'est*-à-dire un produit vétérinaire *pour l'apiculture biologique. L'article montre les limites* des approches classiques *pour l'*étude *d'innovations dans la mesure* où elles sous-estiment le rôle des acteurs hétérogènes, leurs statuts, et comment ils interagissent entre eux. Nous arguons que se focaliser *sur les interactions d'acteurs aide à mieux comprendre les dites «* incertitudes » et « moments charnières » pendant le développement de *l'*innovation, et de les interpréter comme éléments *essentiels du processus d'innovation*. Par ailleurs, nous concluons que les défis à relever devraient être problématisés pour augmenter le succès des programmes de recherche. Nous soulignons également *l'importance des leaders d'opinion au cours des phases d'*implémentation *et de diffusion de l'innovatio*n.

MOTS CLES – *Théorie de l'Acteur Réseau*; Evaluation de la Recherche; Processus *d'Innovation* ; Bulgarie ; Camargue.

Transition words: Towards a general discussion on the results

This thesis has been built on the observation made that quantitative methods fail at highlighting complex mechanisms along the innovation pathway from research intervention to outputs, outcomes and impacts achievement. The concept of innovation was understood as a complex and dynamic system, as opposed to the former linear and simple view of it. It was decided to take account of qualitative methods, tools and instruments, as they are supposed to enlighten the complexity of innovation processes as well as the role and contribution of the research along the pathway from research activities to impacts, with respect to the transition to organic farming.

It was developed in the first paper a general framework to assess qualitatively the impacts and contribution of the research on innovation processes and the society, regarding the transition to organic farming. This approach was applied in the Camargue case study.
The second paper intended to demonstrate the interest of performing a Social Network Analysis (SNA), in its ability in particular to validate the impact pathway links on actors' relationships and to deepen our understanding on the role of the research actors during innovation processes related to the transition to organic farming.
Finally, the third paper studied the rationale of completing our evaluation toolkit with the Actor Network Theory, used as a theoretical framework, in its capacity in particular to orient evaluative questions and to detail the role of interpersonal relationships, individual persons and objects, during innovation processes associated to the transition to organic farming.

In the next part of the thesis, i.e. the general discussion, we discuss, based on our experience from the three articles (part 4, 5 and 6), the contribution of the different methodological developments, taken together, in evaluating ex-post the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming. We also question the contribution of this approach to a better understanding of how the research operates along the impact pathway towards the conversion to organic agriculture.

(Mots de transition : Vers une discussion générale sur les résultats)

Cette thèse a été élaborée à partir *de l'observation que les méthodes quantitatives ne permettent pas d'expliciter les mécanismes complexes opérant au long du chemin de l'innovation, de l'intervention de la recherche à l'obtention* « *d'outputs* », « outcomes » et *impacts. Le concept d'innovation s'entend dans cette thèse comme un système à la fois dynamique et complexe, à l'inverse de l'ancienne vision linéaire* et simplifiée de *l'innovation. Nous nous* sommes appuyés sur des méthodes, outils, et instruments qualitatifs, *supposés faire la lumière sur la complexité des processus d'innovation*s de même que sur le rôle et la contribution de la recherche au long du sentier allant des activités de recherche aux impacts, vis-à-*vis de la transition à l'agriculture biologi*que.

Nous avons développé dans le premier article un cadre général pour évaluer qualitativement les impacts et la contribution de la recherche *sur les processus d'innovation*s et la société, en rapport avec la transition à l'agriculture biologique. Cette approche a été appliquée au *cas d'étude de la Camargue.*

*Le second article avait pour objet de démontrer l'in*térêt de conduire une analyse du réseau social (SNA) *dans sa capacité en particulier à valider les liens du chemin de l'impact sur les relations d'acteurs et* à approfondir notre connaissance sur le rôle des acteurs de la *recherche dans les processus d'innovation*s *en lien avec la transition à l'agriculture* biologique.

Finalement, le troisième article a étudié l'intérêt de compléter notre boite à outils d'évaluation avec la théorie de l'acteur réseau (ANT), utilisée comme un cadre théorique, dans sa capacité en particulier à orienter les questions évaluatives et à renseigner le rôle des relations interpersonnelles, personnes individuelles et objets, au cours des processus *d'innovations liés* à la transit*ion à l'agriculture biologique.*

Dans la partie suivante, *c'est à dire* la discussion générale, nous interrogeons, sur la base de notre expérience et à partir des trois articles (partie 4, 5, et 6), la contribution des différents développements méthodologiques, pris dans leur ensemble, à *l'évaluation* ex-post des impacts et de la contribution de la recherche *sur les processus d'innovation*s et la société, en rapport *avec la transition à l'agriculture biologique*. La contribution de cette approche à une meilleure compréhension de la manière dont la recherche opère au long du *chemin de l'impact vers la contribution à l'agriculture biologique* sera également interrogée.

Part 7: General discussion and lessons learned

Abstract

In this discussion part, we question the contribution of the three articles (see part 4, 5 and 6) in developing a qualitative mixed-method that is suitable for evaluating ex-post the impacts and contribution of the research on innovation processes and the society, with respect to the transition organic farming. We also question the contribution of this approach to a better understanding of how the research operates along the impact pathway towards organic agriculture.

A suitable approach to ex-post evaluate the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming, was developed in this thesis. This approach successfully adapts existing methods and especially the Participatory Impact Pathway Analysis (PIPA) to the requirements of an ex-post evaluation. Also, the reconstruction of the network of actors at different periods in the innovation pathway is of interest for identifying the most important actors as well as the research activities that have had the most important impacts. Other elements of great interest are the table of links to identify underlying mechanisms to pathway links and what that this entails; the "scoring system" for identifying the key pathway components; the counterfactual instrument to establish causal inferences; and the Actor Network Theory (ANT) for highlighting the role of interpersonal relationships, individual actors, and negotiation processes. Moreover, we show that the limitations of participatory instruments are well overcome by our approach as it offers the possibility to reexamine the accuracy of all pathway links using the process tracing approach in combination with other methods, tools, and instruments.

We also show that the approach developed helps to understand the transition process towards organic farming. Nevertheless, we suggest a way of deepening this approach to be more precise on the contribution of both the research and pathway components in achieving outcomes and impacts. We then show the strong interest of the comprehensive approach (including the amendments suggested in this part) for evaluating the effects of the research intervention in the Camargue case and subsequently for improving the pathway of the transition to organic farming. The research program on the transition to organic farming in the Camargue played an

important role in developing and structuring the network of actors. Exchanges between farmers and INRA were essential and increasing during the innovation process. The adoption of the technical incremental innovations is however principally derived from the "tests" set by farmers (refinement and optimization of the rice production system) and the contribution of the research in general in achieving outcomes and impacts was relatively limited.

Based on the knowledge generated on how to assess research impacts of and on the way the transition to organic farming occurs, 13 recommendations for policy makers, researchers and stakeholders are made:

- (1) To **problematize the issue to be tackled before implementing the research program** as such; the problematizing should also be refined all along the transition pathway;
- (2) To **identify key persons when investing into a research program** based agricultural innovations;
- (3) The **interests of the different actors from the research should primarily be aligned** around goals that are beneficial for everybody. In a second step, if the trust is not sufficient, then contracts or commitments should be signed by the different parties;
- (4) **Enable farmers to conduct experimentations on their farms**, either independently or (preferably) in close collaboration with the research;
- (5) To **enroll opinion leaders and regularly meet producers** to maintain close relationships between research and the farmer community;
- (6) To **enroll partners from the international community** even in absence of obvious and direct interest at first sight;
- (7) To **produce leaflets in which the knowledge created is represented and distribute them directly to farmers**;
- (8) Taking into consideration the length of the transition period and **involve progressively the potential beneficiaries**;

- (9) To **enable a favorable economic and institutional environment** to make the research intervention successful;
- (10) To **involve researchers and key stakeholders at the onset of the research program**;
- (11) To **allow flexibility into research programs** to adapt to unexpected developments during innovation processes;
- (12) To **regularly monitor research outputs and outcomes** during the time span of the research program;
- (13) To **conduct an ex-post participatory impact pathway evaluation**.

(Partie 7 : Discussion générale et enseignements tirés)

(Résumé)

Dans cette partie discussion, nous questionnons la contribution des trois articles (voir partie 4, 5 et 6) au développement *d'une* méthode qualitative *à même d'évaluer* ex-post les impacts et la contribution de la *recherche sur les processus d'*innovations et la société, en rapport avec *la transition à l'agriculture biologique*. Nous questionnons aussi la contribution de cette approche à une meilleure compréhension de comment la recherche opère au long du chemin *de l'impact vers la conversion à l'agriculture biologique.*

Une approche appropriée pour évaluer ex-post les impacts et la contribution de la recherche *sur les processus d'innovation*s et la société, par rapport à *la transition à l'agriculture* biologique, a été développée dans cette thèse. Cette approche adapte avec succès les méthodes ex*istantes et particulièrement l'a*nalyse participative du c*hemin de l'*impact (PIPA) aux *conditions d'une évaluation ex-post. Aussi, la reconstruction du réseau d'acteurs à différentes périodes dans le chemin de l'innovation est d'intérêt pour identifier les acteurs les plus* importants ainsi que les activités de recherche ayant eu le plus *d'impacts. D'autres éléments* de grande importance sont la table des liens pour identifier les mécanismes sous-jacents des liens du chemin et ce que cela implique ; le « système de notation » pour identifier les composantes essentielles du chemin *; l'inst*rument contrefactuel pour établir les inférences causales ; et la t*héorie de l'*acteur réseau (ANT) pour mettre en avant le rôle des relations interpersonnelles, des acteurs individuels, et des processus de négociations. De plus, nous montrons que notre approche permet de répondre assez bien aux limites des instruments *participatifs dans la mesure où elle offre la possibilité de réexaminer l'exactitude des liens du* chemin grâce au « process tracing *» en combinaison avec d'autres méthodes, outils, et* instruments.

Nous montrons aussi que l'approche développée aide à comprendre le processus de transition vers *l'agriculture biologique. Néanmoins, nous suggérons une manière d'approfondir cette* approche afin de gagner en précision vis à vis de la contribution de la recherche et des *composantes du chemin dans l'atteinte des* « outcomes » et impacts. Nous montrons ensuite le *fort intérêt de l'approche globale (incluant les amendements suggérés dans* cette partie) pour *évaluer les effets de l'intervention de la recherche dans le cas camarguais et subséquemment d'améliorer le chemin de la transition vers une agriculture biologique. Le programme de*

*recherche sur la transition à l'agriculture biologique en Camargue a joué un rôle important dans le développement et la structuration du réseau d'acteurs. Les échanges entre les agriculteurs et l'INRA étaient essentiels et se sont renforcés au cours du pro*cessus *d'innovation. L'adoption des innovations techniques incrémentales est cependant principalement la résultante des "tests" réalisés par les producteurs (ajustement et* optimisation du système de production rizicole) et la contribution de la recherche en général *dans l'atteinte des* « outcomes » et impacts était relativement limitée.

Sur la base des connaissances développées par rapport à l'évaluation de l'impact et à la manière dont la transition vers l'agriculture biologique opère, nous préconisons 13 recommandations pour les décideurs politiques, les chercheurs, et les parties prenantes. 8 recommandations principales sont:

- (1) **Problématiser le problème à résoudre avant de mettre au point un programme de recherche en tant que tel** ; la problématisation devrait aussi être retouchée au long du chemin de la transition;
- (2) ***Identifier les personnes clés lorsque l'on investit*** **dans des programmes de recherche** axés sur des innovations agricoles;
- (3) Les **intérêts des différents acteurs de la recherche devraient en première instance être alignés** autour de buts qui sont bénéfiques pour tout le monde. Dans une seconde *étape, si la confiance n'est pas suffisante, alors des contrats ou accords devraient être* signés par les différentes parties;
- (4) **Permettre aux agriculteurs de conduire des expérimentations sur leurs exploitations**, de manière indépendante ou (de préférence) en étroite collaboration avec la recherche;
- (5) ***Enrôler les leaders d'opinion et rencontrer régulièrement les producteu*****rs** pour maintenir des relations étroites entre la recherche et la communauté des producteurs;
- (6) **Enrôler les partenaires de la communauté internationale** *même en l'absence d'intérêt dire*ct et évident à première vue ;

- (7) **Produire des brochures dans lesquelles la connaissance créée est représentée et les distribuer directement aux agriculteurs**;
- (8) Prendre en considération la longueur de la période de transition et **impliquer progressivement les bénéficiaires potentiels**;
- (9) **Permettre un environnement économique et institutionnel favorable** pour que *l'intervention de la recherche soit un succès*;
- (10) **Impliquer les chercheurs et parties prenantes clés au début du programme de recherche**;
- (11) **Accorder de la flexibilité aux programmes de recherche** *pour s'adapter aux évènements imprévus au cours des processus d'innovation*s;
- (12) **Suivre régulièrement les « outputs » et « outcomes »** au cours du programme de recherche;
- (13) **Réaliser une évaluation participative ex-*post du chemin de l'impact*.

7.1 Introduction

In this thesis, we focus on qualitative methods in order to evaluate the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming. It was shown that quantitative approaches do not shed light on complex mechanisms that operate along innovation pathways linked to the transition to organic farming, from research investments to impacts achievement. Similar weaknesses, but less important, were also identified for existing qualitative methods. These elements have justified the need to elaborate a further developed approach. This issue was addressed in the three articles included in this thesis (in part 4, 5 and 6). Moreover, the choice was made to use participatory instruments in order to mobilize actors and changes.

It was decided to develop a new approach to (1) overcome weaknesses of existing qualitative methods in ex-post assessing the impacts and contribution of the research on innovation processes and the society, concerning the transition to organic farming, and (2) to mobilize more participatory instruments and controlling for their disadvantages in order to empower stakeholders on sustainability issues.
Also, existing approaches underexplore the contribution of the research along the impact pathway as well as the key elements and linkages acting in the innovation "black box". Nevertheless, the Participatory Impact Pathway Analysis (PIPA) appeared to be the most suitable approach. PIPA has been considerably adapted by the help of several methods, instruments and tools. These are as follows: (1) the Outcome Harvesting, (2) the process tracing, (3) the use of counterfactual situations, (4) the payback framework, (5) the Social Network Analysis, and (6) the Actor Network Theory.

A first section discusses the contribution of the thesis in elaborating an approach that is able to evaluate the impacts and contribution of the research based innovation in agriculture, with a particular emphasis on the transition to organic farming in the Camargue.
A second section discusses the contribution of this approach to a better understanding of the transition to organic farming while suggesting ways of improving the impacts of the research by enhancing this transition. The Bulgarian case is only discussed with respect to the interest of the Actor Network Theory since this case study was not used in the first and second article included in the thesis (in part 4 and 5).

7.2 Methodological aspects

7.2.1 Understanding the contribution of the research within innovation processes

The PIPA approach was taken as basis to set-up our mixed qualitative approach. Here we take a step back as to the interest of the methodological developments made, presented in the three papers included in this thesis (part 4, 5, and 6), in understanding ex-post the role played by and the contribution of the research within innovation processes. TABLE 16 outlines the different methods we used in combination with PIPA (Participatory Impact Pathway Analysis) as well as their interests in understanding ex-post the role and contribution of the research based innovation in agriculture.

Methodological developments	Interests in understanding ex-post the role of the research
(1) Outcome Harvesting	- Adapt PIPA to the requirements of an ex-post evaluation, allowing tracing back the role played by the research along the innovation pathway. - Further consider factors with little or no connection to the research program, since they may also influence outcomes and impacts (better evaluation of what the research produced). - Help to uncover the black box of the innovation process and to identify the enabling & disabling factors that occur in the process.
(2) Consider the strength of the pathway links (also visible in the pathway graph)	- Identification of elements derived from the research in the pathway and which were the most important in reaching milestones and thus the outcomes and impacts. - Estimation of the importance of external factors i.e. unrelated to the research.
(3) Counterfactual situations	- Identification of Crucial Research Points (CRP), in other words of elements in the pathway which would not have happened without the research. - Eliminate pathway links, derived from the research or not, which have not affected the outputs, outcomes or impacts.
(4) Table of links	- Identification of the underlying mechanisms to pathway links, explained by the role of the research, directly or indirectly. - Help to uncover the black box of the innovation process and to identify the enabling & disabling factors that occur in the process.
(5) Social Network Analysis	- Adapt PIPA to the requirements of an ex-post evaluation, in reconstructing the actor network at different points of time along the innovation pathway. - Better understanding of the contribution of the different actors in structuring the network, enhancing in turn the adoption process and the achievement of outcomes & impacts. - Identification of the most important research activities. - Help to uncover the black box of the innovation process and to identify the enabling & disabling factors that occur in the process.
(7) Actor Network Theory	- Orienting evaluating questions for assessing ex-post the impacts and contribution of the research on innovation processes. - Better understanding of the role of the interpersonal relationships, elements of influence & lobbying, and negotiation processes that make the impact pathway happen.

Methodological developments	Interests in understanding ex-post the role of the research
	- Better understanding of the role of the "boundary objects" in the pathway that make the impact pathway happen. - Help to uncover the black box of the innovation process and to identify the enabling & disabling factors that occur in the process.

TABLE 16: INTERESTS OF THE METHODOLOGICAL DEVELOPMENTS IN UNDERSTANDING EX-POST THE ROLE OF THE RESEARCH

Adaptation to ex-post evaluation

The first limitation we have been facing with respect to the PIPA approach was its non-adaptation to ex-post evaluation (further information in the first article, part 4). In that respect, the use of the Outcome Harvesting (OH) but also more surprisingly of the Social Network Analysis (SNA) are of high interest. OH, an approach which was developed by Wilson grau and Britt (2002) to overcome the limitations of the Outcome Mapping (OM) method (a method used to design research programs ex-ante), provides us with a procedure to reconstruct ex-post the pathway of an intervention.

The different types of changes are collected i.e. the outcomes, outputs, and activities; before linking outcomes to the other components, in a "reverse way". The question asked is how outcomes have occurred and not what the research activities have produced. This allows taking all factors into account, either related or not to the research, thus leading to a better estimation of the contribution of the research on the innovation development. From our experience, reconstructing the pathway in reverse allows the analysis not to be restricted to the only effects of the research activities. Outcomes may also arise from other factors than research or from research activities that were not identified or considered (Rogers and Weiss, 2007; Mayne, 2008). Taking the example of the Camargue case; the second workshop, which endeavored to reconstruct the pathway by representing it on posters, has allowed alternative paths to be discussed as we did not only focus on the effects of the research program under review (on the transition to organic farming).

In the Camargue case, it appeared easier to start thinking out of the changes (outcomes), probably because they are more "visible" in the eyes of the actors. In this case study, farmers stated during the second workshop, in first instance, that the research done (under review) had not produced any effects; but when the pathway of the innovation was being reconstructed (in a reverse way), they recognized or realized that research activities and outputs affected to some extent the different changes identified. In fact, stakeholders were too much focused on the

effects of the research at the beginning of the second workshop, that is, when they were asked to list the different changes (outcomes) in relation to the transition to organic farming. Examples of outcomes were previously presented by the organizers to the attendants (before the "exercise"), but it may have been better to present preliminary results on the basis of the first workshop (more details in the first article, part 4) and the face-to-face interviews already done. In a second step, stakeholders may have been asked to revise the list of outcomes. It may also have been preferable to ask outcomes that happened in the personal situations of the stakeholders rather than in a general way (for all of the farms). This may have rendered the exercise more concrete and easier to understand.

More Surprisingly, SNA contributes well in adapting PIPA to the requirements of an ex-post evaluation (further information in the second article, part 5). In the Camargue case, we observed that is was indeed possible with SNA to reconstruct the actor network in an ex-post manner i.e. to reconstruct the actor network that most probably occurred at different periods along the innovation pathway. In the literature, there are many examples of studies using SNA to reconstruct network dynamics (e.g. Cho and Fowler, 2010). They rely on data that are either collected regularly during the whole period of analysis or after but on the basis of tangible and dated documents such as emails, reports, events, etc. The originality of our approach is that actors were asked to detail what their relationships with others were in the past, at different periods (more details in the second article, part 5). Therefore, the actors had to remember well what happened in the past. This worked well, probably because the network is small, with a limited number of members. The actors were asked to estimate the strength of their relationships with others according to a scaling from 0 to 3 but also the underlying mechanisms and reasons of change over time, so that it was possible to validate, at least partially, the accuracy of their statements.

This reconstruction of the network has particularly allowed to understand dynamic relationships among actors over time and a better understanding of their contribution in structuring the network and therefore in driving the adoption process and facilitating the achievement of mid and long-term impacts.

Participatory ex-post impact evaluation

PIPA and OH should preferably be used together (further information in the first article, part 4). PIPA and OH are not very relevant, when used individually, to ex-post evaluate, in a participatory manner, the impacts and contribution of the research. OH provides ideas on how to reconstruct the pathway, as a general procedure, but does not make use of participatory stakeholders' workshops nor take account of the impacts of the intervention. Also, OH does not make reference to impacts contrary to PIPA. In the Camargue case, the impacts were collected during face-to-face interviews because of a lack of time in workshops. These in-depth interviews only concerned the beneficiaries, i.e. the farmers. Researchers may indeed have overestimated the number and significance of the impacts obtained from the intervention because they were the implementers of the research program under review. In other words, they may have a personal interest to overestimate the positive impacts of the research conducted and to underestimate negative ones (Scheirer, 1978). At the same time, general impacts, e.g. on the level of biodiversity, were not considered by the interviewed farmers, probably because these impacts do not directly concern them (global impacts that do not directly affect their farms). Citizens may be involved in the process to avoid this problem and consider more the impacts that affect the society.

Contribution of the research activities and interest of the table of links

An activity that is implemented from the year t to t+2 may not have impacted the configuration of the actor network, for example at t+4. But, this becomes more complex when different activities are implemented at the same time and/or when an activity continues producing effects on the mid and long-term. When different research activities are implemented at the same time, the effects arising from these activities can hardly be attributable to one or another of these activities. This situation is known as problem of attribution, in other words as the difficulty of inferring the respective contribution of different variables to the impacts (Alston et al. 2000; Mayne, 2001; White, 2010).

By the help of the table of links, which we present in the first and second paper (part 4 and 5), it is possible to trace back the underlying mechanisms and infer what was the contribution of the different activities in structuring and/or changing the configuration of the actor network at different periods. More generally, this table of links helps to identify all underlying mechanisms to pathway links and to explain the role played by the research in the innovation process. The

related milestones, i.e. the elements that must be fulfilled to achieving goals, can be identified using this table of links.

Strength of the different pathway links

Another limitation of the PIPA method, but also of the other identified qualitative methods being designed to evaluate the impacts of the research based innovation, is that the extent to which pathway components contribute to subsequent ones is not well considered (further information in the first article, part 4). In other words, there is no precise reading grid, e.g. a scale of values, which may help characterize the contribution of the different pathway components in reaching subsequent ones.

We propose in this thesis to evaluate the strength of the different links (for example an output leading to an outcome), constituting the impact pathway, by a scoring from 0 to 3. This helps to identify the most important elements in the pathway e.g. an activity A which is important to reach a milestone, and without which the adoption process would not have taken place. The interest is also to estimate the importance of the factors which are not linked to the intervention but that influence the innovation process the research is aiming to develop. In doing so, the role played by the research on the observed impacts can be estimated more precisely. This corresponds to an analysis in terms of contribution (Mayne, 2001; Delahais and Toulemonde, 2012). However, a limit of our "scoring system" is that it does not directly inform the extent to which a particular research activity contributes to the process of adoption and impacts achievement. In most of the cases we are unable to draw conclusions on how far, for example, a particular impact is being driven by a specific activity. This is due to the fact that these components (here, an activity and an impact) are not directly linked together (there are steps in-between). There is a need to deepen our methodology on this point, which is discussed later in this part.

Crucial Research Points and exclusion of non-valid pathway links

The use of counterfactual situations allows to identify not only important factors from the impact pathway but also crucial ones i.e. elements that cannot be withdrawn without calling into question the occurrence of other components in the pathway (further information in the first article, part 4). The counterfactual mechanism can be used to identify the so-called Crucial Research Points (CRP) i.e. the elements in the pathway that would not have happened without the research. Still, this can inform on how research programs should be designed (discussed

later in this part). Another use of the counterfactual instrument is to eliminate the hypothesized pathway links which have in reality not affected the impact pathway. In other words, the pathway does not suffer from removing these links. The exclusion of these links allows a more accurate estimation of the role played by research, either in a direct or indirect way (by deduction).

Interpersonal relationships and boundary objects

The Actor Network Theory (ANT) also contributes significantly to a better understanding (ex-post) of the contribution of the research on innovation processes related to the transition to organic farming by (1) orienting evaluative questions, (2) highlighting the role of interpersonal relationships and negotiation processes, and (3) assessing the role of the "boundary objects" in the pathway (further information in the third article, part 6). Particularly, the use of ANT as a theoretical framework to conduct a program evaluation, is of interest to identify the contribution of key actors ("individuals") and of the opinion leaders along innovation processes related to the transition to organic farming. Three types of objects were identified: (1) the "undesired objects", (2) the objects representing the "solutions", and (3) the objects supporting the adoption of the identified solutions. The "undesired objects" are especially crucial as other actors need to negotiate with them for problem-solving purpose.

The "solution object" in the Bulgarian case is the combination between essential oils and carrier, which is represented by the product Ecostop on market. Furthermore, in the Camargue, the "solution objects" are a set of technical and managerial innovations: introduction of new crops in the rotation such as alfalfa and temporary pastures, and adapted use of materials like disc harrows to combat weeds (e.g. increased number of passages and adaptation of the application dates to soil conditions). A third type of object, the so-called "support", is identified as necessary to help develop these innovations and increase their rate of adoption. Leaflets and scientific articles, in which the new knowledge is represented, were important in Camargue to share this knowledge as well as raising funding and enrolling relevant international partners. Coalitions of opinion leaders and "solution actors" have become the most important channels to diffuse and adopt the innovation.

All this information, in turn, is of great interest for drawing recommendations to stakeholders, researchers and policy makers on how to enhance impacts of such research programs (these recommendations are specified in section 7.3.3).

By taking only into consideration humans, objects, or the "institutional pathway" of an innovation, it would be difficult to understand (1) the reasons for which and how an innovation is being initiated, implemented and diffused, and (2) why and in what way actors' objectives are changing during innovation processes. Moreover, ANT allows to complement the previous methodological developments. ANT further develops the following elements: (1) how crucial the phase of problematization is, (2) the key role played by only a few "individuals" and by "opinion leaders" during the implementation and diffusion innovation phases, (3) the key factor of "trust" at the beginning of the process to allow a suitable enrollment of the actors, (4) the utility of leaflets and scientific articles, in getting funded and to enroll international partners, and (5) the specific role played by different types of objects.

Contribution of the research and identification of major pathway components

The different methodological developments excel at uncovering the mechanisms of the pathway as well as estimating the extent to which the different components of the pathway contributed to the achievement of subsequent components. However, the contribution of the research in the pathway remains difficult to estimate as well as the identification of the major components. This situation is due to the complexity of the impact pathway investigated and to the presence of numerous explanatory factors, especially external ones. As already said, the identification of CRP was of interest in that respect. The fact that only a few CRP were identified in the Camargue case and that they were exclusively situated along the linkages from activities to outputs, has confirmed our conclusion that the contribution of the research on innovation processes linked to the transition to organic farming, in that specific case, was limited (further information in the first article, part 4). Having said that, there was no evidence whether the rate of adoption would have been significantly different without the research as "limited contribution" does not mean "non-useful" or "non-crucial" contribution. "Innovation does not only involve adaptation to prevailing contextual conditions, but also the active influencing, redesign, or destruction of pre-existing conditions and institutional frameworks. Such change is affected by complex interdependencies between actors, organizations and artefacts, unintended and unforeseen developments, and coincidence and dynamics of conflicts that challenge linear approaches and reductionist understanding." (Klerkx et al. 2012, p54). The research is not necessarily a direct contributor to the achievement of impacts but could only be a facilitator since research is no longer a linear, non-dynamic, and external process (Klerkx et al. 2012).

7.2.2 To cope with the limitations of participatory instruments

In the case studies conducted, stakeholders' workshops were organized in order to reconstruct the theory of change of the research program investigated. The conduct of workshops is the core of the PIPA method, which we took as basis to elaborate our qualitative approach (further information in the first article, part 4). That is the reason our approach can be qualified as participatory. As already said, however, such an approach does not come without limitations; it was combined with other methods, instruments and tools, in order to overcome these limitations. Other strategies were also undertaken in order to increase the stakeholders' involvement in workshops and facilitate their implementation. We will discuss first in what the different methods, tools and instruments, used in combination with PIPA, could overcome the limitations of a participatory approach. Secondly, we will present the challenges we have been facing with during the evaluation process and how the strategies undertaken could cope or not with the identified pitfalls.

7.2.2.1 *Interest of the approach to cope with potential shortcomings of participatory evaluation procedures*

The baseline, to overcome the limitations of participatory evaluation procedures, was to reanalyze in-depth the different pathway links which were stated by stakeholders in workshops (further information in the first & second article, part 4 & 5). It should be emphasized that answering these limitations also contributes in turn to a more accurate estimation of the contribution of the research. TABLE 17 outlines the different methods we used in combination with PIPA as well as their interests in preventing or limiting difficulties linked to the use of participatory evaluation procedures.

Validation of the general pathway links

The use of the table of links, presented in the first and second paper of this thesis (part 4 & 5), is a key constituent of our approach. Besides helping the classification of the information gathered into different categories [primary and subsequent event of a pathway link, underlying mechanism(s), and alternative explanation(s) to the hypothesized underlying mechanism(s)], the use of the table of links helps to conduct the hoop test (process tracing approach). The hoop test allows pathway links to be confirmed when evidences are identified (for more information, see the first article, part 4). That said, the hoop test is not able to fully confirm all of the pathway

links (Mahoney, 2010); and the use of the counterfactual instrument appears to be of high value to complete the analysis (more details in the first article, part 4).

In the Camargue case, if the majority of the stakeholders argued the first event of a pathway's link might be removed without calling into question the subsequent incidence, the link was eliminated. The combination of the hoop test with reflections in terms of counterfactual situations is greatly useful. In the same way as for the hoop test, the only use of counterfactual situations is not sufficient to make an accurate analysis. The counterfactual instrument is not able by itself to confirm pathway links because the underlying mechanisms on stake are not considered. Taking the example of an output x that hypothetically leads to an outcome y; if y would not have occurred in absence of x, this does not necessarily mean that x is directly linked to y. In effect, the component y may not have occurred in absence of x because x is connected to another event, for example to the event s, which is connected to y.

Methodological developments	Interest in reducing the shortcomings of participatory evaluation procedures
(1a) Table of links (1b) Process tracing & Hoop test	- To confirm pathway links by the identification of evidences. - To eliminate pathway links which in fact did not affect the impact pathway.
(2) Counterfactual situations	- Identification of Crucial Research Points (CRP), in other words of elements in the pathway which would not have happened without the research. The related pathway links were fully validated. - To eliminate pathway links which were in fact not necessary to the impact pathway. - To complete the hoop test, which is unable to fully confirm the pathway links (the hoop test only looks at the presence of necessary conditions, which is insufficient to fully explain the occurrence of the respective links).
(3) Social Network Analysis (SNA)	- To study in-depth the role of the network (the time available in workshops is too limited for this). - To identify the most important actors to invite in advance, thus facilitating the preparation and the elaboration of strategic answers for the workshops. - To confirm pathway links on actors' relationships.
(4a) Outcome Harvesting (OH) (4b) Actor Network Theory (ANT) (4c) Public Value Mapping (PVM)	- To utilize other ways of collecting data and to deepen the analysis done (no time in workshops to analyze the pathway in-depth).

TABLE 17: INTEREST OF THE METHODOLOGICAL DEVELOPMENTS IN REDUCING THE SHORTCOMINGS OF PARTICIPATORY EVALUATION PROCEDURES

Validation of the pathway links focusing on actors' relationships

The use of SNA is of interest during the validation process of the hypothesized pathway links focusing on actors' relationships. In the same way as the other pathway links, those focusing on actors' relationships are validated undertaking the hoop test, i.e. by confirming the presence of the necessary conditions making these links happening. The table of links specifies the list of and helps to identify the types of pathway links and related underlying mechanisms (more information in the last section and in the second article in part 5). SNA is useful in that process to explore evidences with respect to the type, structural patterns, and intensity of social relationships between network's actors (Casieri et al. 2008). Therefore, SNA helps to (1) confirm the occurrence of the two events constituting each of the explored links and (2) their respective underlying mechanisms. The underlying mechanisms are fully confirmed when there is no evidenced alternative explanations. Alternative explanations are identified by the help of a series of iterative SNA explorations and of logical reasoning. An alternative explanation can be for example the increasing importance of a research center over time that may also explain why for instance the clustering coefficient of the innovation network (degree of close relationships between actors) has increased from the time t to t+2. SNA indicators, i.e. the Degrees, Betweenness and Clustering coefficient, are all of interest to validate pathway links focusing on actors' relationships (more details in the second article, part 5). The actors with a high Betweenness (degree of intermediation of an actor) can be considered as knowledge brokers (Scott, 2000). The Clustering coefficient allows a deepening of the understanding of the actors' position evolvement in the network by calculating the level of connectivity between the neighbors of a particular actor (the so-called neighbors are directly connected to the actor studied). This coefficient also shows the extent to which the network is being clustered overall. Finally, the Degrees allow examining the relationships' strength within an actor network and to better comprehend the dynamic of the innovation.

Role & description of the network, and origin of the data

SNA is a structured approach that allows making a thorough analysis of the role of the network in the whole innovation process (further information in the second article, part 5). SNA also helps preparing the workshops by knowing in advance the position of the different actors in the network and what the eventual conflicts between them are (further information in the second article, part 5).

Last but not least, the combined use of the OH, SNA, and ANT, allows diversifying the data sources, thus to triangulate all of the collected information. OH refers to publicly available documents, surveys, questionnaires, and in-depth interviews; while SNA mainly refers to face-to-face interviews, and ANT to all types of data. The use of these methods balances the participatory nature of PIPA. As a result, the approach we developed cannot be described as a "pure" participatory approach (further information in the first article, part 4). The triangulation of data allows making results more scientifically robust (Mayne, 2001, 2008).

7.2.2.2 *Questioning the scientific robustness of participatory approaches*

Whether participatory approaches are scientifically robust is an important debate within the scientific community (Brisolara, 1998). Participatory approaches are often acknowledged for their ability to empower stakeholders and involve them in decisions-making, as well as enhancing process of learning and taking into consideration opinions that may not have been identified using quantitative methods and/or non-participatory approaches (Fetterman, 1996; Wandersman et al. 2005). The main limitations or challenges of participatory approaches, in relation to innovation and impact assessment, are their time consuming nature, the possibility of obtaining misleading results, the stakeholders' conservatism, the measurement of impacts, as well as the scientific quality and dominance biases (e.g. White, 2010; Chambers, 1997). These elements are developed in the following paragraphs.

Time consuming nature of participatory approaches

An important limitation of participatory approaches are their time consuming nature (Papineau and Kiely, 1996; Hisschemöller et al. 2001; Rice and Franceschini, 2007). This is particularly due to the time needed to prepare (e.g. the moderation) and conduct the workshops.

The approach we developed partially answers this challenge by conducting two workshops instead of one and by combining them with several in-depth and face-to-face interviews. However, the second workshop, which aimed at drawing the impact pathway, was a time consuming "exercise" and therefore a very demanding "job" for the invited stakeholders. We would have preferred to split this workshop on different days, but convincing participants to attend a few hours is already difficult given their crowded agenda and their relatively limited interest to participate (no direct benefits perceived).

Misleading results

Participatory approaches can generate "incidental results". In other words, the reproduction of the same "exercise" with another group of stakeholders may produce quite different results (Hisschemöller et al. 2001). We answered this challenge by splitting the group of stakeholders (in the second workshop in Camargue) into three homogeneous sub-groups (see first article, part 4). We obtained three slightly different pictures of the impact pathway of the research (on posters), which were combined afterwards. The pathway links that were raised by only one sub-group and/or considered as minor were not withdrawn at that stage, but they passed later into the "validity check procedure" (process tracing approach and counterfactual instrument). There is also a debate on whether actors' statements in workshops are shared by the others. In effect, some of the participants may not react to avoid criticisms or simply because they are timid. This makes the analysis even more complex and time consuming.

Stakeholders' conservatism

Another challenge we are faced with is the conservatism of the stakeholders. "Suppose that the King of Spain in 1490 had established a focus group in order to find out whether to subsidy the expedition of Columbus. This proposal may well have been evaluated as silly and rejected, because the lay population at that time believed the earth is flat. Stakeholders may formulate their own criteria for evaluating the usability of science, one cannot know whether they may hinder what experts consider as progress, or stimulate what scientists think unnecessary" (Hisschemöller et al, 2001, p64). This raises a broader critic on objectivity. It is often criticized that the evaluator takes account of the opinions of the actors with only little consideration of the self-perception of those actors that use their own criteria of evaluation (White, 2010). However, problems of value conflicts, for example on the meaning of the concepts of worth, merit, standard or interest, cannot be easily solved.

Measuring impacts

Chambers (1997) argues that, under a participatory approach, actors can be asked numerous questions by the evaluator in order to inform impacts of the program intervention. This thesis partially supports this position. A participatory approach can inform on the different changes (impacts but also outcomes) resulting from the program intervention. Changes can be asked directly to actors, but all the more important is the possibility of tracing back the detailed

pathway by which outcomes and impacts were generated. The study of this detailed pathway allows confirming that the outcomes and impacts acknowledged by stakeholders effectively resulted from the research intervention, either directly or indirectly. That said, we should also emphasize the difficulty of measuring the impacts as such, in a participatory way. In the Camargue case, this issue was not tackled in a participatory way as it would have been hardly difficult to add a specific and extensive session on impact measurement during the first or second workshop. Additionally, a third workshop would most probably have failed, with a low participation from participants. Indeed, with the completion of the two workshops, stakeholders already contributed significantly to the study; and the second workshop was already quite challenging in terms of keeping the participants involved and concentrated.

Scientific quality and dominance biases

The scientific quality of participatory approaches is sometimes called into question (Ryan, 1998; Cleaver, 1999). In our view, however, the evaluator remains responsible for the quality of the work performed; and the same means as those used for non-participatory approaches may be used. That is the reason we endeavored in the Camargue case, for instance, to triangulate as much as possible the different information collected and thus to obtain more robust results. The information triangulated came from workshops, in-depth individual interviews, and from the literature and publicly available documents. The information collected out of the workshops served to validate the different pathway links using the hoop test (process tracing approach), that is, through identifying additional evidences on the occurrence of the diverse pathway links. These evidences are the necessary conditions making the respective pathway links happening. We also attempted, during the whole procedure of evaluation, to solve challenges that were not clearly addressed by our general approach. These challenges concerned in particular the way workshops are moderated (see next section).

Moreover, the literature stresses that discussions can be dominated and biased when diversity in workshops is lacking, due to two reasons: (1) non-balanced power among the different involved stakeholders (implementers and beneficiaries or targeted actors), and (2) not all experiences and views are taken into account (Mathie and Greene, 1997). However, we should emphasize that Leeuw (2003), in the context of impact assessment and pathway drawing, rather advocates for a minimization of the actors' diversity within sub-discussion groups, in order to maximize convergence of opinions while maximizing divergence between the sub-groups. The

author also advocates to reunite the sub-groups, in a second step, in order to generate a rich debate around (very) different perceptions and interpretations, and to find a compromise between these diverse views.

7.2.2.3 *Challenges encountered during the evaluation process and strategies undertaken*

The challenges we have been faced with during the evaluation process were of two different types: (1) getting stakeholders involved in workshops, and (2) implementing these workshops.

Involvement of stakeholders in workshops

We encountered the difficulty of getting stakeholders involved in workshops in both the Camargue and Bulgarian case. Three reasons have been identified in that respect:

1. The heavy schedule of the actors;
2. The geographic distances between actors so that it was difficult to reunite all of them in one place;
3. A lack of interest in the evaluation conducted and a lack of perceived benefits from participation. We hypothesize that farmers are more interested in short term issues although impacts happen on the mid and long-term.

Different strategies have been followed to cope with these difficulties. The most important strategy was to provide incentives to get stakeholders involved in workshops. The incentives used were of two types: (1) addressing different topics of interest for stakeholders; these topics being not necessarily directly linked to the "exercise" of the evaluation ([48]), and (2) providing foods and drinks. In the Camargue case, for instance, a break of 30 minutes was made in the middle of the second workshop, where foods and drinks were offered to participants, which was very well appreciated. From our experience, this allowed keeping the invitees concerned.

[48] In the Camargue case, a session of around 30 minutes was about improvements to be brought into future research programs. This session was very well appreciated.

Implementation of workshops

The implementation of workshops requires the presence of a good facilitator. This appeared particularly important in the Camargue case given the level of conflict within the territory. Tensions were expected between local actors during the workshops, which effectively happened to some extent [between INRA and the French Center of Rice (CFR)]. Significant resources were invested to get an excellent facilitator involved in the second workshop in which a wide range of actors was invited. This facilitator had to be very well skilled but also thoroughly informed on the aim of the workshop in order to face with probable conflicts but also to limit potential dominance biases. The facilitator tried to moderate the discussions by undertaking diverse strategies: (1) announcing clearly in advance the agenda as well as the time needed for each of the subjects and their aims, (2) summarizing the discussions at key stages (after each extensive discussions), (3) temperate people who already talked considerably, (4) asking stakeholders at the beginning of each session if everything was clear and whether they agree on the topic to be discussed, (5) suggesting alternatives to the original plan. All of these strategies appeared useful to drive the discussions, temperate some of the people, and minimizes dominance biases; but have remained insufficient. Despite all these efforts, producers have dominated the discussions over researchers from INRA, CIRAD (International Agricultural Center for Development) and CFR. The level of participation from farmers was higher than expected in terms of the number of attendants. Results were probably biased to some extent because researchers' views were not satisfactorily expressed compared to farmers' statements, and with calm and serenity.

The conduct of the Hoop test (process tracing approach), later in the evaluation process, was crucial to reduce or prevent these biases. This test allows confirming pathway links by identifying evidences of their validity. These evidences are the necessary conditions required to make these pathway links happen.

7.2.3 Recommendations on how to evaluate the impacts of the research on innovation processes associated to the transition to organic farming

In this thesis, methodological developments have been made (further information in the first, second and third article; part 4, 5 and 6), in order to ex-post evaluate the impacts and contribution of the research on innovation processes and by extension on the society, in relation to the transition to organic farming. The previous sections further discuss these different developments. This section is not intended to recall all aspects on the developed approach. Instead, we make 4 key recommendations for policy makers, researchers, and stakeholders, based on main results and their interpretation and for evaluating innovation processes linked to the transition to organic farming and related societal impacts (not restricted to ex-post evaluation).

1 - To involve researchers and key stakeholders at the onset of the research program

In both of the case studies considered in this thesis, the way by which research results would / could be utilized by beneficiaries was not very well considered at the onset of the research program. Schmidt et al (2016) also have shown this in the EU IMPRESA project on the basis of six case studies conducted in the EU.

Potential main drivers and disabling factors of the innovation processes may have been identified earlier, and more suitable strategies be defined accordingly. Unexpected drivers could also be highlighted in the course of innovation processes and therefore allow for a revision of the research program (of the intervention).

Both key researchers and stakeholders (relevant advisors, intermediaries…) should first be identified and involved at the design phase and early stages of the program's implementation. Participatory stakeholder workshops can then be organized to tackle these issues, using the OM method (Earl et al. 2001). This may allow producing more appropriate outputs, outcomes, and long-term impacts.

2 – To allow flexibility into research programs to adapt to unexpected developments during innovation processes

In the Camargue case, the process of diffusion went beyond what was initially expected. In effect, Camargue producers needed an access to new outlets and markets in order to sell their organic rice but also other organic cereals like wheat. This was of paramount importance to permit them adopting innovations which in turn allowed their transition to organic farming. This new access to market was rendered possible by the creation of the firm BIOSUD, specialized in collecting and selling organic products. The literature confirms that outcomes may arise from other factors than research or from research activities that were not identified or considered at the onset (Rogers and Weiss, 2007; Mayne, 2008).

This means that enough flexibility should be granted to research programs to allow for changes in the way innovation processes operate and to achieving accurate outcomes and impacts. These modifications may arise from stakeholders' feedback analysis or from a "simple" observation of the innovation development. This also means that stakeholders and researchers should collect intermediate results during the program implementation.

3 - To regularly monitor research outputs and outcomes during the time span of the research program

The previous recommendation implies evaluating regularly outputs and outcomes in the course of the research program. The OM method (Earl et al. 2001) can be used to this purpose. This requires, in turn, a good availability of documents on the research program, including its key results. Although a key informant from INRA was available in the Camargue case and despite of the conduct of two workshops and of a feedback round, collecting information on expected and observed results of the research program investigated remained challenging.

Data collection tools and protocols should be developed at the onset of the research program view a view to monitoring research outputs and outcomes. Stakeholders and research institutions should ensure the long-term access and safe storage of the documentation to facilitate the conduct of an ex-post impact evaluation.

4 - To conduct an ex-post participatory impact pathway evaluation

This thesis aims at developing an approach to ex-post evaluate the impacts and contribution of research programs on innovation processess and the society, in relation to the transition to organic farming. Results show the necessity of performing such an analysis by using a participatory approach, based on PIPA, and in focusing strongly on the role played by the network of actors, with a view to identifying the outcomes and impacts as well as the enabling and disabling factors along the innovation process. Midmore (2017, p619) also underlines the attractiveness of approaches based on PIPA despite of its high cost (extensive work required). Moreover, given the participatory nature of the approach, we recommend to employ an excellent facilitator to moderate workshops. Additionally, potential participants should be invited by offering them some kinds of incentives during the workshop like foods, drinks, and session(s) dedicated to subjects of high interest for farmers (not necessarily linked to the ex-post evaluation of the research program under review).

Results derived from this analysis are of interest for funders, research institutions, policy makers, and more generally for stakeholders for accountability and to improving current and future research programs that intend to support innovations for the transition to organic farming systems. The EU IMPRESA project has shown this. The next section 7.3 will describe more concretely how the results obtained allow to better understand the transition to organic farming and to draw pertinent recommendations to foster this transition.

7.3 Contribution of the approach in understanding the transition to organic farming

In this section, we first discuss a way of deepening our approach, based on the critics made in the last section. Then, we question the contribution of the approach in understanding the pathway undertaken by the research intervention.

7.3.1 Towards a way of deepening the approach to better understand the contribution of the research in the pathway

It was identified the need to deepen our knowledge on the extent to which the activities, outputs and outcomes are explaining the process of adoption and achievement of impacts. There is also a need to generate more knowledge on the extent to which the research as such (the research can be represented in every component of the pathway) did contribute in achieving the different constituents of the pathway. The rationale of this is to inform better stakeholders, researchers and policymakers on how to improve the innovation process and impacts by focusing on key activities, producing suitable outputs, and enabling a favorable environment e.g. in developing markets. In the next paragraphs, we discuss how our approach can be ameliorated by using a "scoring system", which was developed to characterize the strength of the different pathway links (scoring from 0 to 3). We first present a way of calculating the contribution of the research in achieving the different components of the pathway; before proposing a way of calculating the contribution of the different components (whatever the role played by the research) in reaching subsequent ones and in turn the aggregated outcome8 "adoption of the organic production mode" and impacts. The calculations made have then been converted into words according to a Likert scale (Brown, 2010) and a scoring from 0 to 4.

TABLE 18 explains how this conversion was done. The rationale is to avoid making interpretations with very precise numbers expressed in percentage, which should rather be considered as estimations. Results of the calculations are presented in TABLE 19.

- Contribution of the research in reaching the different pathway components

$$CRy = \sum \left(\frac{SLy}{\sum SLy}\right)(CRxj)$$

; Where,
We consider the pathway link(s) PLx_jy, from an event x_j to the event y,
CRy is the contribution of the research in achieving the event y,
CRx_j is the contribution of the research in achieving the event x_j of the link(s),
SLy is the strength of the PLx_jy in achieving the event y.

FIGURE 10 is an example where all activities are fully derived from the research. The black arrow is rated by 1 "point" (out of 3 possible "points") and the red arrows are rated by 3 "points".

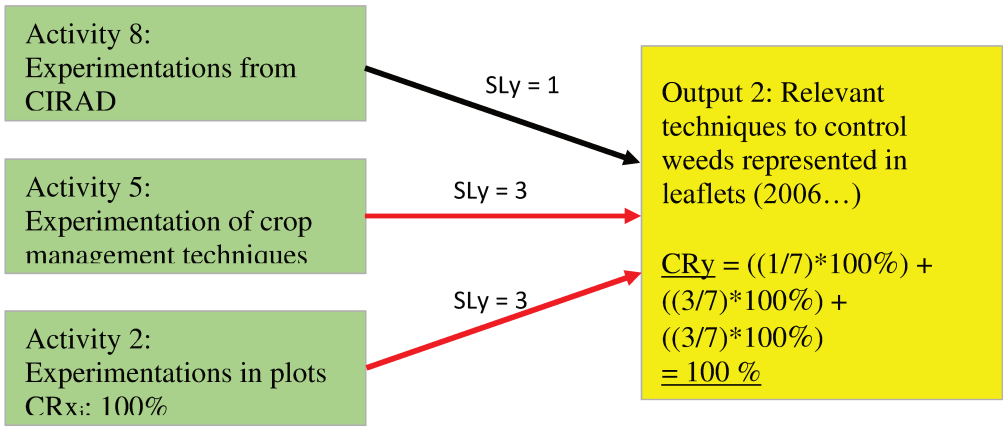

FIGURE 10: EXAMPLE OF CALCULATION : CONTRIBUTION OF THE RESEARCH ACTIVITIES 2, 5 AND 8 IN ACHIEVING THE OUTPUT 2

- Contribution of the different pathway components in reaching subsequent events and in turn the outcome 8 and impacts

  - In reaching subsequent events

$$CCyt = \left(\frac{SLyt}{\sum SLyt}\right)(100)$$

; Where,
We consider the pathway link(s) PLx_jyt, from an event x_j to the event yt;
CCyt is the contribution of an event x_j in achieving the subsequent event yt;
SLyt is the strength of the PLx_jy in achieving the subsequent event yt..

When at least one event separates the event x_j to outcome 8 and impacts; the below formula should then be used to calculate the contribution of the event x_j to outcome 8 and impacts. In the opposite case, the previous formula must be used.

- In reaching the outcome 8 and impacts

$$CCt = \sum(CCyt)[(CCyu) + (CCyv) + (CCyw) + (CCyx) + (\dots)]$$

; Where,
CCt is the contribution of the event x_j in achieving the outcome 8 and impacts;
CCy is the contribution of the event y (t, u, v, w, x, etc) in achieving outcome 8 and impacts;
And where yu, yv, yw, yx, etc, are the events that are directly connected to yt.

Contribution of the research / contribution of pathway components in reaching the outcome 8 and impacts	Conversion into words	Scoring (/4)
= 0	Not important at all.	0
< or = 20	Of little importance.	1
]20 to 45]	Of average importance.	2
]45 to 70]	Very important.	3
]70 to 100]	Absolutely essential.	4

TABLE 18: CONVERSION INTO WORDS OF THE CALCULATIONS MADE ON THE CONTRIBUTION OF THE RESEARCH

Pathway component	(A) Contribution of the research		(B) Contribution in reaching the outcome 8 and impacts	
	%	Into words / Scoring	%	Into words / Scoring
Activity 1: Participative approach and diagnosis on agronomic conditions (CEBIOCA)	100%	Absolutely essential (4/4).	17%	Of little importance (1/4).
Activity 2: Experimentations in plots	100%	Absolutely essential (4/4).	19%	Of little importance (1/4).
Activity 4: Training sessions (ORPESA)	100%	Absolutely essential (4/4).	13%	Of little importance (1/4).
Activity 5: Experimentation of crop management techniques	100%	Absolutely essential (4/4).	3%	Of little importance (1/4).
Activity 6: Experimentations made by farmers	0%	Not important at all (0/4).	24%	Of average importance (2/4).
Activity 7: International conference on rice in 2011	100%	Absolutely essential (4/4).	0%	Not important at all (0/4).
Activity 8: Experimentations made by CIRAD	100%	Absolutely essential (4/4).	2%	Of little importance (1/4).
Output 1: Typology of farms; farmer's problems and constraints known	100%	Absolutely essential (4/4).	15%	Of little importance (1/4).
Output 2: Relevant techniques to fight weeds represented in leaflets	100%	Absolutely essential (4/4).	9%	Of little importance (1/4).
Output 3: ORPESA leaflets	100%	Absolutely essential (4/4).	4%	Of little importance (1/4).
Output 4: Knowledge on weeds	33%	Of average importance (2/4).	5%	Of little importance (1/4).
Outcome 1: Growing influence of INRA	100%	Absolutely essential (4/4).	6%	Of little importance (1/4).
Outcome 2: Stronger relationships between CIRAD and SudCéréales	100%	Absolutely essential (4/4).	0%	Not important at all (0/4).
Outcome 3: Growing influence of CIRAD	100%	Absolutely essential (4/4).	3%	Of little importance (1/4).
Outcome 4: More exchanges and links in the network	100%	Absolutely essential (4/4).	10%	Of little importance (1/4).
Outcome 5: Development of crop rotation	33%	Of average importance (2/4).	13%	Of little importance (1/4).
Outcome 6a: False seed-bed techniques	48%	Very important (3/4).	9%	Of little importance (1/4).
Outcome 6b: Seeding and flooding at a later period	48%	Very important (3/4).	9%	Of little importance (1/4).
Outcome 6c: Increased level of water in rice fields	48%	Very important (3/4).	9%	Of little importance (1/4).
Outcome 6d: Increased plant density	0%	Not important at all (0/4).	4%	Of little importance (1/4).
Outcome 7: Growing awareness on environmental issues	0%	Not important at all (0/4).	4%	Of little importance (1/4).
Outcome 9: Institutionalisation of the supply chain	9%	Of little importance (1/4).	13%	Of little importance (1/4).
Outcome 10: Evolution scenarios for organic rice area	9%	Of little importance (1/4).	0%	Not important at all (0/4).
Initial farmers' skills about crop rotations	0%	Not important at all (0/4).	4%	Of little importance (1/4).
Good selling price for organic rice	0%	Not important at all (0/4).	13%	Of little importance (1/4).
Demand Growth for organic rice	0%	Not important at all (0/4).	26%	Of average importance (2/4).
CAP payments for organic surfaces	0%	Not important at all (0/4).	13%	Of little importance (1/4).
Outcome 8: Adoption of organic farming	27%	Of average importance (2/4).	-	
Impact 1: Increase in incomes	27%	Of average importance (2/4).	-	
Impact 2: Decrease in the use of water	27%	Of average importance (2/4).	-	
Impact 3: Decrease in the use of fuel	27%	Of average importance (2/4).	-	
Impact 4: Increase of the organic rice area	27%	Of average importance (2/4).	-	
Impact 6: Decrease in the use of pesticides	27%	Of average importance (2/4).	-	
Impact 7: Decrease in the use of nitrogen	27%	Of average importance (2/4).	-	

TABLE 19: CONTRIBUTION OF THE RESEARCH AND PATHWAY COMPONENTS ALONG THE TRANSITION TO ORGANIC FARMING

These calculations will be considered in the next sections of this discussion part in order to illustrate the importance of the different components of the impact pathway. TABLE 19 is a scoreboard where it can easily be identified the components in the pathway for which the research has the most contributed to, as well as the most important elements that drive the innovation process and achievement of impacts. We observe for example that the contribution of the research to the development of crop rotations systems was of average importance (2/4). Regarding the contribution of the different components of the pathway in reaching the aggregated outcome 8 "adoption of the organic production mode" and the impacts, the most influential research activities seems to be the CEBIOCA project ("of little importance" – 1/4), the first experimentations ("of little importance" – 1/4), and the training sessions between researchers and farmers – ORPESA ("of little importance" – 1/4). That said, the calculations show a higher importance of the farmers' trials conducted independently ("of average importance" – 2/4). External economic factors are also quite influential compared to the other elements: the good selling price for organic rice ("of average importance" – 2/4), the demand growth for organic rice ("of little importance" – 1/4), and the CAP payments for organic surfaces ("of little importance" – 1/4).

These calculations provide an estimation of the contribution of the research along the impact pathway as well as on the extent to which the diverse pathway components determine outcomes and impacts. This quantitative assessment may help to communicate results, especially to policy makers. Although qualitative research is worth in explaining the complex, the use of a "simple language" and "point estimates" may be easier to communicate to policy makers (Marmot et al. 2004; Brownson et al. 2006). There are different and sometimes opposite goals, expectations, perceptions, and attitudes towards information between scientists and policy makers. The research is a long-term effort, but policy makers do not work to the same time scale as researchers. "Policy makers usually have short tenure managing projects, and will move on quickly to other files, to build up their repertoire of expertise in a wide variety of different areas" (Marmot et al. 2004, p633).

The results indicated in TABLE 19 are potentially easier to communicate but should be interpreted with cautious. For example, a pathway component could only marginally contribute to outcomes and impacts according to the calculations made, but be in reality crucial to the process. This situation could happen when several pathway components contribute to the same

outcomes and impacts. The extent to which a pathway component determines a subsequent one is informed by our approach, according to a scale from 0 to 3 (stakeholders were asked in face-to-face interviews to inform this). However, there is doubts regarding of whether the former event was crucial or not to the process (a crucial component cannot be removed from the process without breaking it up). Counterfactual questions were asked to stakeholders with the aim to solve this issue but stakeholders in the Camargue, especially farmers, encountered difficulties in interpreting "imaginary situations". The literature also stresses the difficulty to predict the situation that would have taken place in case a particular event would not have happened. "It is extremely difficult to ask counterfactual questions in interviews or focus groups; try asking someone who is currently participating in a public program: "What would you be doing now if this program did not exist?" […] It is unlikely to provide a credible evaluation on its own" (Baker, 2000, p21). Whitehead and Blomquist (2006) also underscored the difficulty for respondents to answer counterfactual questions given that they are placed in a "fictional situation".

We must also emphasize that the calculations made are not sufficient by themselves; they need to be complemented by qualitative information to help explain how the impact pathway is being developed and for which reasons. Finally, the calculations made are quite time consuming as no model is yet available to compute results automatically. It could be interesting to elaborate such a model in the future to facilitate and quicken the process. The calculations are especially difficult to make when there are feedback loops between pathway components, i.e. when two components are interrelated.

- Example of feedback loop and calculation of the contribution of the research

We consider the outcome8 (adoption of organic farming) and the outcome 9 (institutionalization of the supply chain). Outcome 8 partly leads to outcome 9; and outcome 9 partially leads to outcome 8. A total of 23 "points" goes to outcome 8 (sum of the strength of the links reaching the outcome 8); and a total of 9 "points" goes to outcome 9 including 6 "points" coming from factors external to research. All of the pathway components contributing to outcome 8 and 9 are represented in the comprehensive pathway diagram in appendix 10.4. The equations below refer to the contribution of the research in achieving the outcome 8 and 9.

(1): Outcome 8 $= \left(\frac{3}{23}\right)(\text{outcome 5}) + \left(\frac{1}{23}\right)(\text{activity 4}) + \left(\frac{2}{23}\right)(\text{outcome 6a}) + \left(\frac{2}{23}\right)(\text{outcome 6b}) + \left(\frac{2}{23}\right)(\text{outcome 6c}) + \left(\frac{1}{23}\right)(\text{outcome 6d}) + \left(\frac{1}{23}\right)(\text{outcome 7}) + \left(\frac{2}{23}\right)(\text{outcome 4}) + \left(\frac{3}{23}\right)(\text{outcome 9})$.

(1'): Outcome 8 $= \left(\frac{3}{23}\right)(33\%) + \left(\frac{1}{23}\right)(100\%) + \left(\frac{2}{23}\right)(48\%) + \left(\frac{2}{23}\right)(48\%) + \left(\frac{2}{23}\right)(48\%) + \left(\frac{2}{23}\right)(100\%) + \left(\frac{3}{23}\right)(\text{outcome 9})$.

(2): Outcome 9 $= \left(\frac{3}{9}\right)(\text{outcome 8})$.

We now replace the outcome 9 in **(1')**.

(3): Outcome 8: $= \left(\frac{3}{23}\right)(33\%) + \left(\frac{1}{23}\right)(100\%) + \left(\frac{2}{23}\right)(48\%) + \left(\frac{2}{23}\right)(48\%) + \left(\frac{2}{23}\right)(48\%) + \left(\frac{2}{23}\right)(100\%) + \left(\frac{3}{23}\right)\left(\frac{1}{3}\text{outcome 8}\right)$.

(4): Outcome $8 - \left(\frac{3}{23}\right)\left(\frac{1}{3}\text{outcome 8}\right) = \left(\frac{3}{23}\right)(33\%) + \left(\frac{1}{23}\right)(100\%) + \left(\frac{2}{23}\right)(48\%) + \left(\frac{2}{23}\right)(48\%) + \left(\frac{2}{23}\right)(48\%) + \left(\frac{2}{23}\right)(100\%)$.

(5): $0.95652(\text{outcome 8}) = 25.51\%$.

(6): Outcome 8 $= \left(\frac{25.51}{0.95652}\right) = 27\%$.

The research contributes to around 27% in reaching the outcome 8.

We now replace outcome 8 in **(2)**.

(2'): Outcome9 $= \frac{1}{3}(27) = 9\%$.

The research contributes to around 9% in reaching the outcome 9.

7.3.2 Understanding the effects of the research intervention in Camargue

It was emphasized along the thesis that the research program on the transition to organic farming in the Camargue played an important role in developing the actor network (further information in the first, second and third article; part 4, 5 and 6). Particularly, the influence of INRA and CIRAD has increased over time. In accordance with the results of the SNA and the second round of face-to-face interviews with farmers (further information in the first & second article, part 4 & 5), the exchanges between farmers and INRA can be qualified as "important" and the exchanges between farmers and CIRAD as "minor". The discussions with INRA were however indicated as "informal" by farmers. The main reason is that these discussions were not based on "evidences"[49] derived from "real"[50] scientific experimentations nor in relation with specific local conditions of each farm. Farmers think the information provided was too vague for immediate up-taking.

The adoption of the technical incremental innovations was principally derived from the "tests" set by farmers (refinement and optimization of the rice production system) and, to a more limited extent, from leaflets produced by INRA (further information in the first article, part 4). These leaflets were built on the basis of the experimentations and the ORPESA "Table"[51]. The latter could occur thanks to the involvement of international partners (further information in the third article, part 6). This enrolment was made possible by the help of the leaflets produced, in which the scientific knowledge is represented and that were distributed to potential partners worldwide. Later on, one partner from Spain contacted INRA, which allowed the ORPESA project to be developed (project consisting of training sessions between farmers and researchers). Interestingly, farmers emphasized that the research did not influence at all the decision of increasing the plant density whereas this technique was also described in the leaflets produced by INRA. Similarly, all incremental techniques for controlling weeds were the subject of an INRA communication orally but farmers did not much recognize this (further information in the first article, part 4).

[49] Farmers reported that INRA and CIRAD did not communicate orally precise results regarding experimentations. In addition, farmers were not able to quote any precise advice they have received orally from INRA and CIRAD.
[50] Experimentations conducted by INRA were not very scientific, farmers said.
[51] Within the second focus group, farmers highlighted that the ORPESA table was linked to farmer's transition to organic production. However, only two farmers out of a total of 12 confirmed during the second round of face-to-face interviews. In addition, if they have confirmed it, they stressed its low importance.

These results raise two important social aspects (further information in the first article, part 4). First is the type of communication support (orally, leaflets, documents) utilized. Second is the way by which farmers receive the information (door to door talking; through plenary sessions; and by phone, post or mail). In the present case, the fact that INRA did not send leaflets to farmers, but left them at the CFR for free consultation, may explain the lack of outreach to producers. In addition to this, there was a lack of precision in the advices provided in leaflets although the recommendations were more precise, farmers said. The crux of the problem are the very specific and heterogeneous local conditions in the Camargue, which reduce the effectiveness of generalized information to all the farms. Moreover, INRA is more acknowledged by farmers who hosted a part of its scientific experimentations (they rated a double score of relationships with INRA when asking information for SNA). They recognized more the relevance of the techniques developed and their appropriateness to local conditions.

Several CRP[52] were identified in the impact pathway (further information in the first article, part 4):

- The whole research program would probably not have taken place without one key researcher from INRA;
- The first experimentations (2005-2006) would not have happened without the CEBIOCA project (identification of agronomic problems) and related results;
- The ORPESA "Table" (training sessions) would not have occurred without the first experimentations made (2005-2006), and therefore without the CEBIOCA project and related results;
- The ORPESA leaflets and the international conference on organic rice systems in Montpellier would respectively not have been produced and held without the ORPESA project and thus without CEBIOCA, its results, and the first experimentations;
- The advanced experimentations (2011) on crop management techniques would not have been conducted without the ORPESA project. By extension, they would not have been done in absence of the CEBIOCA project and its results as well as of the first experimentations (2005-2006);

[52] Reminder: CRP are the pathway links that would not have been "activated" without the research.

- The growing influence of INRA and CIRAD in the network would not have occurred without the CEBIOCA project and the first experimentations in farming plots (2005-2006). In fact, these two activities were crucial in the chain of events leading to the increasing influence of INRA and CIRAD in the network;
- The increasing volume of interactions in the network (more exchanges and links) would not have happened, or to a very limited extent, without the growing influence of INRA over time.

From the above, three crucial events are: (1) the CEBIOCA project, (2) the results of the CEBIOCA project, and (3) the first experimentations conducted in farming plots. By contrast, the incremental technical and institutional innovations (false seed-bed techniques, seeding and flooding at a later period, increase in the level of water in paddy fields, extended crop rotations, and institutionalisation of the supply chain) would probably have occurred to some extent in absence of the research, in the same way as for the conversion to organic production. This conclusion cannot be fully confirmed but we observed that the CRP are only situated within the research system and between activities and outputs. This emphasizes that even though the research produced outputs, the latter have led to outcomes and impacts to a relatively minor extent.

Furthermore, the transition to organic farming appears to be a long process in the Camargue (further information in the first & third article, part 4 & 6). After 15 years of significant research on organic rice systems, the rate of adoption was not exceeding 14% in 2014. Also, a few farmers converted to organic farming before the research program under review was launched so that it was also not a completely new phenomenon.

Then, the understanding of the contribution of the research can be deepened on the basis of the calculations presented in the previous section. The research has fully contributed to output1 (typology of farms, farmers' problems and constraints known), output2 (relevant techniques to control weeds, embodied into leaflets) and to output3 (ORPESA leaflets). The evidence is that in absence of the research these pathway components would not have happened. Furthermore, the research contributed very significantly ("very important" – 3/4) in developing most of the technical innovations (false seed-bed techniques, seeding and flooding at a later period, increased level of water in paddy fields). The research contributed less ("of average importance" – 2/4) in developing crop rotations, and has not contributed at all to the increase

in the plant density of rice. If the CRP would not have been present, the consequences on the impact pathway would have been relatively limited, in the sense that the outcomes and impacts would still somewhat take place. However, it is difficult to say to what extent their magnitude (rate of adoption, degree of impacts, etc.) would have been different; we can only affirm that their magnitude would be lower. We are not able to conclude that if the research would not have happened the rate of adoption of the technical innovations mentioned above would have been two times lower. In effect, the absence of the research may not have allowed those technics to develop sufficiently and therefore the rate of adoption could be null ([53]). It is also not possible to say for example that the technical innovations developed would have been two times less relevant. TABLE 19 also shows that the research contributed well ("of average importance" – 2/4) to the adoption of organic farming and the achievement of impacts. Again, it is difficult to tell exactly what the situation would have been in absence of the research intervention. We can however conclude that there is a non-negligible contribution of the research on the whole process.

Influence of the research	CRP (the links that would not have been "activated" without the research)	Enabling factors	Disabling factors
Rather direct	**The research program on Camargue organic production systems would probably not have taken place without one key scientist from INRA**. **Experimentations in farming plots (in 2005-2006) would not have happened without the CEBIOCA project and related results**. INRA would not have set up suitable experimentations without being aware of organic production systems and the main issues to be studied. **The ORPESA table would not have occurred if the CEBIOCA project and experimentations in farming plots had not taken place**. INRA would not have been able to participate without being aware on organic rice production systems, issues to be studied, and possessing significant knowledge.	**The Problematizing is crucial** in the process of translation at the initiation phase but also during the phase of implementation. **Participatory training sessions (ORPESA project) were useful for participants** (ideas shared, new relevant scientific experiments suggested). That said, only a few farmers attended. **Enrollment of partners from the international community.** **Trust between farmers and INRA's researchers** at the beginning, for the implementation of the on-farm trials. **Leaflets, scientific articles and various documents** in which the knowledge created is represented in order **to get funded and enroll international partners.** **On-farm trials** for **direct visualization** of the results.	**Lack of involvement of the CFR**: Farmers saw this as a **barrier** to them converting to organic production.

[53] The perception of the beneficiaries on counterfactual situations can be called into question given the difficulty to imagine hypothetical scenarios.

Influence of the research	CRP (the links that would not have been "activated" without the research)	Enabling factors	Disabling factors
	The advanced scientific experimentations would not have happened without the ORPESA project which proposed avenues for improvements.	**Face-to-face meetings between researchers and farmers.** **Proposals (tenders) to get funded and involve partners** around research objectives.	
Rather indirect		**Creation of the firm BIOSUD in 2003**, which has supported farmers' conversion mainly through increasing the storage capacities for organic products. **Extending crop rotations** is crucial for switching to organic farming.	
None		**CAP subsidies** for conversion to and maintenance of organic areas. **Price of organic rice**; with an important price difference of around 100% with conventional rice. **"Trials" conducted by producers annually have** allowed them to bring knowledge in the ORPESA sessions.	**Absence of peer-to-peer exchanges between farmers** ("close mentality).

TABLE 20: SUMMARY ON CRP AND KEY ENABLING & DISABLING FACTORS IN THE CAMARGUE CASE STUDY

Finally, the identified impacts of the research are as follows (further information in the first article, part 4):

- The surface under organic rice production has steadily increased and attained 1400 ha in 2014;
- The number of organic rice producers has reached 16% of the total number of rice producers by 2014;
- The fall in the use of pesticides with a decrease in the Treatment Frequency Index (TFI[54]) of around 51% at the farm level;
- The reduction in the water used was about 45% at the farm level;
- The diminution in fuel[55] consumption of about 17% at the farm level;
- The decrease in nitrogen requirements of about 24% at the farm level;

[54] TFI equals the ratio of the dose sprayed to the highest authorized dose. The approved doses were found on the official website: e-phy.agriculture.gouv.fr.

[55] We asked farmers to report their technical itineraries with the material used. We then calculated the consumption of fuel based on the "barème d'entraide" (scoring grid) of the French Chamber of Agriculture.

- An increase in net margins per hectare (higher selling prices) of about 111% on organic crop productions, without taking account of the single payment entitlements;
- A reduction in the total surface devoted to rice (conventional and organic) of about 45% at the farm level.

Our approach vs. the models used by Lopez et al in "Multi-Scale Integrated Assessment of Regional Conversion to Organic Farming (OF)"

The paper of Lopez et al (2014) aims at answering two important questions, from an ex-ante perspective: (1) whether the conversion to organic agriculture in the Camargue is possible, and (2) what the social, economic and ecological impacts, at different scales, could be. The authors discuss the potential of three different methods: the Agent-Based Models (ABM), Bio-Economic Models (BEM), and the models of Land-Use Change (LUC).

The combined use of these models shows that the transition to organic farming in Camargue may mostly happen on diversified cereal farms. It also shows that the productivity would be maintained and the negative impacts on the environment be decreasing. These models are very interesting and show different possible trajectories in terms of economic performance, depending on market prices scenarios. LUC allows identifying, where in the Camargue, changes would most probably occur. Also, the ABM "makes it possible to study the interaction between the resources and the agents' decisions in a dynamic manner and to calculate the impact of these decisions at different aggregation levels" (Lopez-Ridaura et al. 2014, p456).

These models appear more suitable than econometric models using for example the Total Factor Productivity (TFP), but are somewhat weak in describing the detailed mechanisms by which rice producers are being converted their farms to organic farming. Particularly, it must be emphasized the absence of the scientific research in the models considered. Is the scientific research not helping farmers to convert? Is the process only driven by economic and/or militancy motivations? The answer given by this thesis is "no". Scientific research, by the help of scientific experimentations, on-farm trials in close collaboration with farmers, training sessions and informal talks with potential adopters, contributes to the transition towards organic rice farming systems. TABLE 19 indicates that the research intervention in the Camargue has contributed relatively well to the process from 2000 to 2014.

There is a potential for future research to investigate how our comprehensive approach may feed the combined models used by Lopez et al, in order to predict (ex-ante) the pathway of the transition to organic farming and its impacts. This, in turn, may help setting up more suitable agricultural policies and designing well ex-ante research

programs. A possible way of integrating the different approaches may be to consider the "research" as a resource as such; this may be done with the ABM. However, the research produces by essence unpredictable results. Examples of variables that could be used to characterize the research, but that need to be further elaborated, are: number of researchers working at full time on the topic; level of aptitude of the researchers (e.g. ability to do relevant searches); degree of usefulness of what the researchers produced in terms of outputs so far; degree of interactions between farmers and researchers; degree of involvement of the CFR (exchanges, research); etc. This area of research would however require a very significant additional amount of work in order to set up an appropriate approach. This is an opportunity for future research.

7.3.3 Recommendations on how to improve the pathway of the research intervention

The literature on the transition from intensive to organic farming is scarce. Furthermore, this literature often focuses on the motivations, attitudes, and impacts of the conversion as compared to conventional agricultural systems (Lamine and Bellon, 2009). Studies often lead to a simplistic antagonism between militancy motivations or value-oriented farmers on the one hand and farmers determining themselves depending on market opportunities on the other (Fairweather, 1999; Darnhofer et al. 2005; Best, 2008). This relatively simple opposition is also represented by the difference made between motivated and "pragmatic" farmers; the latter being more likely to abandon organic farming in case of economic disturbances and to revert to a conventional production mode (Fairweather, 1999; Darnhofer et al. 2005). These studies do not allow a very good understanding of the conversion process and its determinants, and underestimate the significance of the intermediate and long-term elements along trajectories (Lamine and Bellon, 2009).

Through the different methodological developments made in this thesis (further information in the first, second and third article; part 4, 5 and 6), we bring a more comprehensive and alternative way of understanding the pathway from intensive to organic agriculture. In effect, we trace back the complex process, emphasize the trajectories and detailed mechanisms along the pathway towards organic farming systems. In addition, we integrate the role played by the research actors all along the pathway and not only in terms of productivity e.g. in calculating the TFP. Finally, the trajectories are being formalized in a pathway diagram, which allows identifying key milestones, when they happen, and how they can be triggered.

Based on the knowledge generated by the approach developed, nine recommendations are proposed thereafter with a view to enhancing the adoption process and increasing the impacts of the transition to organic agricultural systems. These recommendations apply for policy makers, researchers, and stakeholders. We take account of both the French Camargue and Bulgarian case study. The latter is however only considered on the basis of the third paper of the thesis (part 6).

1 - To problematize the issue to be tackled before implementing the research program as such; the problematizing should also be refined all along the transition pathway

Both in the French Camargue and Bulgarian case, the phase of problematization appeared very important and underpinned the whole process (further information in the third article, part 6).

We recommend to spend sufficient time before implementing a research program as such in order to characterize well the problem to be tackled and guide the research in a way that will be useful for potential beneficiaries and the society as a whole. Also, the problematizing should be refined over time depending on how the research program is being implemented and operating. The third article on the interest of ANT has shown this (part 6). In the Camargue case, two sub-phases of problematizing appeared to be crucial. If the problematizing would not have been revised during and after the CEBIOCA project (diagnosis on agronomic conditions), the importance of tackling the issue of controlling weeds would not have been well considered and the research program may have been less or not successful in the end. The CEBIOCA project and the output1 (typology of farms; farmer's problems and constraints known) have not contributed considerably ("of little importance" – 1/4) to adoption of organic farming and impacts but this is not negligible either compared to the other influencing factors. The first scientific experimentations, which were done on the basis of the refined problematizing also contributed to some extent ("of little importance" – 1/4) to the adoption of organic farming and related impacts. Matt et al. (2017) also highlighted, on the basis of 32 cases of agricultural innovations conducted by INRA in the frame of the ASIRPA project, the non-negligible role played by the phase of problematization within the pathway leading to impacts. The ASIRPA project also has the particularity to refer to ANT.

2 - To identify key persons at the onset of a research program based agricultural innovations, and allow flexibility for changes in key actors during the process

It was observed in both cases that innovations are initiated and developed only by a few persons in the first phases (further information in the third article, part 6). Mostly one researcher initiated the research program for the transition to organic farming in the Camargue while two veterinarians developed the very idea of Ecostop in Bulgaria. If in the Camargue the key initiators make their research in the frame of an institution (INRA), the decision to start developing a research program on organic rice farming systems was rather taken independently by these researchers. The whole development process mostly relied on the will of one researcher, very experimented, competent and motivated. In Bulgaria, the initiators (two veterinarians) were even fully independent from any institutions and the research program was financed privately.

We advocate that, when investing into a research program based agricultural innovations, these key persons should be identified in order to enroll them at the onset and reinforce their competences for enhancing the production of outcomes & impacts. However, it should be emphasized that the most relevant actors during the research phase are not necessarily the most capable in other phases. In the Bulgarian case, the diffusion phase was mostly driven by recognized and leading farmers and not by the two veterinarians. INRA was leading the diffusion phase in the Camargue case, but this was mainly due to the unwillingness of the CFR in doing it. Stakeholders emphasized that the CFR should have been leading this task and that it would have been more efficient due to their "official" connection to rice and their central position in the Camargue territory. Similarly, results of the ASIRPA project on 30 cases evaluating the impacts of INRA's research projects suggest that "partners who are the most capable to participate in the phase of research are not necessarily the best in the other phases of the impact pathway" (Joly et al. 2014, p10). The authors conclude that "granting exclusive intellectural property rights in the first phases can considerably limit the potential of diffusion" (Joly et al. 2014, p10).

3 - The interests of the different actors from the research should primarily be aligned around goals that are beneficial for everybody. In a second step, if the trust is not sufficient, then contracts or commitments should be signed by the different parties

Trust between actors is a very important factor to allow the knowledge in the network to be disseminated and received well. It is possibly more important than procedures of monitoring and enforcement. In the Camargue case, there was no contract between INRA and farmers for the on-farms trials, but this paradoxically worked very well (further information in the first & third article, part 4 & 6). It seems that no rule is needed when the trust is high, and the results obtained can be fantastic. Still, in the Camargue case, the CFR has not participated actively in disseminating the knowledge created by INRA and has therefore disrupted the way the impact pathway operated. But would have it been better with procedures of monitoring and enforcement?

The theory of collective action (Ostrom, 2009) suggests a positive answer to this question. This is due to the fact that each actor tends to defend its own interest, which leads to a suboptimal social value overall. This is a classical game theory where actors have individually interest not to participative (to reduce costs, the time spent, etc.) while expecting from the other actors to participate. However, is this right in the specific case of the transition to organic farming? And are we really facing a collective action? A collection action is of interest when the goal to reach is beneficial for all the members. It is thus difficult to refer to the collective action theory in that specific case.

On the basis of the third article on the interest of ANT (more details in part 6), we make the recommendation to first align the interests of the different actors around goals that are beneficial for everybody. This should be done in the initial phase of the research program around the elaboration of a clear problematizing. In the same vein, Matt et al. (2017) stressed that in cases which are represented by systemic and complex defies, “the key translation mechanisms are linked to the early involvement and strong engagement of socio-economic partners with high absorptive capacity. This facilitates the process of problematization, as well as of interessement and enrolment” (p213).

In a second step, if the trust is not sufficient among the actors and/or if it is likely that some of them will not respect their engagement, then contracts or commitments should be signed

by the different parties. An analysis of the historical work done in collaboration with partners may also be done in order to define whether it is really necessary to set more rules and sign binding engagements. Finally, regular meetings between the different involved actors should be organized to maintain trust over time.

4 - Enable farmers to conduct experimentations on their farms, either independently or (preferably) in close collaboration with the research

In the Camargue case, it was identified the crucial importance of the on-farm trials but also of the trials conducted independently by farmers (further information in the first paper, part 4). The "tests" conducted by farmers individually contributed significantly ("of average importance" – 2/4) to the conversion to organic farming. Here the table of links and process tracing from our approach have been very useful to obtain these results (more details in the first paper, part 4) and thus to make the following recommendation.

We recommend that on-farms trials should be more developed in order to increase the impacts of the research. It is a way to get farmers and researchers closer, and farmers can directly visualize the results of the trials and take-up ideas which have more chance to be successful compared to "distant" results obtained from experiments in parcels with different conditions (e.g. soil structure and texture). The theory of diffusion of innovations by Rogers (1995) also stresses the importance of both the Trialability and Observability, saying that when experimentations are conducted about innovations, and results easily observable; the rate of adoption is generally higher. An innovation that can be experimented and easily visualized represents less uncertainty for the potential beneficiaries. Furthermore, studies such as JOLISAA[56] (Almekinders et al. 2012) have shown that collaborative research between producers and researchers is able to answer farmers' problems and make changes possible.

The conditions to allow farmers conducting experimentations independently should also be taken more in consideration. This may be done by encouraging the "culture of innovation" in the community by demonstrating its potential benefits. There is no competition between farmers' trials and those more driven by the research; instead, they are complementary.

[56] Joint Learning in Innovation Systems in African Agriculture.

5 - To enroll opinion leaders and regularly meet producers to maintain close relationships between research and the farmer community

It was shown in the third article (part 6), on the interest of ANT, that the fact that no opinion leader was involved in the Camargue case has probably slowed down the transition process towards organic farming. By contrast, the successful enrollment of opinion leaders from the farmer community in the Bulgarian case boosted the adoption of the innovation. This observation would not have been drawn without using ANT as a theoretical framework, which helped to explore the detailed mechanisms by which social interactions are built and producing outputs, outcomes and impacts (further information in the third article, part 6).

Based on the above, we make the recommendation that potential opinion leaders from the farmer community should be identified in the early stages of the process. Close contacts should then be established to involve them more into the research program and in the way it is being implemented. By convincing in priority opinion leaders on the interest of the research program, one may then expect from them to "naturally" convince the whole farmer community. The theory of Rogers (1995) also states that opinion leaders play a major role in activating diffusion networks. And several studies later underlined the importance of opinion leaders in diffusing innovations and/or technologies (e.g. Tuan et al. 2010; Lamine et al. 2012; Kaufmann et al. 2009; Blythe et al. 2017). It is recognized that opinion leaders possess more knowledge on the innovation and/or technology, are more innovative and less receptive to norms (Eck et al. 2011). However, it must be emphasized that only a very few of these studies focused on the transition to organic farming.

Moreover, we recommend that researchers should regularly meet farmers in face-to-face in order to maintain trust and a good level of communication, as well as finding solutions for particular situations farmers are being faced.

6 - To enroll partners from the international community even in absence of obvious and direct interest at first sight

The training sessions between farmers and researchers (ORPESA project) in the Camargue case could happen because international partners were previously enrolled (further information in the third paper, part 6). They were enrolled in particular by the means of leaflets showing scientific results on Camargue organic rice systems. Later on, one partner from Spain contacted INRA, which allowed the ORPESA project to be developed.

On the basis of the above and of the use of ANT in the third article (part 6), we recommend that, even in absence of obvious interest at first glance, researchers should have for objective to enroll as many relevant international partners as possible by providing information on how they tackle topical challenges. At least a few contacts should be established with these partners annually.

7 - To produce leaflets in which the knowledge created is represented and distribute them directly to farmers

Leaflets were created in the Camargue case in order to transcribe the knowledge and communicate it to farmers and partners. These leaflets did not have very significant effects on the adoption process and achievement of impacts, but they were not negligible either (further information in the first paper, part 4). Leaflets from experimentations and the ORPESA project (training sessions) contributed both to a relatively low extent ("of little importance" – 1/4) to conversion to organic farming and related impacts. However, they probably had some more effects as it was identified in the third article (part 6) (thanks to the use of ANT) that leaflets also contributed to the enrollment of international partners, which in turn contributed to the ORPESA activity.

We recommend to produce leaflets, in which the knowledge is transcribed, for research programs dedicated to the transition to organic farming. These leaflets may be given by hand to producers or sent by post in order for the research to keep contact and maintain trust with the farmer community at the same time. What we do not recommend is to leave leaflets for free consultation either in the research center or in partners' buildings. It was shown in the

Camargue case study that the fact of leaving leaflets at the CFR for free consultation has, at least partially, explained the lack of outreach to producers.

8 - Taking into consideration the length of the transition period and involve progressively the potential beneficiaries

The transition to organic farming is a long process (further information in the first & third article, part 4 & 6). We see in the Camargue case that after 15 years of significant research on organic rice farming systems, the rate of adoption was not exceeding 14% in 2014. It should also be noted that a few farmers converted to organic farming before the research program investigated in this thesis was launched in 2000, thus it was also not a completely new phenomenon.

We recommend not to involve potential beneficiaries in too "advanced" research activities and therefore to avoid to somewhat "brutalize" them. There is the example in the Camargue case of the training sessions (ORPESA project) among researchers and farmers, where most of the farmers expected more evidences and robust & scientific results to be shown in these sessions (further information in the first article, part 4). Also, a private organic rice trader stated that the objective of the research was too high regarding the speed of the transition process (could weaken the organic market). The latter observation was highlighted when analyzing the enrollment stage in the innovation process (further information in the third article, part 6). Moreover, it should be emphasized that, according to our "scoring system" we presented in this discussion part, the ORPESA project only slightly contributed to adoption and impacts ("of little importance" – 1/4).

If such training sessions would have to be organized again, it may be better that stakeholders first discuss in an informal workshop, around one or two specific questions, on how to improve scientific experimentations. In a second step, researchers could meet farmers individually to discuss their particular needs and interests. Advanced scientific experimentations could be done in parallel. Training sessions, similar to the ORPESA format, could finally be organized based on significant and robust scientific results.

9 - To enable a favorable economic and institutional environment to make the research intervention successful

Numerous factors, unrelated or with little connection to research, were described as important (further information in the first & second article, part 4 & 5). This was observed mainly by the help of PIPA combined with OH (ex-post assessment in reverse; looking at alternative explanations), the "scoring system", and the use of SNA.

It was recalled in this part the importance of the "tests" conducted independently by farmers. Also, market forces in the Camargue case were quite important. The demand growth and selling price of organic rice had respectively an influence of "average importance" (2/4) and "little importance" (1/4) on adoption and impacts. The institutionalization of the supply chain with the creation of the firm BIOSUD in 2003 also contributed to some extent to adoption and impacts ("of little importance" – 1/4). Furthermore, the literature shows that the evaluator should take other factors than research into account. For instance, it was demonstrated that ameliorated varieties in Asia could only be adopted by producers owning fields where the irrigation system functions well. In fact, these varieties could not be adopted without a suitable structure of production (David and Otsuka, 1994; Chataigner, 1997).

We recommend to enable a favorable economic and institutional environment to make the research intervention successful. This may be done by the help of suitable agricultural policies clearly supporting the conversion to and maintenance of organic farming systems. Furthermore, even though it functioned without public supports in the Camargue case, the institutionalization of the supply chain should be supported publicly if necessary and/or reflected in collaboration with researchers and advisers. In effect, it exists many lock-in within the supply chain structure regarding the paradigm shift towards organic agriculture (Lamine, 2011; Fares et al. 2012). The private trader Thomas in the Camargue case faced with the problem for example that the size of the grain stores was too big and not suitable for organic rice production. The company had the capacity to invest to entirely redesign the silo, and the market was favorable, but this may not always be the case.

Part 8: General conclusion

This thesis contributed to the elaboration of a comprehensive approach with a view to evaluating the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic farming. It also reported the impacts of the research in the Camargue (France) and Bulgarian case, and the way these impacts have been achieved. The Participatory Impact Pathway Analysis (PIPA) has been used as basis and significantly adapted and complemented by several methods, instruments and tools, in order to adapt this approach to ex-post evaluation, shed light on the complex mechanisms underpinning the impact pathway and the related role played by the research, but also to limit problems linked to the use of participatory approaches.

We confirm the hypothesis made that PIPA can be successfully combined with other methods from social sciences and therefore able to inform on the impacts and contribution of the research in the impact pathway. However, it is not confirmed that the contribution of the research in the Camargue case was important; it was useful but at the same time limited in scope. Another hypothesis which is confirmed is that the Social Network Analysis (SNA) can help to understand how new techniques or products are spreaded, to help draw conclusions on the role of the research actors, and to validate stakeholders' statements on actors' relationships. It is also established that the Actor Network Theory (ANT) can actually reinforce our approach by orienting evaluative questions and by deepening the understanding and role of interpersonal relationships between actors in the innovation network.

Taking a broader view, the hypothesis is confirmed that the different methodological developments made in this thesis allow to reduce the size of the "black box" of the innovation process in relation to the transition to organic farming. Some aspects contributed to this, with the recognizing of (1) the importance of the problematizing in the innovation process, (2) the importance of a few key persons in that process and playing a key role of initiator, (3) the decisive role of the trust among actors to disseminate the knowledge with success, (4) the importance of the "trialability" (conduct of experimentations / testing), "objectivity" (direct visualization of testing / experimentation's results), as well as opinion leaders in the

implementation and diffusion phases, and (5) the function of the economic environment and markets.

Furthermore, we could determine how to identify the contribution of the research in the impact pathway, applied to the case of the transition to organic farming in the Camargue. Particularly, it was presented in the general discussion part, in quantitative terms, how to affine the analysis with respect to the contribution of the different pathway components on the adoption process and achievement of impacts.

Based on the application of the approach developed in two case studies focusing on the transition to organic farming, in the French Camargue and in Bulgaria (see part 4, 5 and 6), 13 recommendations for policy makers, researchers, and stakeholders, were drawn and discussed. 8 key recommendations are as follows:

- To **problematize the challenges to be tackled** before implementing a research program as such, and refine this problematic all along the process;
- The **interests of the different actors from research should primarily be aligned** around goals that are beneficial for everybody;
- To **enable farmers to conduct experimentations on their farms**, preferably in close collaboration with the research;
- To **enroll opinion leaders** to make a closer link between research and the farmer community;
- To **enable a favorable economic and institutional environment** to make the research intervention more successful;
- To **allow flexibility into research programs** to adapt to unexpected developments during innovation processes;
- To **regularly monitor research outputs and outcome**s during the time span of the research program;
- To **conduct an ex-post participatory impact pathway evaluation.**

We also suggest to conduct, when possible, an ex-post evaluation of research program tackling the issue of the transition to organic farming. This informs on the quality of the program's results in relation to the objectives set and to the needs of the targeted population. This, in turn, helps to elaborate avenues for improvements for current and future similar programs.

This thesis contributed to a better understanding of the transition to organic farming, especially in the Camargue case. At a broader scale, the recommendations made to increase the impacts of the research feed into theories of innovations. Some of the recommendations we made appear to be very much in line with the literature background while others contribute to a scarce amount of references and/or bring some new aspects.

The importance of the factors of "observability" and "trialability" in facilitating the adoption process, as expressed in the work of Rogers (1995), was confirmed in this thesis for the specific case of the transition to organic farming. An innovation that can be experimented and easily visualized represents less uncertainty for the potential beneficiaries.
However, the importance of the variable "compatibility", as formulated by Rogers (1995), is somewhat called into question. In effect, we observed in the Camargue case that what counted was not the system of values but the economic benefit of producing organically. Farmers' motivations were generally of economic nature, and the environmental concerns only counted to a very little extent in decisions-making. What is important for farmers in Camargue is the survivability of their farm given the difficulties encountered in the conventional production mode. Moreover, this is no mere coincidence if the outcome "growing awareness on environmental issues" contributed only to a low extent to the adoption of organic farming and achievement of impacts.

Then, as it was underlined, the transition to organic farming is a complex process, considered as a radical innovation requiring creation of new knowledge (Šūmane, 2010), with substantial investments in resources to develop adapted technics, and to deepen the network of actors and the mobilization of opinion leaders (Darnhofer et al. 2010; Bellon and Penvern, 2014; Lamine et al. 2014). The transition to organic farming questions existing anchored practices, the system of values, and cannot only be explained by individual farmers' characteristics. Innovation models and the diffusion model in particular should consider more the economic, market and institutional dimensions. More attention should also be paid to changes that affect the conventional production mode (e.g. changes in selling prices) because it can explain, at least partly, the transition to organic farming. The importance of this factor was observed in the Camargue case.

Furthermore, traditional models of innovation often focus on farmers' barriers to conversion, which implicate a pro-innovation bias. It should be paid more attention to the inherent quality of the innovation investigated. In our approach, the quality of the technical and institutional innovations on the one hand and the channels of knowledge transfer on the other are considered. We take account of the different research outputs; and the different links in the impact pathway are weighted depending on their "strength".

Finally, the top down view of an innovation, which refers to approaches like the Demand pull or the Research push should perhaps be replaced, concerning the transition to organic farming, not only by a more dynamic vision (e.g. AKIS or chain-linked model) with several interactions between actors and phases, but also by a more bottom-up perspective. This means changing the governance paradigm and to increase the capacities of the local actors in developing networks of innovation as well as creating original ideas by themselves; and to have the research only as support and not as main driver. A lesson learned from the Camargue case study is that farmers perceive the research as too "far" from their problems. Also, innovation brokers did not appear to be a solution in a territory where the conservatism of the actors, including from some research actors, is relatively important, and the trust in institutions limited.

Such an approach of innovation could have several advantages with respect to the transition to organic farming: (1) to avoid 'brutalizing' actors, (2) to meet the specific needs of the beneficiaries, (3) to increase the level of innovativeness by increasing actors' responsibility and actors' capacity building, (4) to orient research in relation to local actors' aspirations and not the opposite, and (5) to increase the chance that opinion leaders emerge naturally and share ideas and concepts as well as the knowledge created within the farmer community. This type of approach has especially been developed in African countries.

A study focusing on 8 African countries aimed at evaluating whether a decentralized approach to innovation favors innovation processes (Pamuk et al. 2014). This decentralized approach is named as "innovation platform" in which stakeholders are intended to contribute in a participatory manner. They are expected to problematize the issues to be investigated and define strategies accordingly. Not only research experts are involved but also diverse public and private organizations, customers, producers and intermediaries. The concept of innovation

platform refers to mobilization of social, human and financial capital through the notion of learning.

Pamuk et al. (2014) have shown that this approach could boost the acceptance and uptake of managerial innovations for crop productions, even though the results were less evident for other types of innovations. Furthermore, they underline the high stakeholders' heterogeneity and related needs and aspirations within such innovation platforms, as well as differences in terms of social capital, which can both explain results' variability. This is also due to the lack of hindsight on these platforms whose the concept is relatively recent.

At the same time, Black (2000) who explored the pros and cons of four main models or strategies for agricultural extension, underlines that none of these strategies (taken independently) is sufficient by itself. The strategies investigated are as follows: top down, bottom-up, one to one information flow, and formal learning or educational process. "Despite criticisms of linear technology transfer models, there is still a need for access to reliable scientific information, just as there is a need to provide for active participation by farmers in research and development processes" (Black, 2000, p493).

Further research is needed to tackle this issue in relation to the transition to organic farming and more generally for agricultural innovations. Also, this issue should be more studied in "industrialized" countries.

(Partie 8 : Conclusion générale)

*Cette thèse a contribué à l'élaboration d'une approche à même d'*évaluer les impacts et la contribution de la recherche *sur les processus d'innovation*s et la société, en rapport avec la *transition à l'agriculture biologique.* Elle a également contribué à rendre compte des impacts *de la recherche dans le cas d'étude camarguais (France) et Bulgare, et de la manière dont ces* impacts ont été atteints. *L'analyse participative du chemin de l'impact (PIPA) a été utilisée* comme fil conducteur et significativement adaptée et complétée par de nombreuses méthodes, instruments et outils, *afin d'adapter cette approche à de l'évaluation ex*-post, faire la lumière sur les mécanismes complexes sous-*tendant le chemin de l'impact et le rôle que la recherche y* joue, mais aussi po*ur limiter les problèmes liés à l'utilisation d'approches participatives.*

*Nous confirmons l'hypothèse faite que PIPA peut être combiné avec succès à d'autres méthodes venant des sciences sociales, et donc à même d'informer sur les impacts et la contribu*tion de *la recherche dans le chemin de l'impact. Cependant, il n'a pas été confirmé*e que la contribution de la recherche dans le cas de la Camargue est importante ; elle était utile mais *dans le même temps d'une portée relativement limitée. Une autre hypothèse qui est confirmée est que l'*analyse du réseau social (SNA) peut aider à comprendre comment les nouvelles *techniques et nouveaux produits sont diffusés, d'aider à tirer des conclusions sur le rôle des acteurs de la recherche, et de valider les dires des parties prenantes sur les relations d'acteurs.* Il est aussi établi que la théorie *de l'acteur réseau (ANT) peut effectivement renforc*er notre approche en orientant les questions évaluatives et en approfondissant la compréhension et le *rôle des relations interpersonnelles entre acteurs dans le réseau d'innovation.*

En prenant une *perspective plus large, nous confirmons l'hypothèse faîte que les différents* développements méthodologiques réalisés dans cette thèse permettent de réduire la taille de la « boite noire » *du processus d'innovation en relation avec la transition au bio. Que*lques *aspects ont contribué à cela, à savoir la reconnaissance de (1) l'importance de la* problématisation *dans le processus d'innovation, (2) l'importance de quelques personnes clés* dans ce processus et j*ouant un rôle clé d'initiateur,* (3) le rôle décisif de la confiance entre acteurs pour disséminer la connaissance avec succès, *(4) l'importance de la «* trialabilité » *(réalisation d'expérimentations /* tests), objectivité (visualisation directe des résultats des tests

et expérimentations, ainsi que des leader*s d'opinion dans les phases de mise en œuvre et de* diffusion, *et (5) la fonction de l'environnement économique et des marchés.*

De plus, nous avons pu déterminer comment identifier la contribution de la recherche dans le *chemin de l'impact, appliqué au cas de la transition à l'agriculture biologique en Camargue.* En outre, nous avons présenté dans la discussion générale, en termes quantitatifs, comment affiner notre analyse vis-à-vis de la contribution des différentes composantes du chemin de *l'impact au processus d'adoption et à la génération d'impacts.*

*Sur la base de l'application de l'approche développée dans les de*ux cas étudiés qui se *focalisent sur la transition à l'agriculture biologique, en Camargue (France) et en Bulgarie* (voir partie 4, 5 et 6), 13 recommandations pour les décideurs politiques, chercheurs, et parties prenantes, ont été exposées et discutées. 8 recommandations clés sont :

- **Problématiser les challenges à considérer** *avant de mettre en œuvre un programme* de recherche en tant que tel, et réviser cette problématique tout au long du processus ;
- Les **intérêts des différents acteurs de la recherche devraient en première instance être alignés** autour *d'objectifs s'avérant bénéfiques pour tout le monde* ;
- **Permettre aux agriculteurs de mener des expérimentations sur leurs fermes**, de préférence en étroite collaboration avec la recherche ;
- **Enrôler les leader*s d'opinion*** pour établir un lien étroit entre la recherche et la communauté des agriculteurs ;
- **Permettre un environnement économique et institutionnel favorable** pour que *l'intervention de la recherch*e ait plus de chances de succès ;
- **Accorder de la flexibilité aux programmes de recherche** *pour s'adapter aux évènements imprévus au cours des processus d'innovation*s ;
- **Suivre régulièrement les « outputs » et « outcomes »** au cours du programme de recherche ;
- **Réaliser une évaluation participative ex-post du *chemin de l'impact***.

Nous suggérons également de réaliser si possible une évaluation ex-post des programmes de *recherche traitant du sujet de la transition à l'agriculture biologique. Ceci informe sur la*

qualité des résultats du programme par rapport aux objectifs fixés et aux besoins de la *population ciblée. Ceci, à son tour, aide à définir les pistes d'améliorations* pour des programmes similaires, actuels et futurs.

Cette thèse a contribué à une meilleure compréhension de la transition à l'agriculture biologique, en particulier dans le cas de la Camargue. À une échelle plus large, les recommandations faites pour améliorer les impacts de la recherche alimentent les théories de *l'innovation. Quelques recommandations sont fondamentalement en ligne avec la littérature tandis que d'autres contribuent à une quantité de références assez* faible et/ou apportent quelques nouveaux aspects.

*L'impo*rtance du facteur « *d'*observabilité » et de « trialabilité » dans la facilitation du *processus d'adoption, comme* énoncé dans les travaux de Rogers (1995), a été confirmée dans cette thèse pour le cas spécifique de la transition au bio. Une innovation qui peut être expérimentée et facilement visible représente moins d'incertitude pour les bénéficiaires potentiels.
*Cependant, l'importance d*e la variable « compatibilité », comme exprimé par Rogers (1995), est quelque peu remise en question. En effet, nous avons observé dans le cas de la Camargue que peu importe le système de valeurs, ce qui a compté est le bénéfice économique de produire de façon biologique. La majorité des agriculteurs ont clairement expliqué que leur motivation est de nature économique et que les problèmes environnementaux comptent seulement dans une mesure limitée dans leur prise de décision. Ce qui est important pour les agriculteurs en Camargue est la pérennité de leur ferme étant donné les difficultés rencontrées par le mode de *production conventionnel. D'ailleurs, ce n'est pas un hasard si le changement «* conscience croissante des enjeux environnementaux *» n'ait contr*ibué que de manière très limité à *l'adoption du bio et à la production d'impacts.*

Ensuite, comme nous l'avons souligné, la transition à l'agriculture biologique est un processus complexe, considéré comme une innovation radicale nécessitant la création de nouvelles connaissances *(Šūmane, 2010)*, des investissements substantiels dans des ressources pour développer des techniques adaptées, et de *renforcer le réseau d'acteurs et* mobiliser les leaders *d'opinion* (Darnhofer et al. 2010; Bellon and Penvern, 2014; Lamine et al. 2014). La transition au bio questionne les pratiques ancrées existantes, le système de valeurs, et ne peut être

expliquée seulement par les caractéristiques individuelles des producteurs. Les modèles d'innovations et le modèle de diffusion en particulier devraient considérer davantage les aspects économiques, le marché et les facteurs institutionnels. Une attention plus importante devrait être portée aux changements affectant le mode de production conventionnel (par exemple des changements dans les prix de ventes) car ceci pourrait expliquer, au moins *partiellement, la transition à l'agriculture biologique. L'importance de ce facteur a été* observée dans le cas de la Camargue.

De plus, les modèles traditionnels de l'innovation se focalisent souvent sur les barrières à la conversion du côté des producteurs, ce qui implique un biais pro-innovation. Une attention plus *importante devrait être accordée à la qualité intrinsèque de l'i*nnovation investiguée. Dans *notre approche, la qualité des innovations techniques et institutionnelles d'une part et les canaux de transfert du savoir d'autre part sont pris en compte. Nous prenons en compte les* différents « outputs » de la recherche ; et *les différents liens dans le chemin de l'impact font l'objet d'une notation en rapport avec leur «* force ».

Finalement, la vision « top down » *d'une innovation, qui renvoie à des approches telles que* « demand pull » ou « research push » devrait probablement être remplacée, en ce qui concerne *la transition à l'agricultur*e biologique, pas seulement par une vision plus dynamique (par exemple AKIS ou le modèle « chain-linked ») avec de nombreuses interactions entre acteurs, mais aussi par une perspective davantage « bottom-up ». Cela signifie un changement du paradigme de gouvernance et le renforcement des capacités des acteurs locaux à développer *des réseaux d'innovation*s et à générer des idées originales par eux-mêmes *; et d'avoir la* recherche seulement comme support et non comme principal levier. Un enseignement tiré dans le cas de la Camargue est que les producteurs perçoivent la recherche comme trop « loin » de leurs problèmes. Aussi, les « brokers *» de l'innovation ne sont pas apparus comme une solution* dans un territoire où le conservatisme des acteurs, y compris de certains acteurs de la recherche, est relativement important, et la confiance dans les institutions limitée.

Une telle approche de l'innovation pourrait avoir de multiples avantages vis-à-vis de la *transition à l'agriculture biologique* : (1) éviter de « brutaliser » les acteurs, (2) être en ligne avec les besoins spécifiques des bénéficiaires, *(3) améliorer le niveau de l'innovation en* responsabilisant davantage les acteurs et en renforçant leurs capacités, (4) orienter la

recherche par rapport aux aspirations des a*cteurs locaux et non l'inverse,* et (5) accroître les ch*ances que des leaders d'opinion* émergent naturellement et puissent partager les idées, concepts, et les connaissances générées au sein de la communauté des producteurs. Ce type *d'approche a particulièrement été développé dans les pays africains.*

Une étude se concentrant sur 8 pays africains *a tenté d'évaluer si une approche décentralisée de l'innovation favorise les processus d'innovation*s (Pamuk et al. 2014). Nous appelons cette approche décentralisée « *plateforme d'innovation* », dans laquelle les parties prenantes contribuent de manière participative. Elles sont supposées problématiser les problèmes devant être étudiés et de définir en parallèle les stratégies à suivre. Pas seulement les experts-chercheurs sont impliqués mais aussi diverses organisations publiques et privées, les *consommateurs, et les producteurs et intermédiaires. Le concept de plateforme d'innovation se* réfère à la mobilisation du capital social, humain et financier à travers la notion *d'apprentissage.*

Pamuk et al. (2014) *ont montré que cette approche pouvait améliorer l'acceptabilité et l'adoption d'innovation*s de management concernant les productions végétales, même si les *résultats étaient moins évidents pour d'autres types d'innovations. De plus, ils soulignent la* grande hétérogénéité des parties prenantes et de leurs besoins et aspirations au sein de telles platefo*rmes d'innovations, aussi bien que des différences en termes de capital social, qui* peuvent tout deux expliquer la variabilité des résultats. Ceci est aussi dû au manque de recul sur ces plateformes dont le concept reste relativement récent.

Dans le même temps, Black (2000), qui a exploré les avantages et inconvénients de quatre *modèles principaux ou stratégies pour la vulgarisation agricole, souligne qu'aucune de ces stratégies (prisent individuellement) n'est suffisante par elle*-même. Les stratégies étudiées sont les suivantes : « top down », « bottom-up *», flux d'information «* un à un », et apprentissage ou *processus d'éducation formel. «* En dépit des critiques des modèles linéaires de transfert *technologique, il y a encore un besoin pour l'accès à des* informations scientifiques pertinentes, *tout comme il y a un besoin d'amener une participation active des agriculteurs dans la* recherche et les processus de développement » (Black, 2000, p493).

Davantage de recherche est nécessaire pour traiter ce problème en relation avec la transition *à l'agriculture biologique et plus généralement pour les innovations agricoles. Aussi cette* question devrait-elle être davantage étudiée dans les pays industrialisés.

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General annexes

A. Actors description in the Camargue case study

A.1. Cooperative and private traders

- The cooperative SudCéréales: SudCéréales processes both organic and conventional agricultural products from Camargue, including rice. In the late 70s, the cooperative was the only trader for rice. In the year 2007, the cooperative has invested in a silo with high capacities, but this strategy was not successful because other important players in the Camargue followed the same strategy at the same time. There was therefore an excess of storage capacity on the scale of the Camargue, and the cooperative was operating at a loss. The group Soufflet Alimentaire has then taken control of the business. The different parts signed a contract specifying that Soufflet Alimentaire must be the only outlet of the cooperative. In 2012, SudCéréales collected roughly 60,000t of conventional rice and 0.3t of organic rice.

- The SARL Thomas: the SARL Thomas is a private trader that was founded in the year 1982 in the Camargue. That time it collected around 6000-7000t of conventional rice annually. But in the year 1990, the company decided to switch from conventional to organic. The rationale of this is that the SARL Thomas was not able to compete with the cooperative SudCéréales on the conventional market.

- The firm BIOSUD: BIOSUD was created in the year 2003. Both the cooperative and the SARL Thomas took the opportunity to create a specific value chain dedicated to organic production. BIOSUD is specialized in selling organic products, collected by the cooperative and the SARL Thomas.

- Biocamargue: this Company was found in the year 2005. It only processes organic rice. In 2012, Biocamargue collected around 1000t of organic rice from Camargue.

- The Comptoir Agricole du Languedoc (MADAR): it collects many different products, including Camargue rice. The company collected respectively 29,000t and 1,000t of conventional and organic rice in 2012.

A.2. Research and extension institutes

- INRA: it stands for "National Institute of Agronomic Research". It launched many research programs related to conversion to organic rice production. Jean Claude Mouret from INRA Montpellier is specialized on this topic. He possesses consequent knowledge of and experiences on rice management issues. He has been working with rice farmers for more than 30 years.
- CFR: it stands for "French Centre of Rice". It was founded in 1985. The CFR experiments cultural technics, implements plant breeding programs, and provides technical supports for rice farmers.
- The CIRAD: it stands for "French Agricultural Research and International Cooperation Organization". CIRAD creates and provides new knowledge in partnership with developing countries in the South, with the aim to support agricultural development and to contribute to debate around major agronomic issues in the world.

A.3. Other institutions

- The Rice Farmers Union: it was founded in 1986. It aims at defending the interest of actors involved in the Camargue rice supply chain. It is funded by rice producers, traders and processors, FranceAgriMer, the PACA & Languedoc Roussillon region, the General Council of the Bouches-du-Rhône and the EU through the grant FEADER (European fund for the rural development).
- The Natural Park of the Camargue: it was created in 1970 with the goal to protect the cultural heritage, to ensure control over the land use, to boost the social and economic development, to provide publicly available information on the Camargue, and to conduct research and experimentations.
- FranceAgriMer: it is the national institute of the agricultural and seafood products. Regarding markets, its missions are to implement a business intelligence, monitor markets, manage measures on market regulations, and to alert professionals in case of a crisis. It endeavors to reinforce the supply chains efficiency and to communicate on risks throughout value chains.

- The Tour du Valat: it is a private research centre that was founded more than 50 years ago by Luc Hoffmann. The centre focuses its research activities on the conservation of Mediterranean wetlands with the aim to halt the loss and degradation of the local natural resources and to restore them.
- SupAgro: it is a national institute of further education in agricultural sciences and offers a full range of courses from bachelor to PhD level. SupAgro also aims at improving sustainable development in agriculture.
- Agropolis foundation: it is a French scientific foundation that was created in 2007 to encourage high level research and education as well as to enlarge international research partnerships in agricultural sciences and sustainable development research. The members of the foundation are CIRAD, INRA, SupAgro and the IRD. The latter is a research institute for development; it focuses its research on relationships between humans and their environment.

B. Measurement of the impacts in the Camargue case study

- Total surface under rice: during the second round of face-to-face interviews, we asked 12 organic and partially-organic farmers what is and was, respectively, their current (in 2014) and previous (before converting to organic) crop rotation. The difference between the surface under rice between the year 2014 and before the conversion was then calculated. This difference was expressed in percentage and equalled 45%. Since the surface of organic rice accounts for 17% of the total surface under rice in Camargue, we could estimate the share of the decrease in the total rice area caused by the transition to organic farming (45%*17%=8%).

- The use of pesticides: it was estimated through the Treatment Frequency Index (TFI)[57] which equals the ratio of the dose applied to the approved dose. Interviews conducted with organic / partially-organic farmers raised this issue by asking the products sprayed and the dosages applied, in the year 2014 and before having converted to organic agriculture. The approved doses were found on the official website: E-phy.agriculture.gouv.fr. The diminishment (in percentage) in the use of pesticides at the level of the Camargue was deduced in the same way as for the surface dedicated to rice (see above).

- The use of nitrogen: given the difficulty to get directly the information from organic / partially-organic farmers, we first asked the yields and the crop rotations before calculating the quantity of nitrogen required, on the basis of the needs per 100kg of output. Still, the information was asked for two periods, before the conversion and in 2014. Moreover, we made the assumption that the nitrogen residue in the soil (from the previous crop production) is about 20kg/ha, apart after cultivating alfalfa. After alfalfa, we made the assumption that the N residue is about 50kg/ha. The nitrogen required is calculated as follows: [(yield*needs/ha)-N residue].

[57] TFI equals the ratio of the dose applied to the approved dose. Interviews made at the fourth step of the methodology raised this issue with farmers by asking the products and the dosages applied. The approved doses were found on the official website: e-phy.agriculture.gouv.fr.

Crop production	Needs (kg)/100kg of product/ha
Durum wheat	3.5
Rice	3
Rape	7
Barley	2.2
Soft wheat/Triticale	3
Alfalfa	0

Source: based on interview with experts at INRA

TABLE 21: NEEDS OF NITROGEN/HA

- The use of fuels: it was also difficult to measure directly the consumption of fuel. We asked organic / partially-organic farmers to report their crop management techniques with the material they have been using (in 2014 and before converting). We then calculated the consumption of fuel on the basis of the "barème *d'entraide*" (scoring grid) from the French Agricultural Chamber of the Loiret ([58]). We calculated the consumption of fuel per hour and the performance (ha/hour) of the material in order to estimate the consumption of fuel per hectare.

- The use of water: we asked organic / partially-organic farmers whether their consumption of water per hectare of organic rice has changed because of their transition to organic farming and to what extent.

[58]http://www.loiret.chambagri.fr/fileadmin/documents/Machinisme/grandeculturelevage2015sanscouverture.pdf.

C. Guideline of the second workshop in the Camargue case study

N°	Timing	Activity	Goal	Type of discussion	Persons mobilized	Materials used
1	**13h20-14:00**	**Welcome, round table, and presentation of the objectives.**	To get actors actively involved.	-	All.	-
1.1	13h30-13h40	Initial words.	-	-	Sylvain.	- Slide PowerPoint (N°1) (welcome words). - Computer 1.
1.2		Presentation of the participants.	To get know each other.	Round table.	All.	
1.3	13h40-13h50	Presentation of the objectives: (1) To identify changes in technics, behaviors, and actors' relationships in relation to the conversion to organic farming. (2) To identify the causes of these changes (the outputs or "means") and try to define to what extent the different research activities undertaken for 15 years have contributed to these causes.	To get actors interest and actively involved.	Speech.	Sylvain. Moderator.	- Slide PowerPoint (N°1) showing the objectives. - Computer 1.
2	**13h50-15h10**	**To engage actors in formulating changes.**				
2.1	13h50-13h57	Presentation of the definition of "outcome". Presentation of the types of changes (technics, behaviors, relations, others). Examples are given.	To guide the workshop and especially the next exercise.	Speech.	Sylvain. Moderator.	- 1 slide PowerPoint (n°1): table. - Computer 1.
2.2	13h57-14h03	By group of two persons, the participants are asked to reflect on the changes - what (description of the change), who (who change?), when (when the change occurred?).	In small groups of two persons to make the exercise simpler, interactive and fruitful.	Group exercise.	Sylvain. Moderator. All.	
2.3	14h03-14h30	Each group tell the different changes, for each question (what, who, and when) under each type (technics, behaviors, relations, others).	To link these changes with the activities and outputs or "means".	Round table.		- Table PowerPoint (PPT n°1), with the example, remains visible for all. - Computer 1.
2.4		To classify the stakeholders' statements in the different categories (sub-categories of outcomes, i.e. technics, behaviors and relations).	Participants can visualize the results.		Sylvain.	Blackboard N°1.

N°	Timing	Activity	Goal	Type of discussion	Persons mobilized	Materials used
2.5		At the same time, the outcomes raised by stakeholders are written down on cards (3 copies).	These cards are distributed later to 3 different groups, in order to reconstruct the impact pathway.		Assistant A. Assistant B.	- Cards of color1. - Pencils.
2.6	14h30-14h40	Presentation of the definition of "outputs" and "activities". Taking over the previous table with the different categories of outcomes, 2 columns are added to show example of stakeholders' statements on how changes may have happened thanks to activities, outputs, or other factors.	To guide the workshop and especially the next exercise.	Speech.	Sylvain. Moderator.	- 2 slides PowerPoint (PPT n°1). - Computer 1.
2.7	14h40-15h10	The actors are invited to tell how the outcomes occurred thanks to outputs, activities, and other factors.	To link all of these elements afterwards and therefore obtain the so-called impact pathway.	Group discussion (3).	Sylvain. All. Assistant A. Assistant B. Moderator.	- Table. - PowerPoint (PPT n°1), with the example, remains visible for all. - Computer 1.
2.8		The outputs, activities, and other factors are written down on cards (3 different copies).	These cards are distributed later to 3 different groups, in order to reconstruct the impact pathway.		Assistant A. Assistant B. Key Researcher from INRA.	- Cards of color2. - Cards of color3. - Pencils.
2.9		Note-taking.			Sylvain.	- Paper n°1. - Pencils.
15h10-15h25		**BREAK**				
3	**15h25-18h30**	**Impact pathway.**				
3.1	15h25-15h35	Presentation of an example of simple impact pathway.	To give an idea to participants as to how the pathway may look like.		Sylvain. Moderator.	- Blackboard n°2: poster "pathway".
3.2	15h35-16h15	The participants are asked to reconstruct the pathway by linking all the different cards together. Participants are asked to start with the outcomes before going backward to outputs, activities, and other factors.	Reconstruction of the impact pathway.	Exercise.	Sylvain. Assistants. Moderator. All.	- Blackboard n°1. - Blackboard n°3. - Blackboard n°4.

N°	Timing	Activity	Goal	Type of discussion	Persons mobilized	Materials used
3.3		Note-taking.			Sylvain.	- Paper n°2. - Pencils.
16h15-16h45		**Break "King cake" (Galette des rois).**				
3.4	16h45-17h30	Presentation of each of the impact pathway by each group.	To understand the story behind the pathway.	Discussion.	Sylvain. Assistants. Moderator.	- Blackboard n°1. - Blackboard n°3. - Blackboard n°4.
3.5		Note-taking.	To have a summary of the discussions.		Assistants.	- Paper n°3. - Pencils.
3.6	17h30-17h50	Presentation of the impact pathway of the researcher (made in advance by a key researcher from INRA).	To discuss the differences.	Speech.	Key researcher from INRA. Moderator.	- Blackboard n°2.
3.7		Note-taking.			Assistants. Sylvain.	- Paper n°4. - Pencils.
4	**17h50-18h20**	The participants are asked to discuss the perspectives. This discussion is guided by one general question: **What should be improved in research programs?** Sub-questions: (1) Should research projects be withdrawn? (2) What research projects should be improved? (3) What research projects should be created? (4) What are your expectations for the future?	To propose solutions/options to improve research projects in the future.		Moderator. All.	
		Writing down in tables what the stakeholders state. Each table is dedicated to one question.			Assistant 1.	Table n°1
					Assistant 2.	Table n°2.
					Key researcher from INRA.	Table n°3.

TABLE 22: GUIDELINE OF THE SECOND WORKSHOP IN THE CAMARGUE CASE STUDY

D. Comprehensive impact pathway of the research in the Camargue case

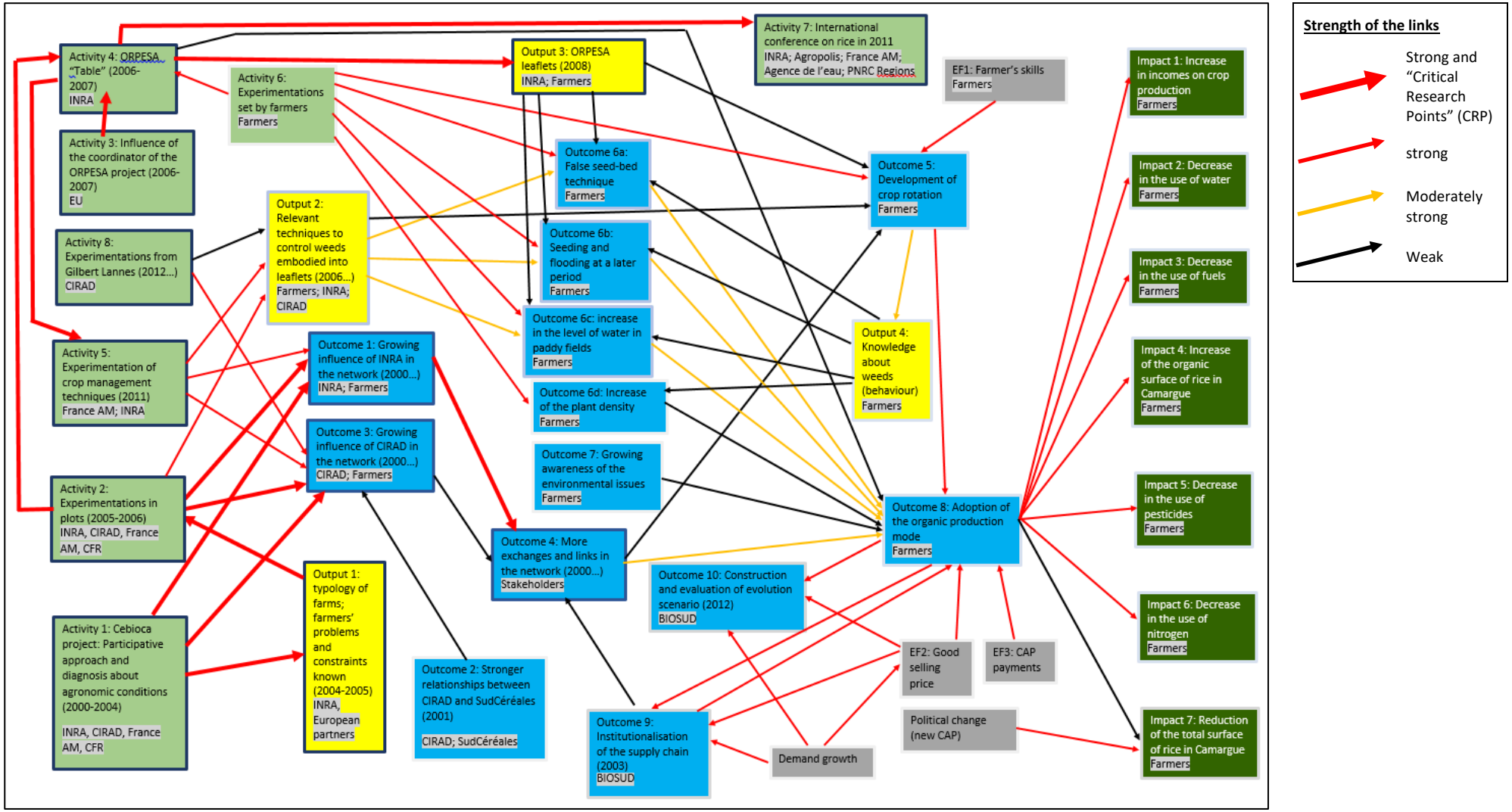

FIGURE 11 : COMPREHENSIVE IMPACT PATHWAY FROM THE CAMARGUE CASE STUDY

E. Table of links of the innovation pathway in the Camargue case

N	Link				Mechanism (explanation of the underlying link)		Alternative explanations of the mechanism	Validity of the alternative explanations / Measure of the impacts
	Variable		Actor		Description of the mechanism	Origin Inf (information)		
	Origin	Destination	Origin	Destination				
1	Activity 1: Cebioca project: participative approach and diagnosis about agronomic conditions (2000-2004).	Output 1: Typology of farms; farmers' problems and constraints known (2004-2005).	INRA, CIRAD, FranceAM (France AgriMer), CFR.	INRA, European partners.	The CEBIOCA project allowed the INRA to be aware on organic production systems and the main issues to be studied.	INRA.	No.	
2	Activity 1: Cebioca project: participative approach and diagnosis about agronomic conditions (2000-2004). Activity 2: Experimentation in farming plots (2005-2006). Activity 5: Experimentation of crop management techniques (2011). Activity 4: ORPESA "Table" (2006-2007).	Outcome 1: Growing influence of INRA in the network (2000…).	INRA, CIRAD, FranceAM, CFR.	INRA.	Increase of the knowledge transfer from INRA to farmers.	"Stak" (stakeholders) via in-depth interviews; SNA.	a) Increase in relationships between INRA and others institutes. b) Relationships among involved actors in the network decreased, when excluding the INRA.	a) No: relationships between INRA and other institutes did not increase from 1999 to 2014. b) No: the average "degrees" (SNA) in the network increased from 4.1 in 1999 to 4.8 in 2014 (+18%), when excluding the INRA. Similarly, the distance between actors decreased from 2.5 in 1999 to 2.2 in 2014. The second plausible alternative explanation can thus not be confirmed.
3	Activity 2: Experimentations in plots (2005-2006). Activity 5: Experimentation of crop management techniques (2011).	Output 2: Relevant techniques to control weeds embodied into leaflets (2006…).	INRA, CIRAD, FranceAM, CFR.	Farmers.	The experimentations were mainly focused on weeds management issues.	"WS" (Workshop) - "Stak".	These techniques were derived from existing knowledge or/and other research programs.	Not valid.

Link					Mechanism (explanation of the underlying link)		Alternative explanations of the mechanism	Validity of the alternative explanations/Measure of the impacts
N°	Variable		Actor		Description of the mechanism	Origin Inf		
	Origin	Destination	Origin	Destination				
5	Activity 2: Experimentations in plots (2005-2006). Activity 6: Experimentations set by farmers.	Activity 4: ORPESA "Table" (2006-2007).	INRA, EU, Farmers.	Farmers, INRA.	Awareness of the problems/constraints of the farmers. Knowledge to bring into discussions on the basis of the experimentations conducted.	INRA.	The implementation of the ORPESA "Table" was decided by the European Union and not by the INRA.	The decision was taken both by the coordinator of the project ORPESA (EU) and by Jean-Claude Mouret from INRA. It was not decided yet to take account the Camargue at the design phase of the ORPESA project.
6	Activity 3: Influence of the coordinator of the ORPESA project (2006-2007).		EU.		The coordinator of the ORPESA project (EU) contacted Jean-Claude Mouret from INRA.	INRA.		
7	Activity 4: ORPESA "Table" (2006-2007).	Output 3: ORPESA leaflets (2008).	INRA.	INRA, Farmers.	The exchanges between farmers and researchers produced some interesting results. The INRA therefore decided to embody results into leaflets with a view to help farmers in their transition to organic farming.	INRA, Farmers (in-depth interviews).	a) The decision to set-up leaflets was decided at the European level. b) The technical manuals have not only been written on the basis of the ORPESA results.	a) The decision of writing the leaflets was made by INRA. b) The technical manuals have been written on the basis of the ORPESA results: 50% from participant's statements, 50% from experimentations in farming plots conducted by INRA (reminder: the results of the experimentations were discussed at the "ORPESA Table".
8	Activity 6: Experimentations set by farmers.	Outcome 6d: Increase of the plant density.	Farmers.	Farmers.	It was found that a higher plant density helps to smother weeds.	Farmers (in-depth interviews).	Advices or/and leaflets from INRA or/and other institutes.	These alternative explanations are not true, farmers reported.
9	Output 1: Typology of farms; farmers' problems and constraints known (2004-2005).	Activity 2: Experimentations in farming plots (2005-2006).	INRA, European partners.	INRA, CIRAD, FranceAM."	Awareness of the problems/constraints of the farmers.	INRA.	No.	

Link					Mechanism (explanation of the underlying link)		Alternative explanations of the mechanism	Validity of the alternative explanations/Measure of the impacts
N°	Variable		Actor		Description of the mechanism	Origin Inf		
	Origin	Destination	Origin	Destination				
10	Activity 1: Cebioca project: participative approach and diagnosis about agronomic conditions (2000-2004). Activity 2: Experimentation in farming plots (2005-2006). Activity 5: Experimentation of crop management techniques (2011). Activity 8: Experimentations from Gilbert Lannes (2012…).	Outcome 3: Growing influence of CIRAD in the network (2000…).	CIRAD.	"Stak".	Knowledge transfer from CIRAD to farmers and stronger relationships between CIRAD and INRA.	Researcher (SNA).	a) Increase in relationships between CIRAD and others institutes. b) Relationships among involved actors in the network decreased, when excluding the CIRAD.	a) Yes: between CIRAD and SudCéréales. b) No: the average "degrees" (SNA) in the network increased, when excluding the CIRAD.
11	Outcome 2: Stronger relationships between CIRAD and SudCéréales (2001).				The "degrees" (SNA) between CIRAD and SudCéréales have increased from 0 in 1999 to 2 in 2015 (breeding activities). In fact, few researchers from CIRAD work at the CFR, and the later developed stronger relationships with the cooperative. The cooperative was granted the exclusive right to sell varieties selected by the CFR.			

Link					Mechanism (explanation of the underlying link)		Alternative explanations of the mechanism	Validity of the alternative explanations/Measure of the impacts
N°	Variable		Actor		Description of the mechanism	Origin Inf		
	Origin	Destination	Origin	Destination				
12	Output 2: Relevant techniques to control weeds embodied into leaflets (2006…).	Outcome 6a: False seed-bed technique. Outcome 6b: Seeding and flooding at a later period. Outcome 6c: Increase in the level of water in paddy fields.	INRA.	Farmers.	INRA advised farmers through various documents and leaflets (the discussions did not play a significant role).	"WS" - "Stak"; INRA.	a) CIRAD or/and other institutes also provided information to farmers in that respect. b) Farmers conducted their own experimentations: learning by doing. c) Farmers looked at the techniques of their neighbors: peer effect. d) More knowledge about weeds (their behavior).	a) No. b) Yes: it is important. c) No. d) Yes: but it is of little importance.
13	Output 3: ORPESA leaflets (2008).		INRA, European partners.	Farmers.	The leaflets derived from the ORPESA "Table" deal with those issues.	"WS" - "Stak".		
14	Activity 6: Experimentations set by farmers.		Farmers.	Farmers.	Learning by doing.	Farmers (in-depth interviews).		
15	Output 4: Knowledge about weeds (behavior).		Farmers.	Farmers.	The weeds management is adapted in accordance with the behavior of the weeds.	"WS" - "Stak".		

Link					Mechanism (explanation of the underlying link)		Alternative explanations of the mechanism	Validity of the alternative explanations/Measure of the impacts
N°	Variable		Actor		Description of the mechanism	Origin Inf		
	Origin	Destination	Origin	Destination				
16	Outcome 6a: False seed-bed technique. Outcome 6b: seeding and flooding at a later period. Outcome 6c: putting more water in the parcels. Outcome 6d: increase of the plant density.	Outcome 8: Adoption of the organic production mode.	Farmers.	Farmers.	Techniques adapted to organic farming systems.	"WS" - "Stak".	1) Other relevant techniques helped the transition towards organic farming. 2) The meeting organized by BIOSUD in 2013 at the Park of the Camargue has led some farmers to be convinced.	1) Not valid. 2) Not valid.
17	Outcome 7: Growing awareness of the environmental issues.		Farmers.	Farmers.	"Ethical" considerations.	Farmers (in-depth interviews).		
18	Outcome 6: Development of crop rotation.		Farmers.	Farmers.	Techniques adapted to organic farming systems.	Farmers; "WS" - "Stak".		
19	EF2: Good selling price EF3: CAP payments.		Market.	Farmers.	Switching towards organic farming is a way to improve earnings.	Farmers; "WS" - "Stak".		
20	Outcome 4: More exchanges and links in the network.		Stakeholders.	Stakeholders.	Exchange of information about organic production systems.	Farmers; "WS" - "Stak".		
21	Activity 4: ORPESA "Table" (2006-2007).		Farmers, INRA.	Farmers.	Some arguments provided to switch to organic production.	Farmers; "WS" - "Stak".		
22	Outcome 1: Growing influence of INRA in the network (2000…).	Outcome 4: more exchanges and links in the network (2000…).	INRA.	"Stak".	INRA has become an important broker in the network.	"Stak" via in-depth interviews.	Other actors have become important knowledge brokers in the network.	Not valid.
23	Outcome 3: Growing influence of CIRAD in the network (2000…).		CIRAD.	"Stak".	CIRAD has become an "average broker" in the network.	Researcher (SNA).		

Link					Mechanism (explanation of the underlying link)		Alternative explanations of the mechanism	Validity of the alternative explanations/Measure of the impacts
N°	Variable		Actor		Description of the mechanism	Origin Inf		
	Origin	Destination	Origin	Destination				
24	EF2: Good selling price. EF4: Demand growth.	Outcome 9: Institutionalization of the supply chain (2003).	Market.	BIOSUD.	Opportunity to ameliorate earnings through the demand growth and the good selling price.	BIOSUD.	No.	
25	Outcome 8: Adoption of the organic production mode.							
26	Outcome 5: Development of crop rotation.	Output 4: Knowledge about weeds.	Farmers.	Farmers.	By their own experimentations and observations as to how to fight the weeds.	"WS" - "Stak".	Some institutes provide information in that respect.	Not valid.
27	EF2: Good selling price. EF4: Demand growth.	Outcome 10: Construction and evaluation of evolution scenarios (2012).	Market.	BIOSUD.	BIOSUD tried to convince farmers to switch to organic farming in order to improve its business.	BIOSUD.	No.	
28	Outcome 8: Adoption of the organic production mode.							
29	Output 2: Relevant techniques to control weeds embodied into leaflets (2006…).	Outcome 6: Development of crop rotation.	INRA.	Farmers.	Leaflets were produced by INRA to disseminate knowledge.	Farmers; INRA.	1. ORPESA leaflets. 2. Farmers: peer effect. 3. Farmers set their own experimentations. 4. Farmer's skills.	1. No. 2. No. 3. Yes: very important. 4. Yes: very important.
30	Output 3: ORPESA "Table".		INRA.	Farmers.	Technical elements provided.	Farmers; INRA.		
31	Outcome 4: More exchanges and links in the network (2000…).		INRA.	Farmers.	Exchange of information about organic production systems.	Farmers; "WS" - "Stak".		
32	EF1: Farmer's skills (not related to the research, either directly or indirectly).		Farmers.	Farmers.	Learning by doing.	Researcher.		
33	Activity 6: Experimentations set by farmers.		Farmers.	Farmers.				

Link					Mechanism (explanation of the underlying link)		Alternative explanations of the mechanism	Validity of the alternative explanations/Measure of the impacts
N°	Variable		Actor		Description of the mechanism	Origin Inf		
	Origin	Destination	Origin	Destination				
34	Activity 4: ORPESA "Table" (2006-2007).	Activity 7: International conference on rice (2011).	INRA, Farmers.	INRA, Agropolis, France AM, Agence de l'eau, PNRC Regions.	A list of relevant techniques was made on the basis of the ORPESA "Table". Additionally, some challenges were raised. Both the international conference (2011) and the experimentations (2011) tried to answer those issues.	INRA.	No.	
		Activity 5: Experimentation of crop management techniques (2011).	INRA, Farmers.	INRA, CIRAD, France AM, CFR.				
35	Outcome 8: Adoption of the organic production mode.	Impact 1: Increase in incomes on crop productions.	Market.	Farmers.	Due to a higher selling price that compensate more than proportionally the loss of yield.	Farmers, INRA.	No.	Net margin/ha: +146 % for the partial organic farmers. Net margin/ha: +111% for the organic farmers.
36	Outcome 8: Adoption of the organic production mode.	Impact 2: Decrease in the use of water.	Farmers.	Farmers.	Reduction of the surface devoted to rice.	Farmers, INRA.	No.	The consumption of water has decreased about 45% for the organic and partial organic farmers. At the level of the region Camargue, this consumption has decreased about 8%.
37	Outcome 8: Adoption of the organic production mode.	Impact 3: Decrease in the use of fuel.	Farmers.	Farmers.	Due to the introduction of crops (grasslands and alfalfa) less demanding in terms of soil working.	Farmers, INRA.	No.	The consumption of fuel has decreased about 17% for the organic and partial organic farmers. At the level of the Camargue territory, this consumption has decreased about 3%.
38	Outcome 8: Adoption of the organic production.	Impact 4: Increase of the organic surface of rice in Camargue.	Farmers.	Farmers.	Obvious.	Farmers, INRA.	No.	From around 200 hectares in 1980 to 1400 hectares in 2014.

Link					Mechanism (explanation of the underlying link)		Alternative explanations of the mechanism	Validity of the alternative explanations/Measure of the impacts
N°	Variable		Actor		Description of the mechanism	Origin Inf		
	Origin	Destination	Origin	Destination				
41	Outcome 8: Adoption of the organic production mode.	Impact 7: Reduction of the surface of rice in Camargue.	Farmers.	Farmers.	(1) Transition to organic production requires lengthening the rotations (for fighting weeds) and this automatically reduces the total surface devoted to rice. (2) As longer rotations reinforces the problem of the salt concentration in the lands; it is not possible anymore to cultivate rice in the lands having a low altitude compared to the sea level. Therefore, this phenomenon also leads to a reduction of the surface devoted to rice.	Farmers, INRA.	No.	The conversion to organic production has led to a reduction of the surface devoted to rice about 45% for the organic and partial organic farmers. At the level of the Camargue region, the decrease of the surface rice (due to the conversion) is about 8%.
42	EF5: Political changes (new CAP).		EU.	Farmers.	Abolishment of aids specifically dedicated to rice, for the last 2 years.	Farmers.	No.	

TABLE 23 : TABLE OF LINKS FROM THE CAMARGUE CASE STUDY

Glossary

Activities	Actions taken or work performed through which inputs, such as funds, technical assistance and other types of resources are mobilized to produce specific outputs (UNAIDS, 2017).
Assessment	We use in this thesis the term assessment as equivalent to evaluation.
Beneficiaries	The individuals, groups, or organizations, whether targeted or not, that benefit, directly or indirectly, from the development intervention (UNAIDS, 2017).
Counterfactual	The situation or condition which hypothetically may prevail for individuals, organizations, or groups were there is no development intervention (Collins et al. 2004; Bigaj, 2005).
Diffusion	The way in which innovation spreads, through market or non-market channels, from their very first implementation to different consumers, countries, regions, sectors, markets and firms. Without diffusion, an innovation has no economic impact (Anandajayasekeram et al. 2009, p305).
Evaluation	It should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision-making process of both recipients and donors. Evaluation also refers to the process of determining the worth or significance of an activity, policy or program (OECD, 2016; Baehr et al. 2010).
Ex-ante evaluation	Evaluation that is performed before implementation of a development intervention (OECD, 2002).
Ex-post evaluation	Evaluation of a development intervention after it has been completed (OECD, 2002).

Ex-post Impact Evaluation / Assessment	Specific type of evaluation designed for identifying and measuring impacts resulting from a program or project's earlier interventions (Walker et al. 2008).
Impact	Positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended (OECD, 2002).
Impact Evaluation	Assessment of how the intervention being evaluated affects outcomes (changes) in the actions, relationships, and behaviors of enterprises, individuals or communities, whether these effects are intended or unintended (OECD, 2002).
Impact Pathway	Characterization of actors that interact during the innovation process on the one side and dimensions of impacts on the other side (Walker et al. 2010). It provides a global view of the change processes that may be linked to a program research (Springer-Heinze et al. 2003).
Innovation	It can be defined as the implementation of a new or significantly improved product (good or service) or process, a new marketing method or a new organizational method in business practices, workplace organization or external relations (OECD, 2016).
Incremental innovation	It can be defined as the refinement, improvement, and exploitation of existing innovations. Incremental innovations build on and reinforce the applicability of existing knowledge, and subsequently strengthen the dominance and capabilities of incumbent firms and the dominant design. Incremental innovations are characterized by reliability, predictability, and low risk (Narayanan and O'Connor, 2010).
Knowledge broker	Person or organization that, from a relatively impartial third-party position, purposefully catalyze innovation through bringing together actors and facilitating their interaction. Innovation brokering expands the role of [traditional] agricultural extension from that of a one-to-one intermediary between research and farmers to that of an intermediary

	that creates and facilitates many-to-many relationships (Klerkx et al. 2009).
Radical innovation	It can be defined as innovations with features offering dramatic improvements in performance or cost, which result in transformation of existing markets or creation of new ones. They involve fundamental technological discoveries for the firm, and thus are new to the firm and/or industry, and offer substantially new benefits and higher performance to customers (Narayanan and O'Connor, 2010).
Outcome	The likely or achieved short-term and medium-term effects of an intervention's outputs (OECD, 2002). Outcome implies changes in the behaviors, relationships, activities and/or actions of a boundary partner that can be logically linked to a program (Earl et al. 2001).
Outcome	The likely or achieved short-term and medium-term effects of an intervention's outputs (OECD, 2002). Outcome implies changes in the behavior, relationships, activities and/or actions of a boundary partner that can be logically linked to a program (Earl et al. 2001).
Outcome Harvesting	It is an utilization-focused, highly participatory tool that enables evaluators, grant makers, and managers to identify, formulate, verify, and make sense of outcomes they have influenced when relationships of cause-effect are unknown (Wilson grau and Britt, 2002).
Output	The products, capital goods and services which result from a development intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes (OECD, 2002). Outputs are directly achievable and observable (Earl et al. 2001; Byrne and Ragin, 2009).
Process tracing	It seeks to uncover the causal link by focusing on the intervening steps in a hypothesized causal process (Bennett, 2010).

Scaling out	Spread of project output from farmers to farmers, community to community, within the same stakeholder groups (Douthwaite et al. 2003).
Scaling up	Institutional expansion, from adopter and their grassroots organizations to policy makers, donors, development institutions, and the other stakeholders key to building a more enabling environment for the scaling-out process (Douthwaite et al. 2003).
Theory of change	Theory of how and why an initiative works; conceptual model linking the activities, all changes, and the context of the initiative (Weiss 1997; Connell and Kubisch, 1998).

This thesis intends to evaluate, develop and test different qualitative methods and ways of ex-post assessing the impacts and contribution of the research on innovation processes and the society, in relation to the transition to organic agriculture.
We have conducted two case studies focusing on the transition to organic farming. First is the Camargue case (in France) that encompasses a broad range of technical innovations. Second is on the development of the organic product Ecostop to protect bees against the varroatosis disease in Bulgaria.
We evaluate the potential of a broad approach based on the Participatory Impact Pathway Analysis (PIPA) and adapted & complemented by several other methods (first article, part 4), as well as the potential of the Social Network Analysis (SNA) (second paper, part 5) and of the Actor Network Theory (ANT) (third paper, part 6), in evaluating ex-post the impacts and contribution of the research. We study the impacts of the research in the Camargue and how they were generated. The Bulgarian case is only used to evaluate the potential of ANT (together with the Camargue case).
The approach based on PIPA allows assessing successfully the impacts and contribution of the research. We could show that the research contributed to change in the Camargue by developing co-learning interactions with farmers although this was not critical to the success of the innovation as a whole. The agricultural policies, economic factors, the testing conducted independently by farmers, and the institutional framework, were the most important and influential factors. With respect to SNA, it was of interest to validate stakeholders' views on actors' relationships and their implications on the transition to organic farming. For example, the growing role played by INRA (National Research Agronomic Institute) within the actor network was confirmed as well as its contribution to the transition. As to ANT, it allows highlighting interpersonal actors' relationships and their effects on the innovation development. We particularly underline the importance of opinion leaders in the phases of implementation and diffusion; and also show the importance of problematizing the issues to be tackled in order to increase the success of research programs.

Key words – Evaluation; Program Theory; Innovation Process; Ex-post Participatory Impact Pathway Analysis; Social Network Analysis; Actor Network Theory.

Cette thèse a pour objet d'évaluer, de développer et de tester différentes méthodes qualitatives et manières d'évaluer ex-post les impacts et la contribution de la recherche sur les processus d'innovations et la société, par rapport à la transition à l'agriculture biologique.
Nous avons réalisé deux cas d'études traitant de la transition à l'agriculture biologique. Le premier est le cas camarguais (en France) englobant un ensemble d'innovations techniques. Le second concerne le développement du produit biologique Ecostop pour protéger les abeilles contre la maladie de la varroatose en Bulgarie.
Nous évaluons le potentiel d'une approche globale basée sur l'analyse participative du chemin de l'impact (PIPA) mais adaptée et complémentée par de nombreuses autres méthodes (premier article, partie 4), ainsi que le potentiel de l'analyse du réseau social (SNA) (deuxième article, partie 5) et de la théorie de l'acteur réseau (ANT) (troisième article, partie 6) pour l'évaluation ex-post des impacts et de la contribution de la recherche. Nous étudions les impacts de la recherche en Camargue et la manière dont ils ont été générés. Le cas Bulgare est seulement utilisé pour évaluer le potentiel d'ANT (avec le cas camarguais).
L'approche basée sur PIPA permet d'évaluer avec succès les impacts et la contribution de la recherche. Nous avons pu mettre en évidence que la recherche a contribué au changement en Camargue à travers le développement d'interactions de co-apprentissage avec les producteurs bien que cela ne se soit pas avéré crucial pour le succès de l'innovation dans son ensemble. Les politiques agricoles, facteurs économiques, tests conduits indépendamment par les agriculteurs, et le cadre institutionnel, ont été les facteurs les plus importants et ayant eu le plus d'effets. En ce qui concerne SNA, elle est apparue utile pour valider les dires des parties prenantes sur les relations entre acteurs ainsi que leurs implications sur la transition à l'agriculture biologique. Par exemple, le rôle grandissant joué par l'INRA (Institut National de la Recherche Agronomique) au sein du réseau d'acteurs a été confirmé de même que sa contribution à la transition vers l'agriculture biologique. Quant à l'approche ANT, elle permet de mettre en avant les relations interpersonnelles d'acteurs et leurs effets sur le développement de l'innovation. Nous soulignons en particulier l'importance des leaders d'opinion au cours des phases d'implémentation et de diffusion ; et montrons également l'importance de problématiser les questions devant être traitées afin d'améliorer le succès des programmes de recherche.

Mots clés – Evaluation ; Théorie du Programme ; Processus d'Innovation ; Analyse Ex-post et Participative du Chemin de l'Impact ; Analyse du Réseau Social ; Théorie de l'Acteur Réseau.