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UNIVERSITÉ GUSTAVE EIFFEL
École doctorale Organisations, Marchés, Institutions (OMI)

Thèse de doctorat en Sociologie

Renée VAN DIS

Re-envisioning Responsible Research: The Inextricable Role of Visions in Translation

The case of ASIRPA Real-Time in the French 0-Pesticides mission

Thesis co-supervised by: Allison-Marie LOCONTO and Mireille MATT

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Re-envisioning Responsible Research: The Inextricable Role of Visions in Translation

The case of ASIRPA Real-Time in the French 0-Pesticides mission

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Summary in English

To what extent can we responsabilise researchers to respond to societal challenges? Within Europe, governments are seeking to achieve societal missions through policy programmes that support alternative ways of conducting research. This policy innovation highlights the responsibilities for resolving problems in society that governments attribute to researchers. Such policies diverge from a context of 'excellent science', where research efforts are oriented towards economic growth and blue-sky objectives, and where scientific advances are not tempered by societal context. Instead, directing research to meet societal needs requires a different understanding and means of assessing the societal impact of research. Formative evaluation has emerged as a means to support the responsabilisation of researchers, which involves the evaluation of real-time impact as a learning process involving all actors in the R&I programme. Therefore, responsabilisation of researchers could be conceptualised as a formative process of (re)orienting research towards societal impact in real time. In this thesis, I question how formative evaluation encourages researchers to take responsibility for contributing to a societal mission through their research.

To respond to this question, I studied the case of a French research programme launched in 2019: The Priority Research Programme 'Growing and Protecting crops Differently' (PPR-CPA), with the ambitious mission of eradicating pesticides by 2040. I worked with the researchers of the ten funded research projects who are encouraged to think about their contribution to the constitution of a pesticide-free society with the alternative solutions to pesticides that they study. The PPR-CPA has integrated ASIRPA Real Time (RT), a formative evaluation approach, to support researchers in this process. ASIRPA RT mobilises the sociology of translation to highlight the chains of translation that occur during the process of generating societal impacts. In conducting my research within the ASIRPA TR team, I compared researchers' visions of eradicating pesticides before their participation in ASIRPA TR (T_0) and one year after (T_1). I introduce the notion of 'responsible translation' to describe the process I observed of how researchers move from holding visions of alternative solutions they study in their projects to those of a society that eradicates pesticides. This process highlights the fact that researchers must envision the roles and responsibilities of actors in reconfigured heterogeneous networks in order to anticipate their impact on society. My thesis contributes to academic knowledge as I demonstrate the links between the responsabilisation of researchers and processes of translation, supported by formative evaluation. I show that normative visions of responsibility guide research, but they need to be translated in order to work. Consequently, these visions become part of the translation process in mission-oriented contexts.

Summary in French

Dans quelle mesure pouvons-nous responsabiliser les chercheurs pour qu'ils répondent aux défis de la société ? En Europe, les gouvernements mettent en place des politiques d'innovation dites de mission qui soutiennent des manières alternatives de mener la recherche. Cette approche met en évidence les responsabilités que les gouvernements attribuent aux chercheurs dans résolution des problèmes de la société. Ce contexte diffère de celui de la 'science d'excellence', où les efforts de recherche sont orientés par la croissance économique et des objectifs scientifiques, et où les avancées scientifiques ne sont pas considérées dans leur contexte sociétal. Au contraire, l'orientation de la recherche pour afin de répondre aux besoins de la société exige une compréhension différente et des moyens d'évaluer l'impact sociétal de la recherche. L'évaluation formative est un moyen de soutenir la responsabilisation des chercheurs, qui implique l'évaluation de l'impact en temps réel en tant que processus d'apprentissage incluant tous les acteurs du programme de recherche et d'innovation. Par conséquent, la responsabilisation des chercheurs pourrait être conceptualisée comme un processus formatif de (ré)orientation de la recherche vers l'impact sociétal en temps réel. Dans cette thèse, je questionne la manière dont l'évaluation formative encourage les chercheurs à prendre la responsabilité de contribuer à une mission sociétale par le biais de leurs projets de recherche.

Pour répondre à cette question, j'ai étudié le cas d'un programme de recherche français lancé en 2019 : le Programme prioritaire de recherche « Cultiver et protéger autrement » (PPR-CPA), avec la mission ambitieuse d'éradiquer les pesticides d'ici 2040. J'ai travaillé avec les chercheurs des dix projets de recherche financés qui sont encouragés à réfléchir à leur contribution à la constitution d'une société sans pesticides avec les solutions alternatives aux pesticides qu'ils étudient. Le PPR-CPA a intégré ASIRPA Temps Réel (TR), une approche d'évaluation formative, pour soutenir les chercheurs dans ce processus. ASIRPA TR mobilise la sociologie de la traduction afin de mettre en évidence les chaînes de traduction tout au long du processus de génération des impacts sociétaux. En menant ma recherche au sein de l'équipe ASIPRA TR, j'ai comparé les visions des chercheurs sur l'éradication des pesticides avant leur participation à ASIRPA TR (T0) et un an après (T1). J'ai développé la notion de « traduction responsable » afin de décrire le processus que j'ai observé sur la façon dont les chercheurs passent de visions de solutions alternatives qu'ils étudient dans leurs projets à celles d'une société qui éradique les pesticides. Ce processus met en évidence le fait que les chercheurs doivent envisager les rôles et les responsabilités des acteurs dans des réseaux hétérogènes reconfigurés afin d'anticiper leur impact sur la société. Ma thèse contribue à la connaissance académique en démontrant les liens entre la responsabilisation des chercheurs et les processus de traduction, soutenus par l'évaluation formative. Je montre que les visions normatives de la responsabilité guident la recherche, mais qu'elles doivent être traduites pour fonctionner. Par conséquent, ces visions font partie du processus de traduction dans les contextes orientés vers une mission.

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‘A PhD is a marathon not a sprint’ – it is one of the many metaphors I have heard during the past years. Well, after almost 3,5 years of hard work I crossed the finish line. Although it was very intense at times and the road towards starting the PhD was difficult, it was still a great intellectual experience. I am happy that I decided to pursue a PhD and that I got this unique opportunity. I thought of it as a big puzzle, and the discovery of connecting pieces has been a satisfying process to me. But I could never have done this without all the people around me, who I want to thank for their support and encouragements throughout this journey.

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Table of Contents

Summary in English	i
Summary in French	ii
Acknowledgements	iii
Abbreviations	x
List of Figures	x
List of Tables	xi
List of Boxes	xii
General Introduction	2
1. General context of the thesis	2
2. Responsible Research: Rethinking associations between science and society.....	4
2.1 Science in Society.....	5
2.2 Science for Society.....	7
2.3 Science with Society: A limited understanding	11
3. Responsible Translation: a concept to embed visions of associations	12
4. Thesis plan	17
Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France	24
1.1 150 years of chemical pesticides use in France.....	25
1.2 Over 150 years of pesticides' regulations in France.....	27
1.2.1 The first government decrees and regulations on chemical pesticides	29
1.2.2 The French pesticides registration system.....	29
1.2.3 International frameworks to regulate pesticides use.....	32
1.2.4 Authorisation and withdrawal of pesticides in France	35
1.3 R&I activities and strategies on (the reduction of) pesticides	37
1.3.1 Research strategies in agricultural policy.....	39
1.3.2 The French research environment on pesticides	40
1.3.3 The Ecophyto plan: the French National Action Plan on the sustainable use of pesticides.....	49
1.3.4 Investing in the future: the PPR-CPA.....	54
1.3.5 Current controversies and public discussions about the reduction of pesticides use	57
Conclusion.....	59
Chapter 2. Responsibility of Researchers for the 0-pesticides Mission.....	62
2.1 The notion of responsibility in research and innovation.....	63
2.1.1 Responsibility of Researchers	64
2.1.2 Emergence and development of RRI and RI: responding to societal challenges	72

2.1.3 The implementation and institutionalisation of RRI: Challenges and barriers.....	80
2.2 A concept to study responsible research for the eradication of pesticides.....	89
2.2.1 Future looking activities: The Sociology of Expectations as an approach to studying expected contributions to the mission	89
2.2.2 An ANT Perspective to Performing Expectations.....	94
2.2.3 Responsibility of researchers and other actors for the expected contributions to the mission	98
Conclusion.....	101
Chapter 3. The Research Methodology: exploring the intervention of ASIRPA Real-Time for the PPR-CPA researchers.....	
	104
3.1 Objects of Research: ASIRPA Real-Time in the PPR-CPA	105
3.1.1 An introduction to the ASIRPA Real-Time approach.....	105
3.1.2 An introduction to the PPR-CPA	107
3.1.3 An introduction to the ten funded PPR-CPA projects.....	109
3.2 The collection of data with ASIRPA Real-Time: A comparison between two phases	113
3.2.1 Data collection in the T ₀ -phase	115
3.2.2 Data collection in the T ₁ -phase	117
3.2.3 Data collection for the socio-historical analysis (Chapter 1).....	123
3.3 The analyses of data: Responsible translation processes	124
3.3.1 Inductive coding.....	125
3.3.2 The responsible translation process	126
3.3.3 Abductive reasoning: building theory on responsible research.....	128
3.3.4 Using the analysed data in empirical chapters	129
3.4 Reflexive learning in research.....	129
3.4.1 My researcher positionality	130
3.4.2 Reflexivity on ASIRPA RT.....	133
3.4.3 Reliability and validity of the qualitative research	135
3.4.4 Reflections of the PPR-CPA researchers on ASIRPA RT in navigating Research visions.....	136
Conclusion.....	139
Chapter 4. The Construction of Mission-Oriented Research: How Researchers Envision their Contribution to the 0-Pesticides Mission	
	142
4.1 Researchers' Visions of the Eradication of Pesticides	144
4.1.1 Research field: Agri-food system, markets and policies	146
4.1.2 Research field: Genetics, diversity and biocontrol	149
4.1.3 Research field: Epidemiosurveillance and prophylaxis.....	152
4.2 Contributing to a '0-pesticides society' in the mission-oriented context	156
4.2.1 The Scientific Performance of a 0-pesticides society	158
4.2.2 Visions of Viability and Acceptability in Society	160
4.3 Visions of the multiple characteristics of mission-oriented research projects.....	164

4.3.1 Multidisciplinary Consortia	164
4.3.2 Multiple Dimensions of Research	166
4.3.3 Multiple Levels of Analyses	168
4.3.4 Multi-Actor Research.....	170
4.3.5 Multiple (Knowledge) Resources	172
4.4 From Research to Society: visions of the associations between researchers and 0-pesticides society.....	174
4.4.1 From Research to Society: Envisioned Roles for actors in a 0-pesticides society	175
4.4.2 From Research to Society: raising interest of actors in a 0-pesticides society	179
Conclusion.....	181
Chapter 5. Establishing Associations Between Science and Society: Researchers' Visions of the Constitution of a 0-Pesticides Society	184
5.1 Researchers' visions of societal impacts	187
5.1.1 Researchers' Visions: Impacting Society with alternative solutions to pesticides	188
5.2 Researchers' visions of Transformations for a 0-pesticides society	193
5.2.1 Five interdependent poles of societal transformations	194
5.3 Obligatory Passage Points and blocking factors of science-society relations in the mission.....	203
5.3.1 Two Obligatory Passage Points to constitute a society that eradicates pesticides	204
5.3.2 Potential Obstacles to establishing science-society relations.....	206
Conclusion.....	211
Chapter 6. Realising Associations between Science and Society: Anticipating Heterogenous Networks to Perform the Researchers Expected contributions to a 0-Pesticides Society	214
6.1 Intermediary actors in the network: inputs and outputs of the research projects	219
6.1.1 Convincing actors with demonstration and proof of the alternative solutions	221
6.1.2 Adapting alternative solutions to actors' financial constraints	223
6.1.3 Building capacity of actors for the alternative solutions	225
6.2 Intermediary actors in the network external to the research projects.....	228
6.2.1 Enabling the adoption of alternative solutions.....	229
6.2.2 Valorising the alternative solutions	234
6.3 Actor associations in the network to perform chains of translation	238
Conclusion.....	243
Chapter 7. Mobilising Associations between Science and Society: A Change in Visions of Alternative Solutions to Pesticides becoming Spokesmen of the Heterogenous Networks.....	247
7.1 How to contribute to a 0-pesticides society with research on alternative solutions	252
7.1.1 Mobilisation through scientific breakthrough is insufficient	252
7.1.2 Mobilisation through the emergence of "chains of changes"	255
7.2 How to impact society with research on alternative solutions	258
7.2.1 Mobilising impacts to society through excellent science	259

7.2.2 Mobilising impacts to society through envisioning responsibilities of other actors.....	260
7.3 How to enrol actors’ responsibilities to enable the eradication of pesticides with the alternative solutions	265
7.3.1 Mobilisation is not the result of scientific socio-economic studies	265
7.3.2 Mobilising alternative solutions through chains of translation for raising interest and enrolling actors	267
Conclusion.....	270
General Discussion and Conclusion	274
1. The inextricable link between responsibility and translation: the contributions of the notion of ‘responsible translation’ and the role of formative evaluation	275
1.1 Responsibilities in responsible translation: associating actors’ responsibilities in envisioned networks	277
1.2 Normative visions of responsibility as part of responsible translation.....	282
1.3 ASIRPA RT as formative evaluation approach to support responsible translation	286
2. Sociological implications for responsible research: responsible translation in a mission-oriented context	291
2.1 Establishing science-society associations: a paradigm shift to a mission-oriented responsible translation process.....	291
2.2 Realising science-society associations: co-responsibility in the mission-oriented responsible translation process.....	297
2.3 Mobilising science-society associations: ontology in the mission-oriented responsible translation process.....	302
3. Research Limitations and future research directions.....	307
3.1 Research limitations	307
3.2 Future research directions	310
4. Final conclusions.....	312
References	317
Annex I – T₀ interview Protocol.....	328
Annex II – Transformations Table at T₀	330
Annex III – Codebook data analyses.....	336
Annex IV – Endnotes: French Translations of quotes	339

Abbreviations

ANR	Agence nationale de la recherche (French National Research Agency)
ANT	Actor-Network Theory
CAP	Common Agricultural Policy
EU	European Union
FP	Framework Programme
INRAE	Institut national de recherche pour l'agriculture, l'alimentation et l'environnement (French national research institute for agriculture, food and the environment)
IP	Impact Pathway
NAP	National Action Plan
PI	Principal Investigator
PIA	Programme d'investissements d'avenir (Investment for the future programme)
PPP	Plant Protection Products
PPR-CPA	Programme Prioritaire de Recherche « Cultiver et Protéger Autrement » (Priority Research Program “Growing and Protecting Crops Differently)
R&I	Research and Innovation
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RI	Responsible Innovation
RRI	Responsible Research and Innovation
RT	Real-Time
SaS	Science and Society
SiS	Science in Society
SwafS	Science with and for Society

List of Figures

FIGURE 1. OVERVIEW OF THE THESIS STRUCTURE	16
FIGURE 2. PESTICIDES USE (TONNES) IN FRANCE FROM 1990-2020 (SOURCE: FAOSTAT)	27
FIGURE 3. AN OVERVIEW OF OVER 150 YEARS OF PESTICIDES’ REGULATIONS IN FRANCE	28
FIGURE 4. TOTAL AUTHORISED ACTIVE SUBSTANCES IN 2020 PER EU COUNTRY (SOURCE: EU PESTICIDES DATABASE, 2020)	36
FIGURE 5. EVOLUTION OF THE AUTHORISATION AND WITHDRAWAL OF PESTICIDES IN FRANCE (INCLUDING TOTAL NUMBER OF AUTHORISED PESTICIDES) (SOURCE: E-PHY AND DATABASE FRENCH GOVERNMENT (DATA.GOUV.FR))	36
FIGURE 6. CLUSTERS OF THE MOST FREQUENT ASSOCIATED TERMS IN PESTICIDES RESEARCH IN FRANCE (1965-2019)	42
FIGURE 7. HEATMAP HIGHLIGHTING THE FOCUS OF THE FRENCH PESTICIDES RESEARCH ECOSYSTEM IN THE PERIOD 1960-1969; THE DARKER RED THE TERM OR CLUSTER, THE MORE THOSE TERMS OR CLUSTERS APPEARED IN THIS PERIOD	43
FIGURE 8. HEATMAP HIGHLIGHTING THE FOCUS OF THE FRENCH PESTICIDES RESEARCH ECOSYSTEM IN THE PERIOD 1970-1979; THE DARKER RED THE TERM OR CLUSTER, THE MORE THOSE TERMS OR CLUSTERS APPEARED IN THIS PERIOD	44

FIGURE 9. HEATMAP HIGHLIGHTING THE FOCUS OF THE FRENCH PESTICIDES RESEARCH ECOSYSTEM IN THE PERIOD 1980-1989; THE DARKER RED THE TERM OR CLUSTER, THE MORE THOSE TERMS OR CLUSTERS APPEARED IN THIS PERIOD	45
FIGURE 10. HEATMAP HIGHLIGHTING THE FOCUS OF THE FRENCH PESTICIDES RESEARCH ECOSYSTEM IN THE PERIOD 1990-1999; THE DARKER RED THE TERM OR CLUSTER, THE MORE THOSE TERMS OR CLUSTERS APPEARED IN THIS PERIOD	46
FIGURE 11. HEATMAP HIGHLIGHTING THE FOCUS OF THE FRENCH PESTICIDES RESEARCH ECOSYSTEM IN THE PERIOD 2000-2009; THE DARKER RED THE TERM OR CLUSTER, THE MORE THOSE TERMS OR CLUSTERS APPEARED IN THIS PERIOD	47
FIGURE 12. HEATMAP HIGHLIGHTING THE FOCUS OF THE FRENCH PESTICIDES RESEARCH ECOSYSTEM IN THE PERIOD 2010-2017; THE DARKER RED THE TERM OR CLUSTER, THE MORE THOSE TERMS OR CLUSTERS APPEARED IN THIS PERIOD	48
FIGURE 13. ASIRPA'S RT IMPACT PATHWAY AND THE THREE STEPS IN THE CONSTRUCTION.....	106
FIGURE 14. TIMELINE OF THE ASIRPA RT ACTIVITIES ON PROJECT LEVEL IN THE PPR-CPA.....	116
FIGURE 15. THE ASIRPA' STEAM UP' FRAMEWORK	118
FIGURE 16. FIRST ELEMENTS OF THE HETEROGENOUS NETWORKS: EXAMPLE OF ACTORS IN THE FIVE POLES OF SOCIETAL TRANSFORMATIONS BASED ON CHAPTER 5	217
FIGURE 17. EXAMPLES OF THE EXPANSION OF THE HETEROGENOUS NETWORK WITH INTERMEDIARY ACTORS LINKED TO THE PPR-CPA PROJECTS, WHO HAVE THE RESPONSIBILITY FOR ENROLMENT AND INTERESSEMENT IN LINE WITH THE ENVISIONED SOCIETAL TRANSFORMATIONS. THE BLUE CIRCLES REPRESENT ACTORS, THE DOTTED CIRCLES REPRESENT ENVISIONED RESPONSIBILITIES BUT THE SPECIFIC ACTORS ARE NOT YET IDENTIFIED.	220
FIGURE 18. EXAMPLES OF THE EXPANSION OF THE HETEROGENOUS NETWORK WITH INTERMEDIARY ACTORS THAT ARE EXTERNAL – AND NOT YET ASSOCIATED – TO THE RESEARCH PROJECTS, WHO HAVE THE RESPONSIBILITY FOR ENROLMENT AND INTERESSEMENT IN LINE WITH THE ENVISIONED SOCIETAL TRANSFORMATIONS.	230
FIGURE 19. EXAMPLES OF THE EXPANSION OF THE HETEROGENOUS NETWORK WITH THE ENVISIONED ASSOCIATIONS BETWEEN THE VARIOUS ACTORS – THE DOTTED LINES INDICATE ASSOCIATIONS BETWEEN ACTORS THAT ARE NOT YET DEFINED IN DETAIL NOR ANTICIPATED	239
FIGURE 20. SCHEMATIC OVERVIEW OF HOW SOCIETAL CHANGE GETS REPRESENTED BY THE ALTERNATIVE SOLUTIONS STUDIED IN THE PROJECTS.....	282
FIGURE 21. THE INEXTRICABLY INTERLINKAGE OF THE THREE PHASE OF RESPONSIBLE TRANSLATION AND THE FOUR-DIMENSIONAL FRAMEWORK OF RI IN THE CONSTRUCTION OF FUTURE NETWORKS TO PERFORM VISIONS OF SOCIETAL CHANGE (BUILDING FURTHER ON FIGURE 15).....	285

List of Tables

TABLE 1. MENTIONS ADDED TO THE CHEMICAL PLANT PROTECTION PRODUCTS (PPP) IN THE FRENCH REGULATION SYSTEM (SOURCE: E-PHY DATABASE AND DATABASE FRENCH GOVERNMENT: DATA.GOUV.FR)	37
TABLE 2. PIA 3: THREE PRIORITY AREAS AND NINE OBJECTIVES.....	55
TABLE 3. THE TEN FUNDED PPR-CPA PROJECTS PER PROJECT TYPE	109
TABLE 4. OVERVIEW OF THE PROCESS OF CONSTRUCTING THE PROJECTS' FIRST IP FOR THE EIGHT PROJECTS.....	120
TABLE 5. OVERVIEW OF THE PARTICIPANTS TO THE ASIPRA RT WORKSHOPS PER PROJECT.....	121
TABLE 6. OVERVIEW OF THE DATA COLLECTED AT T ₀ AND T ₁	123

TABLE 7. THE RESEARCHERS' VISIONS ON THE ERADICATION OF PESTICIDES: THREE ELEMENTS	145
TABLE 8. THE CHARACTERISTICS OF RESEARCH FIELD 1 BASED ON THE THREE RESEARCH DIMENSIONS (AGRI-FOOD SYSTEMS, MARKETS AND POLICIES)	146
TABLE 9. THE CHARACTERISTICS OF RESEARCH FIELD 2 BASED ON THE THREE RESEARCH DIMENSIONS (GENETICS, DIVERSITY AND BIOCONTROL)	149
TABLE 10. THE CHARACTERISTICS BASED ON THE THREE RESEARCH DIMENSIONS OF RESEARCH FIELD 3 (EPIDEMIOSURVEILLANCE AND PROPHYLAXIS)	153
TABLE 11. THE FIVE POLES OF SOCIETAL TRANSFORMATIONS, AND THEIR INTERDEPENDENCES IN THE CONFIGURATION OF THE NETWORK.....	201
TABLE 12. AN OVERVIEW OF THE EIGHT PPR-CPA PROJECTS ARE THEIR POSITIONING TOWARDS CHANGE ALONG THE FIVE POLES OF SOCIETAL TRANSFORMATIONS FOR THE 0-PESTICIDES MISSION	202
TABLE 13. A SUMMARY OF THE THREE CHANGED VISIONS THAT DEMONSTRATE A CHANGE FROM THE 'TRANSFER OF RESEARCH OUTPUTS INTO SOCIETY' (T ₀) INTO 'THE RESPONSIBLE TRANSLATION OF RESEARCH ON ALTERNATIVE SOLUTIONS TO A SOCIETY WITHOUT PESTICIDES' (T ₁).	251
TABLE 14. A SUMMARY OF THE CHANGED OBSERVED AMONG THE PPR-CPA RESEARCHERS FROM VISIONS OF THE TRANSFER OF RESEARCH OUTPUTS, TO THE RESPONSIBLE TRANSLATION PROCESS	271
TABLE 15. FOUR PARADIGMS OF RESPONSIBILITY; EXTRACTED FROM ARNALDI & GORGONI (2016)	293
TABLE 16. A COMPARISON BETWEEN THE RRI PARADIGM BY ARNALDI AND GORGONI (2016) AND THE RESPONSIBLE TRANSLATION PARADIGM IN THE PPR-CPA; ADAPTED TO THE AUTHORS' FRAMEWORK.....	294

List of Boxes

BOX 1. THE CASE STUDY OF ASIPRA RT AS FORMATIVE EVALUATION IN THE PPR-CPA	13
BOX 2. PROMOTION OF SUSTAINABLE USE OF CHEMICAL PLANT PROTECTION PRODUCTS IN THE COMMON AGRICULTURE POLICY (CAP) (2014-2020)	35
BOX 3. OVERVIEW OF ARTICLES ON RESEARCH OF THE LAW ON AGRICULTURAL ORIENTATION FROM 1980-2014 (SOURCE: LEGIFRANCE.GOUV.FR)	39
BOX 4. EIGHT THEMATIC RESEARCH PRIORITIES OF THE ECOPHYTO PLAN	52
BOX 5. THREE MAINS R&I ACTIONS OF THE ECOPHYTO II PLAN	53
BOX 6. THREE R&I ACTIONS OF THE ECOPHYTO II + PLAN.....	54

General Introduction

General Introduction

1. General context of the thesis

What if farmers stopped using pesticides? Would we lose our crop production, and need larger areas of farmland? Would the bee mortality be stopped? Would we suffer less from chronic diseases? Since World War II, agricultural systems have been intensified through the use of pesticides, with the aim to increase food production. Nowadays, we are aware of the negative impacts on society this has caused, such as the loss of biodiversity, water-, air- and soil pollution and human health effects. Despite this awareness, pesticides sales did not decrease over the past decade; in Europe, the usage rates are particularly high in Germany, Spain, Italy and France.¹ Today's conventional farming systems heavily depend on the use of pesticides to protect crops against pests. Therefore, simply eradicating them from agricultural systems is a major challenge. This requires appropriate alternatives to control pests instead (Jacquet et al., 2022).

On national and international level, governments have been aiming to reduce pesticides use. For instance, the French government launched a national policy plan called 'Ecophyto' in 2008, with the aim to reduce pesticides use with 50% by 2018. Despite the ambition of Ecophyto, its mid-term assessment in 2013 documented that the goal of reducing pesticides was not being met. Instead, over this period of time, pesticides sales in France did not decrease and its use even increased (Hossard et al., 2017).² According to Guichard et al. (2017), the plan was a failure as Ecophyto did not embed systemic visions of the pest-management system, nor did it consider broader 'socio-technical lock-ins' that keep pesticides in use. As a response, the French government presented a revised 'Ecophyto II plan' in 2015, which included the scaling up of Research and Innovation (R&I) initiatives.

This was even further strengthened by the 'Ecophyto II+ plan' in 2019. As part of this plan, research efforts were reinforced through a dedicated research programme with the objective of identifying alternative options to the use of chemical pesticides.³ Consequently, in June 2019, the French Ministry of Higher Education, Research and Innovation launched the national Priority Research Programme 'Growing and Protecting Crops Differently' (PPR-CPA⁴). The PPR-CPA is a six-year research programme with an ambitious mission: a French agricultural system without pesticides by 2040. In

¹https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_consumption_of_pesticides#Key_messages; visited on 22.03.23

²The French Government reported such data on the increase only in 2020: https://www.statistiques.developpement-durable.gouv.fr/sites/default/files/2020-05/datalab_essentiel_215_prod_phytopharma_glyphosate_2018_mai2020.pdf; visited on 15.02.23

³<https://agriculture.gouv.fr/le-gouvernement-confirme-son-ambition-de-reduire-les-produits-phytosanitaires-de-moitie-dici-2025>; visited 15.02.23

⁴ In French: Programme Prioritaire de Recherche « Cultiver et Protéger Autrement »

contrast to the Ecophyto plan that aimed for a reduction of pesticides, the PPR-CPA has set the goal of their full eradication in France through a systemic approach (Jacquet et al., 2022). Hence, the French Government is making a concerted effort to achieve a pesticide-free agricultural future by its significant investment in this research programme (30 million euros over 6 years). The call for research projects of the PPR-CPA emphasised the following⁵ [*Translated from French*]:

*The Ecophyto plan was launched in 2008 with the objective of halving the use of pesticides in agriculture in 10 years. This objective has not been achieved. The use of plant protection products in agriculture continued to increase between 2008 and 2018. Today, the impact of plant protection products on the environment and biodiversity, as well as their effects on human health, are increasingly well documented and are a source of concern for all citizens. **This situation has led the Government to accelerate action to reduce the use of plant protection products in agriculture and to increase the resources invested in research to find alternatives. The Priority Research Programme (PPR) "Growing and Protecting Crops Differently" is part of this context.** (p.5)*

The programme is funding ten research projects, which are required to conduct research on alternative solutions to pesticides. This reinforcement of research efforts highlights the responsibility that the French Government attributes to researchers to contribute in resolving the problem of the overuse of pesticides. The researchers are encouraged to think about their contributions to the constitution of a pesticide-free society as they study alternative solutions to pesticides. This highlights the governments' belief in the capacity of researchers to address such an ambitious societal goal. We are thus speaking about expectations of particular associations between science and society in a mission-oriented context. By conducting my thesis research in the context of the PPR-CPA '0-pesticides mission', I study how researchers could be guided in this process to take on responsibility for contributing to a societal mission.

Hence, this mission-oriented context diverges from a context of 'excellent science', where research efforts are oriented towards economic growth and blue-sky objectives (Joly, 2018). Directing research towards a societal mission requires a different understanding and means of assessing the societal impact of research (Matt et al., 2023). In this regard, formative evaluation is a potential means to support the responsibility of researchers, which involves the evaluation of real-time impact as a learning process involving all actors in the R&I programme (Molas-Gallart et al., 2021). Therefore, the responsibility of researchers could be conceptualised as a formative process of (re)orienting research towards societal impact in real time. Thus, in this thesis, I question how formative evaluation encourages researchers to take on responsibility for contributing to a societal mission through the research they are conducting. I develop the concept of 'responsible translation' to explore the process

⁵ <https://anr.fr/fileadmin/aap/2019/aap-ia-pprcpa-2019.pdf>; visited on 15.02.23

from research on alternative solutions to a society that eradicates pesticides with these alternatives. Through this concept, I problematise what it means in terms of responsibility of researchers, to establish, realise and mobilise science-society associations in a mission-oriented context.

2. Responsible Research: Rethinking associations between science and society

Despite a broadening of the notion of innovation in academia, institutions responsible for innovation policy continue to tend to adopt the definition of innovation proposed in the 1960s. [...] This vision has led to implicit or explicit assertions that “Science is the solution, society the problem”.

(Joly 2018, p.5)

Joly (2018) argues that the linear model of R&I remains the dominant paradigm. However, if researchers are to take on responsibility for a societal mission, such as in the PPR-CPA, we have to rethink the associations between science and society. We have seen this, for instance, in the evolving policy context on responsibility in the European Union (EU). The EU is demonstrating its efforts through the Responsible Research and Innovation (RRI) approach, which emerged in the early 2000s following a period of controversy around genetic engineering where citizens placed pressure on public policy and scientists to become more responsive to societal needs and interests. It aims for researchers to rethink associations between their science and society, by involving a variety of non-academic actors, and by responding to societal challenges.⁶

While the concept of RRI was institutionalised in the EU only in the H2020 framework programme (FP) through the call on ‘Science with and for Society’ (SWaFS), it evolved from a responsible research paradigm in the calls on ‘Science and Society’ (SaS) in FP6 and ‘Science in Society’ (SiS) in FP7. The objective of SaS⁷ was to better engage non-scientific actors in science and technology discussions and processes (Owen et al., 2012). In SiS⁸ the emphasis evolved to a focus on the benefits of research to citizens, industries and SMEs. This period of SiS in FP7 (2007-2013) was characterised by demands of the EU for R&I efforts to bridge the gap between science and society. In particular, R&I was called for its role and responsibility to address societal challenges. The EU introduced funding calls in response to seven domains of societal challenges in H2020, and institutionalised RRI through its SWaFS call. It asked for a better collaboration between researchers and other stakeholders. The EU’s

⁶ <https://rri-tools.eu/about-rri>; visited 19.12.22

⁷ <https://cordis.europa.eu/programme/id/FP6-SOCIETY>; Visited 14.10.22

⁸ <https://cordis.europa.eu/programme/id/FP7-SIS>; Visited 14.10.22

Competitiveness Council meeting in 2014 characterised RRI as “a process for better aligning research and innovation with the values, needs and expectations of society”.⁹

Put differently, this evolution of the RRI policy concept in the EU highlights how their responsibility paradigm evolved together with understandings of associations between science and society. Scholars are increasingly questioning the types of R&I efforts that are needed to deal with the challenges that society is facing today (Loconto & Constance, Forthcoming 2023). The current period, which embeds for instance the French PPR-CPA, is thus marked by a new era of responsibility where researchers are required to rethink the associations between their research and the type of future society that is needed for their results to work.

In the following sections, I illustrate two widely acknowledged paradigms in academic literature that help understanding alternative science-society associations. First, there is the understanding of ‘Science in Society’, which has long been recognised. While it stresses that science and society constitute an interactive, interwoven relationship, this literature also focusses on the role of researchers in this regard, and less on other actors. Second, the understanding of ‘Science for Society’ is highlighted by the literature that discusses transformative R&I policy paradigms. Even though this literature stresses the need for systemic changes, it also highlights the difficulties in directing excellent science towards societal goals. Building further upon these two, I add a third understanding namely: Science with Society. Despite its mention through the EU’s SWaFS call, this formulation of the science-society relationship has not been widely problematised in the literature. I show in this thesis that the responsibility of researchers in a mission-oriented context can be understood through changes in their visions of the contributions to a future society by scientists with other actors. I illustrate how formative evaluation encourages researchers to change their visions.

2.1 Science in Society

“Science and society, in a word, are co-produced, each underwriting the other’s existence”.

(Jasanoff 2004, p. 17)

For decades Sociology of Science scholars have challenged themselves with questions about how science and society are interwoven, and the interactive relationship they constitute (Merton, 1942; Kuhn, 1962; Latour & Woolgar, 1979; Giddens, 1984; Gibbons et al., 1994; Jasanoff, 2004a). These scholars discuss the social construction of science and thereby the interactive constitution of scientific and societal realities. Robert Merton was one of the first sociologists to theorise the relations

⁹ <https://www.horizon-europe.gouv.fr/social-innovations-enablers-security-solutions-and-increased-security-perception-25775#r1>; Accessed 17.11.22

between science and society. In 1942, he published the influential book entitled: *'The Sociology of Science: Theoretical and Empirical Investigations'*. Merton (1942) discusses the notion of the 'ethos of modern science' as not being autonomous from society and depending on social structures, as he argues:

Three centuries ago, when the institution of science could claim little independent warrant for social support, natural philosophers were likewise led to justify science as a means to the culturally validated ends of economic utility and the glorification of God. The pursuit of science was then no self-evident value. With the unending flow of achievement, however, the instrumental was transformed into the terminal, the means into the end. Thus fortified, the scientist came to regard himself as independent of society and to consider science as a self-validating enterprise which was in society but not of it. A frontal assault on the autonomy of science was required to convert this sanguine isolationism into realistic participation in the revolutionary conflict of cultures. The joining of the issue has led to a clarification and reaffirmation of the ethos of modern science (p.268).

Hence, Merton emphasised that science is in society, but it is not of society. As Jasanoff (2004c) argued: *"scientific knowledge, in particular, is not a transcendent mirror of reality. It both embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments and institutions – in short, in all the building blocks of what we term the social"* (p.3). Jasanoff thus emphasises that science is not developed, and should thus not be understood, outside its social context. Instead science and 'the social' are integrated *"as indispensable elements in the process of societal evolution"* (p.17) (Jasanoff, 2004b). In this regard science should be perceived as a social practice (Latour, 1987; Jasanoff, 2004a), about which Latour (1987) argues that science is a 'set of situated practices'. He emphasises that scientific facts are constructed through the interaction of human and non-human actors in heterogenous networks. The structures of society are reconstructed and reconstituted each time that interaction occurs (Giddens, 1984).

In line with Latour's (1983) argument that micro-level studies are useful for understanding macro-level problems, the PPR-CPA research projects are required to come up with solutions for a problem that exists in society caused by the overuse of pesticides. According to Latour, it is a weak and dominant view among sociologists that a laboratory – and in the case of the PPR-CPA thus a research project – is isolated from society. But even to say that research influences or is influenced by society is too weak for Latour.¹⁰ Instead, research has the capacity to actively modify society, which in

¹⁰ This argument of Latour is based on his 'laboratory work' where he follows Pasteur in his microbiology laboratory to develop the vaccine against the cow disease 'anthrax' (Latour, 1983). In this case of Pasteur's research on the vaccine, to say that microbiology influences or is influenced by society is too weak for Latour. According to Latour, from his laboratory, Pasteur actively modified society - by moving the most important actors: the microbes. Currently we find a similar situation with the new COVID vaccines on a global level, which mobilised society out of lock-down situations and enabled human actors to live together with the COVID virus.

the PPR-CPA would be the result of 'moving' the alternative solutions to pesticides studied in the research projects, and thereby thus to constitute a society without pesticides.

In this regard, Latour (1983) provides interesting perspectives that can teach us about the societal embeddedness of science. For instance, beyond the differences between the micro and macro level, he discusses the inside-outside dichotomy. To apply this to the case of the PPR-CPA, in contributing to the mission, the research projects are required to 'deconstruct' the dichotomy between their research projects (the inside) and a society without pesticides (the outside) with the alternative solutions they study. Hence, research and society cannot be separated from one another in this societal mission, as they both have key roles to play.

However, Latour emphasises that it is particularly the associations with actors, which construct science and technology, that get 'black boxed' and thus become invisible. Latour (1999) defines black boxing as follows:

The way scientific and technical work is made invisible by its own success. When a machine runs efficiently, when a matter of fact is settled, one need focus only on its inputs and outputs and not on its internal complexity. Thus, paradoxically, the more science and technology succeed, the more opaque and obscure they become (p.304).

Consequently, Latour (1983) emphasises the difficulties of opening this black box of science, so to understand the social construction of it. Therefore, he argues 'how much simpler' it would be to follow scientists before the box is closed and thus before the science or technology has been black boxed. This means that if researchers should take on responsibility to direct their research towards a societal mission, it requires understanding the associations between science and other actors in society earlier on in the R&I process.

This paradigm of science in society teaches us about the interactive and interwoven relationship that science and society constitute. This helps to understand that researchers should consider the societal context that embeds their research. However, this literature also puts the emphasis on the role of science. This is not explanatory enough in recognising the role of other actors who must also contribute to the constitution of a future society in a mission-oriented context.

2.2 Science for Society

A second, more recent understanding of science-associations is that of 'science for society'. In the past decades, transformative R&I policy has been an up and coming policy paradigm in literature (Schot & Steinmueller, 2018). It discusses the framing of R&I for transformative change in society, by aiming to better align R&I efforts with societal challenges. Scholars argue that to be transformative, R&I activities should go beyond just setting new objectives. It is rather about unlocking 'business as

usual' by contributing to transformative change in socio-technical systems, and thereby addressing societal needs (e.g., Kuhlmann and Rip 2018; Schot and Steinmueller 2016, 2018; Weber 2003; Fagerberg, 2018).

Consequently such R&I activities should aim for contributing to transformative changes in society (Geels, 2002; Schot & Steinmueller, 2018). According to Schot & Steinmueller (2018), this goes beyond 'just developing new radical technological solutions': *"[it] is about changing skills, infrastructures, industry structures, products, regulations, user preferences and cultural predilections. It is about radical change in all elements of the configuration"* (p. 1562). Weber & Rohracher (2012) emphasise the need for the implementation of transformative R&I policies based on a framework of system failures. Earlier R&I policies have been largely based on 'market failures'. According to the authors, the argument for the setting of R&I policies should go further than that when addressing societal challenges through a system change. As a response, they provide a framework for guiding the design and 'legitimation' of transformative R&I policy approaches that combines market failures with structural and transformational failures.

To be transformative, thus means setting directionality of R&I activities to socio-technical system change and thereby to change in society. R&I always considers some kind of directionality (Schot & Steinmueller, 2018). In line with this, a particular type of transformative R&I policy are Mission-Oriented R&I policy programmes (Diercks et al., 2019; Wanzenböck et al., 2020). R&I programmes with a mission-oriented ambition are not new. However, as Wanzenböck et al. (2020) outline, missions have not always been necessarily about tackling societal challenges as we see currently in the EU. For instance, the United States of America (USA) has been successful in achieving missions such as their Manhattan-mission or the Apollo moon-landing mission in the 1960s. Such Technology-led missions are difficult from an engineering point of view ('engineering problem'), but are less complex than societal challenges-led missions (Wanzenböck et al., 2020).

On the European level, R&I efforts addressing societal challenges got popularised through the EU's research framework programmes. The EU's H2020 programme (2014-2020) emphasised the need for R&I to respond to what they call Grand Societal Challenges (GSCs). The programme aimed to couple R&I efforts through its three pillars of implementation: 1) Excellent Science; 2) Industrial Leadership; and 3) Tackling Societal Challenges¹¹. The EU's current R&I programme 'HorizonEurope' (2021-2027), the three pillars changed as follows¹²: Open Science (Pillar I); Global Challenges and

¹¹ Pillar III embedded seven domains of societal challenges: 1) Health and wellbeing; 2) Food and Sustainable agriculture; 3) Energy; 4) Transport; 5) Climate action; 6) Reflexive societies; 7) Secure societies.

¹² <https://www.horizon-eu.eu/>; visited 16.12.22

Industrial Competitiveness (Pillar II); and Open Innovation (Pillar III). As part of Pillar II, the EU added the so-called 'EU missions' framework to address societal challenges, by supporting collective effort. Societal challenges are complex and require coordinated cross-cutting actions with clear goals. In addition, missions go beyond the efforts of R&I, but bring together different stakeholders in innovative ways and actively engage citizens. This is seen, for instance, in collaborations during the COVID-19 crises.^{13;14}

Five missions have been identified by the EU to support the Horizon Europe R&I programme^{15;16}, which are defined as 'ambitious goals to deliver concrete results by 2030'.¹⁷ The missions' framework is largely influenced by the various experts reports developed by Mazzucato (e.g., 2018; 2019) for the European Commission, which popularised the concept of 'Mission-Oriented Research & Innovation' (MOIP).¹⁸ According to Mazzucato (2018) "*Missions provide a solution, an opportunity, and an approach to address the numerous challenges that people face in their daily lives*" (p.4). Mazzucato, (2018) defined five criteria for a mission,¹⁹ which illustrate that societal challenges-led missions are about setting R&I directions for tackling specific problems in society.

As tackling societal challenges requires considering the socio-economic system as a whole, it makes the governance and directionality of research to address such challenges and missions rather complex. According to Schot and Steinmueller (2018):

While available framings of science and technology policy that evolved since World War II remain relevant, they offer little guidance for managing the substantial negative consequences of the socio-technical system of modern economic growth to which they have contributed and of which they are a part (p.1554).

However, despite the appearance of transformative and mission-oriented R&I policy paradigms, according to Joly (2017, 2018) the linear model of R&I remains dominant. Schot & Steinmueller (2018) detail two main paradigms of R&I policies of the past decades, which underly this

¹³ https://ec.europa.eu/commission/presscorner/detail/en/ip_21_4747; visited 15.02.23

¹⁴ https://ec.europa.eu/commission/presscorner/detail/en/QANDA_21_4748; visited 15.02.23

¹⁵ https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en; visited 16.12.22

¹⁶ 1) Adaptation to Climate Change; 2) Climate-neutral and Smart Cities; 3) Cancer; 4) Soil deal and Europe; 5) Restore our Ocean and Waters.

¹⁷ https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe_en; visited 16.12.22

¹⁸ https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/mission-oriented-policy-studies-and-reports_en; visited 16.12.22

¹⁹ 1. Bold, Inspirational with wide societal relevance; 2. A clear direction: targeted, measurable and time-bound; 3. Ambitious but realistic research and innovation actions; 4. Cross-disciplinary, cross-sectoral and cross-actor innovation; 5. Multiple, bottom-up solutions

linear thinking, as it shows a focus on 'excellent science' that is driven by market dynamics and blue-sky objectives. The first paradigm dates from post-WWII thinking. Investments in R&D were made with the assumptions that scientific discoveries and/or knowledge would lead to innovations that were to be commercialized by the private sector and would lead to economic growth. The second paradigm dates from the 1980s, when scholars actually started questioning the linear model of innovation. The authors found that international differences also resulted in differences in the capacity to innovate. The term 'national systems of innovation' was employed by Freeman (1988) and Lundvall (1992), with the idea that innovation increases countries' competitiveness.

However, according to Joly (2017):

The coupling of the linear model and the competitiveness frame is now so strong as to make it possible to suggest that the 'master narrative' or the imaginary of innovation is defined by the attributes of technology centeredness, relatedness to the market, competition, entrepreneurship, diffusion, exclusivity and creative destruction (p.82).

Joly (2017) provides three reasons why this is still the case. First, it is the simplicity of the linear model that keeps it in place, as it represents innovation as 'sequencing steps' from research to diffusion of innovation without focussing on the complexity of interactions. As a second reason, Joly refers to institutionalisation of the linear model, about which he argues:

The activities of many actors involved in the design of statistical categories and indicators and in the construction of databases (for scientific production, patents, R&D indicators, etc.) ensure that the linear model becomes a social fact. This continues to translate into the tools and indicators used to measure innovation activity based mainly on R&D funding, and the numbers of researchers and patents (p.84).

And the third reason is actor attachment and strong interests of actors for the linear model. R&D companies benefit from innovation policies as they receive subsidies to innovate since they are still seen as the 'core actors of innovation processes'. This results in the companies' improved competitiveness and hence in countries' competitiveness. Also, within research the rhetoric of fundamental science continues to exist. According to Joly the idea remains that the linear model couples "research autonomy with its massive utility for society" (p.86), even though this has already proven wrong decades ago (Rosenberg, 1983).

This paradigm of science for society teaches us that research efforts with a transformative aim to address societal challenges, should contribute to socio-technical systems change. This helps to understand the need for systems thinking when conducting research within a mission-oriented context. However, this literature also emphasises the difficulties in directing excellent science towards societal goals as the main paradigm remains that of the linear model. Hence, it requires further

understanding of how excellent science can contribute to the constitution of a future society within a mission-oriented context.

2.3 Science with Society: A limited understanding

Building further upon the previous two paradigms of science-society associations, in this thesis I demonstrate a third understanding that emphasises the contributions of ‘science with society’ to the constitution of a future society in a mission-oriented context. While the previous two understandings of science-society associations are widely recognised, ‘science with society’ is not largely problematised. The ‘Science in Society’ paradigm (section 2.1) emphasises the role of researchers, and less so the active role of other actors. The ‘Science for Society’ paradigm (section 2.2) emphasises the imperative of aiming research towards socio-technical system change, but highlights also the difficulties in directing excellent science towards societal goals. In order to contribute to a societal mission, I show that scientists share responsibilities with other actors in society. This notion of being with other actors in processes of societal change offers an opening for addressing the contradictions of the previous two paradigms.

Already since the 1940s, participatory action research emerged as a way to open this (Kemmis & McTaggart, 2005; Macaulay, 2017). Over time, various participatory research approaches appeared, which got particularly acknowledged since the 2000s (Macaulay, 2017). Beyond participatory action research, other examples are multi-actor research, co-design, or co-creation processes. Macaulay (2017) argues:

Since the early 2000s, there is ever increasing acknowledgement in many countries that PR [red. participatory research] strengthens academic–community relationships; ensures relevancy of research questions; increases capacity of data collection, analysis and interpretation; minimizes the negative or stigmatising effects of research on the partners; and enhances programme recruitment, sustainability and extension. (p.257)

However, such approaches have shown how other actors can become part of science, but it does not necessarily problematise how science with society can contribute to addressing challenges in society. Nor does participatory research necessarily guide researchers to contribute to a societal mission. Instead, in this thesis I point out that assuming responsibility by researchers requires visions of contributing – with other actors in society – to achieving a societal mission. I hypothesise that formative evaluation can guide researchers to assume responsibility in this regard, as it helps identifying the role of other actors in R&I processes.

Formative evaluation is an approach that has its roots in impact evaluation of R&I policy programmes (Molas-Gallart et al., 2021). In contrast to ex-post evaluation, formative evaluation

involves impact assessment in real-time as a formative process focussed on mutual learning involving all actors in the R&I programme (Molas-Gallart et al., 2021; van Drooge & Spaapen, 2022). According to van Drooge & Spaapen (2022) formative evaluation is an “*evaluation[s] that aim[s] at mutual learning and improving*” p.752. As responsible research in a mission-oriented context requires researchers to (re)direct their research towards these specific goals, this might be conceptualised as a formative process of (re)direction towards societal impact in real-time.

How should a future society look in a mission-oriented context? How do researchers expect to contribute to a future society they envision? In the research that I present in this thesis, I use the Sociology of Expectations (e.g., van Lente & Rip, 1998; Brown & Michael, 2003; Borup et al., 2006) to bring in visions of a future society that should become part of mission-oriented research processes. In other words, I explore how formative evaluation can guide researchers through this process. Making visions of societal impact explicit helps to (re-)define visions of a future society to which researchers aim to contribute, and what change is expected in society to achieve this. This embeds visions of expected contributions and roles of other actors towards change in society. Even though these visions start from the perspective of researchers, they should become participative over time.

The Sociology of Expectations teaches us that expectations are performative (Borup et al., 2006; van Lente, 2012). I take an Actor Network Theory (ANT) perspective (e.g., Callon, 1986; Latour, 1996a; Law & Urry, 2004), to emphasise the heterogenous set of actors that are required to perform expectations in a mission-oriented context. Hence, it is about performing expected contributions of research to a future society that the mission represents. Following the Sociology of Translation (Callon, 1986), we can understand this performance of a future society through chains of translation in these heterogenous networks, from research to society. Hence, I argue that formative evaluation has the potential to guide researchers to envision their embeddedness with other actors in envisioned networks. This means that they must perform together the expected contributions to a societal mission – they cannot do it alone. In this way, I am redefining what it means for researchers to take on the responsibility for mobilising science-society associations in a mission-oriented context. As I highlight in the next section, I develop the notion of Responsible Translation to help me to understand and explain this process.

3. Responsible Translation: a concept to embed visions of associations

In this thesis, I demonstrate how scientists with other actors share responsibilities for a societal mission, and what that means in terms of the assumption of responsibility by researchers. To describe this process – and thereby to answer how formative evaluation encourages researchers to take responsibility for contributing to a societal mission through their research - I developed the

notion of 'responsible translation'. Through this notion, I demonstrate the links between the responsibility of researchers and the processes of translating visions that are supported by formative evaluation.

Box 1. The case study of ASIPRA RT as formative evaluation in the PPR-CPA

The PPR-CPA has integrated the ASIRPA Real Time (RT) impact assessment approach, a formative evaluation approach, to support the PPR-CPA project' researchers. The ASIRPA RT approach is developed based on the experiences of almost ten years of ASIRPA ex-post and over 60 case studies (Matt et al., 2023). Hence, the aim of ASIRPA RT is to guide— in real-time - the researchers in considering their contributions to pesticides eradication in society with the alternative solutions they study, and the societal impacts that this eradication could bring.

This goes beyond the assessment of research performance on the basis of purely scientific results, which still need to be translated into practice (or impact) or be communicated. Instead, the ASIRPA approach embeds five dimensions of societal impact: economic, environmental, health, social and political (Joly et al., 2015; Matt et al., 2016). ASIRPA's central tool is the 'impact pathway' (IP), which describes the non-linear process of how scientific knowledge is expected to be translated into five dimensions of societal impacts. Through the IP, ASIRPA accompanies researchers to envision the process from scientific knowledge, into outputs, and how this through the intermediary context eventually translates into societal transformations and impacts. The particularity of ASIRPA is that it mobilises the Sociology of Translation and Actor Network Theory (ANT) (Callon, 1986), to highlight the chains of translations that occur during the process of generating societal impacts.

For the entirety of my doctoral programme, I have been a member of the ASIRPA RT team. By conducting my research as part of ASIPRA RT in the PPR-CPA, I had unique access to the intervention of a formative evaluation approach to support researchers to responsabilise in a mission-oriented setting. Consequently, my research context enabled me to study how ASIPRA RT - as a formative evaluation - has the capacity to contribute to the responsabilisation of researchers in a particular mission-oriented context. I achieved this by following the researchers' participation in the ASIRPA RT activities within the PPR-CPA, and by comparing this to a T₀-situation before the researchers got involved in the approach.

In Chapter 3 (the Methodology), I explain in more detail the ASIRPA RT approach and its implementation in the PPR-CPA; https://www6.inrae.fr/asirpa_eng/ASIRPA-real-time.

I explored this through the case of the PPR-CPA and its ambitious societal mission to eradicate pesticides in France by reinforcing research. I worked with the researchers of the ten funded research projects who are encouraged to think about their contributions to the constitution of a pesticide-free society with the alternative solutions to pesticides that they study. The PPR-CPA has integrated a formative evaluation approach, to support researchers in this process (see Box 1). They are accompanied to take on responsibility for the 0-pesticides mission, as they are helped to navigate their visions of the expected contributions of the alternative solutions towards societal impacts in real-time.

By following the researchers' participation in this formative evaluation approach, I present a comparative analysis of their visions of eradicating pesticides before their participation (T_0) and one year after (T_1).

In this case, I introduced the notion of responsible translation to describe the process I observed of translating visions of alternative solutions into those of a society that has used these solutions to eradicate pesticides. This concept enabled me to understand the inextricable roles of responsibility in processes of translation and of translation in responsible research. In particular, I demonstrate how formative evaluation supports this process in the mission-oriented context of the PPR-CPA. The notion is largely inspired by the four moments of the Sociology of Translation by Callon (1986): problematisation, intersement, enrolment and mobilisation. Responsible translation consists of three phases in envisioning 1) the establishment (through problematisation), 2) the realisation (through intersement and enrolment) and 3) the mobilisation of science-society associations in a mission-oriented context. This process demonstrates how researchers assume responsibility for the 0-pesticides mission, and thus for the performance of the expected contributions of the alternative solutions to the eradication of pesticides in society. I explain this concept in more detail in Chapter 3 'the Methodology'.

Hence, through the notion of responsible translation, I am redefining what it means to conduct 'science with society' in a mission-oriented context, and how researchers are encouraged to take on responsibility in this regard. As the PPR-CPA researchers are accompanied by a formative evaluation approach, they start constructing envisioned networks that are to perform chains of translation from their research on alternative solutions to a future society that eradicates pesticides. This means that the science-society associations are represented by these networks that are envisioned to perform the contributions of the alternative solutions to the mission. Hence, through their associations in the envisioned networks, the researchers are realising that it is only by envisioning themselves together with other actors and sharing responsibilities that their alternative solutions will be able to eradicate pesticides. Only at this point can I then claim that science-society associations are mobilised through the alternative solutions to pesticides.

In contrast to Callon's (1986) demonstration of the Sociology of Translation, where researchers become representatives of heterogeneous networks, I demonstrate how the responsible translation process leads to a different situation. Instead, the responsibility of researchers reflects their realisations that they are not the spokespersons, but that the alternative solutions need to become the legitimate spokespersons for these envisioned networks that represent the science-society associations. It is in this way that science is conducted with society (i.e., associations), and that

visions of associations needed in the future society become part of the network when researchers take responsibility for the mission.

Hence, in this thesis, I question how formative evaluation encourages researchers to take on responsibility for contributing to a societal mission through their research. I explore this through four intermediate steps, which is set up around my comparative analysis of the researchers' visions before their participation in ASIRPA RT as a formative evaluation approach (T_0) and one year after (T_1). This represents through four empirical chapters. First (Chapter 4), I provide a baseline analysis of the T_0 -phase. I demonstrate how the PPR-CPA researchers envisioned contributing to the 0-pesticides mission by studying alternative solutions to pesticides, before they got involved in the ASIRPA RT formative evaluation approach (see Box 1). In particular, I illustrate how these visions influenced the construction of their research projects. This is based on interviews with the project PIs and the PPR-CPA project proposals.

Second, in the three following chapters (Chapter 5, 6 and 7) I provide the analysis of the T_1 -phase. This is based on data that I collected throughout their first year of participation in ASIRPA RT as a formative evaluation approach, through participants observations (e.g., workshops, webinars, brainstorming) and their development of a first Impact Pathway. I explore this through the three phases of responsible translation. In the first phase (Chapter 5), I explore the researchers' visions of establishing science-society associations. I demonstrate how the researchers envision a future society without pesticides through the alternative solutions they study in their projects. This is the result when they were supported by ASIRPA RT to navigate their visions of societal transformations and impacts. In the second phase (Chapter 6), I explore the researchers' visions of realising science-society associations. I demonstrate how the researchers envision the construction of future heterogeneous networks of actors a society without pesticides through chains of translation. This is the result when they were supported by the ASIRPA RT approach to navigate their visions of the intermediary context. In the third phase (Chapter 7), I explore researchers' visions of mobilising science-society associations. I demonstrate how the researchers' visions changed from before their involvement in ASIRPA RT to after their involvement. It reflects constructive changes of how the researchers take on responsibility for the mission.

The structure of the thesis is outlined in Figure 1.

Research Question: *How does formative evaluation encourage researchers to take on responsibility for contributing to a societal mission through the research they are conducting?*

Thesis contribution: The notion of ‘Responsible Translation’ - the process of translating visions of alternative solutions into those of a society that eradicates pesticides with these solutions

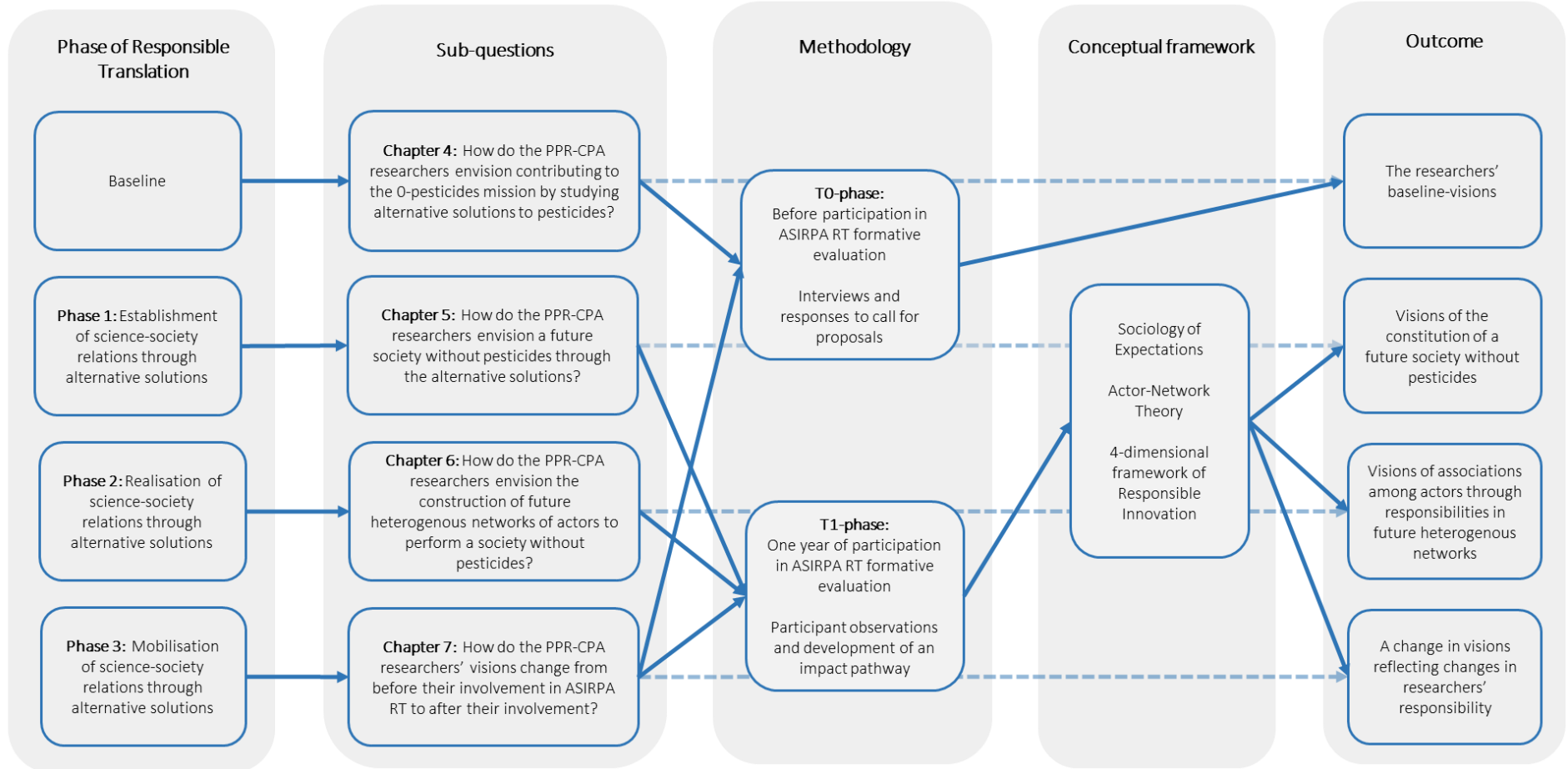


Figure 1. Overview of the thesis structure

4. Thesis plan

This thesis consists of seven chapters, and at the end I provide a final discussion and conclusion chapter. In this section I give an overview of these chapters, which together provide the response to the general research question.

Chapter 1: Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

In this first chapter I provide a socio-historical overview of pesticides use, regulation and research in France. I outline the over 150 years of pesticides use: from the beginning of the use of pesticides in France in the 19th century, and I end at the launch of the PPR-CPA in 2019. In particular, I highlight what has been done to control the use of pesticides, to understand why there is at present the need for a mission-oriented research programme like the PPR-CPA? What did the French government do to control pesticides use, and why has this been insufficient so far?

France has a long history in trying to control or even ban (certain substances of) pesticides, which I show in this chapter by exploring regulatory frameworks, policy programs and (an evolution of) R&I strategies. However, up till today pesticides control remains stuck in the trade-offs between the efficiency of pesticides for agricultural production and the negative impacts of pesticides on society. Eventually, in 2019 the PPR-CPA is implemented with the aim to eradicate pesticides by 2040. This mission-oriented research programme was launched to reinforce research efforts to reduce pesticides use, and has to overcome system lock-ins. To guide researchers in this regard, the ASIPRA RT approach is implemented. However, despite the efforts of the French government through its investments in this research program, current controversies are still at play.

Chapter 2: Responsibility of Researchers for the 0-pesticides Mission

In the second chapter, I discuss the concept of ‘responsibility’ in research. Through two sub-chapters I elaborate an understanding of responsible research as well as the conceptual framework that guides the analysis and interpretation of my data. In the first sub-chapter, I discuss the state-of-the-art literature on responsible research. I discuss how the understandings of the notion of responsible research have evolved over time in line with changing societal challenges: from notions of research ethics and developing into more complex understandings of how science and society interact and co-produce each other. In this sub-chapter, I highlight what this literature teaches us about the types and paradigms of responsibility, science-society relations, and the implementation and institutionalisation of Responsible Research and Innovation (RRI) as a policy approach in the EU. This leads to the identification of four knowledge gaps to which this thesis contributes.

In the second sub-chapter, I present the conceptual framework, which I used to demonstrate the contributions of ASIRPA RT to the responsabilisation of the PPR-CPA researchers. My conceptual framework is constructed through three parts. First, I am building upon the Sociology of Expectations (SoE), which teaches us that expectations are performative. However, as I explain, the researchers' expectations of the contributions of the alternative solutions they study to this particular mission are not yet performative. Therefore, second, I mobilise Actor-Network Theory (ANT) to study the performance of these expectations by associating actors in envisioned heterogenous networks. Third and final, I explain how the construction of these envisioned networks are based on visions of responsibilities of researchers in their professional role in science, as well as on the expected roles and responsibilities of other actors. I build upon the four-dimensional framework of Responsible Innovation (RI) by Stilgoe et al. (2013) (anticipation, reflexivity, inclusion, responsiveness) to understand the construction of the envisioned networks.

Chapter 3: The Research Methodology: exploring the intervention of ASIRPA Real-Time for the PPR-CPA researchers

In this chapter, I present my research methodology. I describe how I collected and analysed my data through the implementation of ASIRPA RT in the PPR-CPA, to answer my research question. The particular case of this research methodology is that it is embedded in an experimental set-up. The PPR-CPA provides a test-bed for the development of the ASIRPA RT tools and its implementation in mission-oriented research, in which I have been closely involved throughout the doctoral programme. In my methodology, I have adopted a grounded theory approach, which guided me in the analyses of the data. Through four sub-chapters, I explain how I collected, analysed and interpreted my data in this unique context of ASIRPA RT in the mission-oriented context of the PPR-CPA.

In the first sub-chapter, I introduce my research objects: ASIRPA RT, the PPR-CPA programme, and the ten funded research projects of the PPR-CPA. This provides the context of the methodology and it gives background information on the PPR-CPA and the research projects that are funded. As I am comparing two phases – T_0 and T_1 : before and after the intervention of ASIRPA RT – in the second sub-chapter I explain how I collected my data during both phases. At T_0 , data was collected in two ways: 1) the PPR-CPA project proposals; 2) semi-structured interviews. At T_1 , I have been involved as a member of the ASIRPA team on three methodological levels: 1) the development of ASIRPA RT tools, 2) the implementation of ASIRPA RT in the PPR-CPA (e.g., construction of Impact Pathway, and workshops) and 3) the observation of ASIPRA. All three phases fed into my data collection.

In the third sub-chapter, I demonstrate how I inductively coded and analysed my collected data. As ASIRPA mobilised the sociology of Translation (Callon, 1986), I explain how I analysed the

responsibility of the PPR-CPA researchers through the process of translation. However, I adapted Callon's translation process to two unique situations of the 0-pesticides mission and the role of ASIPRA RT, namely: 1) visions of a future society without pesticides; and 2) the performance of expected contributions to these visions in real-time, through chains of translation in heterogenous networks. This resulted in the analyses of three phases of what I explore as the process of 'Responsible Translation', describing three phases of envisioning 1) the establishment, 2) the realisation, and 3) the mobilisation of science-society associations in the mission-oriented context. I finalise this methodology chapter by providing a reflection of my personal researcher positionality and illustrate how I took responsibility for my different positions as a researcher, and the methodological decisions I made in this regard.

Chapter 4: The Construction of Mission-Oriented Research: How Researchers Envision their Contributions to the 0-Pesticides Mission

This fourth chapter represents the first empirical chapter of the thesis. In this chapter, I present the data collected at the T_0 -phase. The ten funded PPR-CPA projects study alternative solutions to contribute to the eradication of pesticides in society. I demonstrate how the researchers' visions of the expected contributions of the alternative solutions to the 0-pesticides mission influenced the construction of their research projects. In this regard, through four sub-chapters, I explore: 1) how the researchers' visions of eradicating pesticides with the alternative solutions define their research orientation; 2) how the researchers' visions of their contributions to a society without pesticides are reflected in the construction of their projects; 3) how the researchers constructed their projects differently compared to previous projects they have been involved in, considering the 0-pesticides mission; and 4) how the researchers envision the associations between their research projects and a society without pesticides in this societal mission.

As a T_0 -measurement, the researchers illustrated how they expect to contribute to the societal mission by studying alternative solutions to pesticides. I demonstrate that, at T_0 , the projects pose renewed and more ambitious research questions in their aim to contribute to the 0-pesticides mission compared to their previous projects. However, the envisioned contributions are shaped in a rather linear way with a focus on blue-sky excellent science, whereby change in society is the envisioned result of the transfer and straightforward use of research result in society. Hence, it reflects a rather scientific way of approaching a 'society without pesticides'.

Chapter 5: Establishing Associations Between Science and Society: Researchers' Visions of the Constitution of a 0-Pesticides Society

The fifth chapter represents the second empirical chapter of the thesis, and I present data collected during the T_1 -phase. I demonstrate how the PPR-CPA researchers expect that the alternative solutions they study in their research projects can contribute to the 0-pesticides mission. This is the result of ASIRPA RT's support in navigating the researchers' visions of societal transformations and impacts. This chapter describes the first phase of the Responsible Translation process, by exploring the researchers' visions of establishing science-society associations through the phase of 'problematisation'. This highlights the researchers' visions of the constitution of a '0-pesticides-society' through the alternative solutions to pesticides.

In three sub-chapters I explore: 1) How do the researchers think they would impact society with the alternative solutions to pesticides they study?; 2) what transformations are envisioned, which requires society to change to enable the eradication of pesticides with the alternative solutions?; 3) what are the envisioned OPPs to pass and what could potentially block the translation process? I demonstrate how the researchers at T_1 envision the constitution of a society without pesticides, which illustrates their capacity to reflect on how society should be enabled to eradicate pesticides with the alternative solutions. It reveals how the researchers reflect on responsibilities for themselves and other actors in this mission-oriented translation process. The researchers have to conduct research on alternative solutions, and other actors hold responsibilities to enact societal transformations. These transformations are essential to enable the development and implementation of the alternative solutions, which requires these actors to change how they act in the future.

Chapter 6: Realising Associations between Science and Society: Anticipating Heterogenous Networks to Perform the Researchers Expected Contributions to a 0-Pesticides Society

The sixth chapter represents the third empirical chapter of the thesis, and I present data collected during the T_1 -phase. I demonstrate how the PPR-CPA researchers envision the construction of heterogenous networks of actors to enable the eradication of pesticides with the alternative solutions they study. This is the result of ASIRPA RT's support in navigating the researchers' visions of the intermediary context. This chapter describes the second phase of the responsible translation process by exploring the researchers' visions of realising science-society associations through interessement and enrolment. I highlight how the researchers consider the contributions of various actors – including themselves - at different points in time, to anticipate the chains of translations that might be performed by these networks to enable the eradication of pesticides. This highlights the involvement of intermediary actors in the heterogenous networks with responsibilities for interessement and enrolment of those actors that should enact the societal transformations (Chapter 5).

Through three sub-chapters, I illustrate how the researchers envision realising the associations between the PPR-CPA projects on alternative solutions and a future society without pesticides, by exploring: 1) What intermediary actors are anticipated in the network, associated to the inputs and outputs of the research projects?; 2) What intermediary actors are anticipated in the network, external to the research projects?; And 3) How are the actor associations in the network envisioned to perform chains of translation? I demonstrate how these future networks are based on associations among actors through their envisioned responsibilities for the 0-pesticides mission. It reflects three types of actors and their responsibilities: the researchers, actors that are to enact the envisioned societal transformations (chapter 5), and intermediary actors responsible for interestment and enrolment. Even though these actors are (broadly) identified as nodes in the network, their associations are still rather limited at this early phase of the research projects (T_1).

Chapter 7: Mobilising Associations between Science and Society: A Change in Visions of Alternative Solutions to Pesticides becoming Spokesmen of the Heterogenous Networks

The seventh chapter represents the fourth and final empirical chapter of the thesis, which is based on a comparison of data between the T_0 - and the T_1 -phases. In this chapter, I demonstrate how the PPR-CPA researchers' visions have changed from before their involvement in ASIRPA RT to after their involvement. This chapter describes the third phase of the responsible translation process, by exploring the researchers' visions of mobilising science-society associations within the 0-pesticides mission. It highlights the constitution of each alternative solution to pesticides as a 'spokesperson' of the future heterogenous networks to perform the expected contributions to the 0-pesticides mission, and thus as legitimate spokespersons associating between science and society.

This chapter demonstrates a change from visions of the 'transfer of research outputs into society' (T_0) into 'the responsible translation of visions of alternative solutions into those of a society that eradicates pesticides' (T_1). I illustrate this in this chapter through three changed visions: first, it reflects a change from visions of a '0-pesticides society' from a scientific point of view, to one that is co-produced with the researchers' expectations of the contributions of the alternative solutions to the eradication of pesticides. Second, it reflects a change from visions of impacting society that are based on the scientific analyses of the multilevel performance of alternative solutions, to impacts as the result of shared responsibilities between researchers and other actors for enabling the eradication of pesticides. Third, it reflects a change from visions of favouring acceptability of the use of alternative solutions through a scientific approach to study feasibility, to anticipating enrolling actors' responsibilities into the visions of the eradication of pesticides. These changed visions reflects four constructive changes of how the researchers take on responsibility for the mission.

General discussion and final conclusions

I conclude this thesis in the final chapter, where I provide a general discussion and conclusion of my research findings. I demonstrate how a formative evaluation approach like ASIRPA RT encourages researchers to take on responsibility for contributing to a societal mission through their research. Through my notion of responsible translation, I emphasise what we can learn about the responsibility of researchers in a mission-oriented context, by demonstrating the inextricable links between responsibility, the process of translation and formative evaluation. This chapter is subdivided into four parts. First, I demonstrate the contributions of my research that explored responsible translation to academic debates about Responsible Research, the Sociology of Translation and Responsible Innovation. I discuss this by demonstrating that responsibilities are embedded in the process of translation, that visions of societal change become actors in the translation process, and that normative visions of responsibility need to be translated to be performed. I also discuss how ASIRPA RT contributed to operationalising the responsible translation process, by responding to the knowledge gaps identified in Chapter 2. My results illustrated how ASIRPA RT, as a formative evaluation approach, supported the PPR-CPA researchers to navigate their visions, and thereby to translate their responsibility at T_1 .

In the second part, I follow the three phases of responsible translation to discuss the sociological implications of the findings of this thesis research. Hence, I draw upon three sociological perspectives to discuss: 1) a paradigm shift to a mission-oriented responsible translation; 2) co-responsibility in the mission-oriented responsible translation process; 3) ontology in the mission-oriented responsible translation. In the third part, I provide my reflections on the limitations of this research as well as on future research directions. Finally, in the fourth part, I detail the final conclusions of the thesis. I emphasise responsible translation as a notion to understand expected research contributions in a societal mission. By showing the embeddedness of actors' responsibilities through associations in the responsible translation process, I prove the co-production of science with society. I highlight that 'science-society associations' as a concept is too vague if researchers are to take on responsibility. Instead, I conclude that these associations are made through responsible translation.

Chapter 1

Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

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There was once a town in the heart of America where all life seemed to live in harmony with its surrounding. The town lay in the midst of a checkerboard of prosperous farms, with fields of grain and hillsides of orchards where, in spring, white clouds of bloom drifted above the green fields [...] Then a strange blight crept over the area and everything began to change. Some evil spell had settled on the community: mysterious maladies swept the flocks of chickens; the cattle and sheep sickened and died. Everywhere was a shadow of death. The farmers spoke of much illness among their families. In the town the doctors had become more and more puzzled by new kinds of sickness appearing among their patients.

(Carson 1962, pp.1-2)

The paragraph above highlights a few of the first lines of the book 'Silent spring' published by Rachel Carson in 1962. The book describes the impact of the use of agricultural pesticides on human health and the environment. The title refers to a metaphor of how animals, such as birds and frogs were killed by the organochlorine pesticide DDT (Dichloordifenyiltrichloorethaan) residues in the environment, and yet spring became 'silent' without the sounds of these animals. The book evokes a big discussion worldwide - among policy makers, scientists, but also by citizens - about the trade-offs between agricultural production and the negative effects of pesticides in society.

The impacts of pollution caused by pesticides use on public health and the environment became an increasingly pressing issue at international and national levels in the late 1960s. It is seen as the start of early environmental movements. It led to changes in, for instance, pesticides regulation procedures and to ban DDT in France in the early 1970s. However, 60 years later the same discussion is still ongoing: the launch of the PPR-CPA with the ambitious aim to eradicate pesticides, clearly demonstrates this. Why is there at present still the need for a programme like the PPR-CPA? What did the French government do to control pesticides use and why was this insufficient?

In this chapter, I provide a socio-historical overview of over 150 years of pesticides history in France, and particularly what has been done in terms of its regulation and the research and innovation (R&I) efforts to control its use. I particularly look into these dimensions to explore where the need for such a unique research programme as the PPR-CPA emerged. I will start this 150-years' timeline from the beginning of the use of pesticides in France in the 19th century, and I will end at the launch of the

Chapter 1. Setting the scene of the O-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

PPR-CPA. I illustrate the long history in France of trying to control or even ban (certain substances of) pesticides.

This chapter is subdivided into three sub-chapters, which together highlight the rise of pesticides use in France, what the French government has done to control it, and why this worked or not. In the first sub-chapter, I give a short overview of the rise of chemical pesticides use in France. The second sub-chapter illustrates a historical overview of pesticides regulation in France, from its first regulatory policy until the current situation of pesticides regulations. In the third and final sub-chapter, I emphasise the R&I environment around pesticides in France. This includes a historical overview of research activities in France related to pesticides as well as R&I strategies supported by the government to reduce (the impact of) pesticides use.

1.1 150 years of chemical pesticides use in France

The use of pesticides worldwide has a long history. Already from 2000 B.C. documentation of the use of Sulphur, in the form of brimstone, against pests has been found (Fishel, 2009). The use of 'modern' chemical pesticides as we know today dates back from the second half of the 19th century, from a vineyard in Bordeaux, France, which was suffering from a common fungal disease in grapes 'downy mildew'. Fishel (2009) narrates:

A vineyard producer was having problems with people pilfering grapes from his vines. Thinking that he could make the grapes unattractive to the thieves, he applied a mixture of copper and lime to part of his vineyards. The result not only deterred thieves, but it was also noticed that where the copper-lime mixture was applied, there was no disease incidence (p. 2).

This mixture forms the basis of one of the first 'modern' fungicides in the 1880s, called 'Bordeaux mixture'. Jas (2007) studied the history of pesticides regulations and public health in France. She states about the first use of chemical pesticides:

Well before 1900, copper sulfate-based herbicides, ferrous sulfate, copper salts and sulfur-based fungicides, as well as nicotine-based insecticides were widely used. Sulfuric acid and coloring agents-based herbicides, respectively, were introduced around 1900 and from the late 1920s. However, arsenical insecticides, first used in the 1880s in vineyards and orchards, constituted the most marked innovation (p.372).

The upcoming use of chemical pesticides is considered as the consequence of new crop pests, such as insects and diseases. They started to spread widely in this period as the result of intensification and specialisation of farming systems and practices from the 1870s (Jas, 2007). The early development of chemical crop protection was mostly supported by the French Ministry of Agriculture as to find strategies against these upcoming pest problems. In this regard, the use of chemical control was

actually stimulated and sometimes even subsidised. Mainly entomologists, phytopathologists and phytopharmacists from research departments of the French Ministry of Agriculture were working on this, but also the chemical pesticide industry developed in the late 1800s. Even though, the use of chemical pesticides was new, discussions around the public health impact of pesticides had emerged as well. French hygienists occupied themselves with studying the toxicity of chemicals on human health, especially the long-term effects of arsenic insecticides (Jas, 2007).

In the early 20th century, particularly the use of arsenic insecticides increased tremendously. This was specifically the case in the interwar period, as it turned out to be effective against the Colorado beetle that was a huge pest at the time (Jas, 2007). This was also the period in which the French government realised that they had to increase their food production and prevent food shortage after the first world war. The increase of pesticide uses in this period triggered various opponents – especially because of the negative health impact caused by their use. Hygienists started campaigns to highlight the toxicity of arsenical insecticides. Particular in the interwar period, also doctors and pharmacists got involved in the debates around health issues related to arsenic compounds and the need for a ban.²⁰

The emergence of the French pesticides-era

The 1940s were seen as the start of the ‘pesticides-era’ in France – the usage increased drastically. The government was in favour of chemical crop protection and promoted pesticides use. There was a strong focus on intensive agricultural production (Jas 2007; Levain et al. 2015). The 1950s and 1960s – hence the period of the publication of *Silent spring* – were marked by immense industrial R&D and commercialisation, and an increase in consumption, of pesticides (Fishel, 2009). Many new pesticides products became available from the early 1950s onwards, such as DDT and TEPP (Fourche, 2004; Levain et al., 2015). Even though the negative effects of chemical pesticides use such as DDT became widely known and reported in the 1950s and 1960s, the application increased drastically over these decades (Levain et al., 2015).

From 1990 until 2010 pesticides sales in France reduced drastically – from almost 100 000 tonnes in 1990 to 62 000 tonnes in 2010, but it increased again in the past decade up to over 80 000 tonnes in 2018. However, in 2019 and 2020 pesticides sales seem to decrease again (Figure 2). Even though I cannot provide a definite explanation of this decline, it should be noted that France depends on imports of pesticides products. As Lamichhane & Reay-Jones (2021) describe, imports of such agricultural inputs have been restricted as a result of closed borders and regulations caused by the

²⁰ As I illustrate in the next sub-chapter there was already a government decree from 1846 to ban arsenic substances, but it was not adhered

COVID-19 pandemic. Today, pesticides use in France is above the average in the European Union (EU), and the highest in Europe together with Germany, Spain and Italy. In fact, Eurostat (2020)²¹ shows that in 2018 total pesticide sales in France were the highest of the EU, and compared to 2011 sales have increased with almost 40%. While in contrast, in most other EU countries sales decreased in this period. Pesticides use per area of cropland is not the highest of the EU, but France still appears in the top 10.

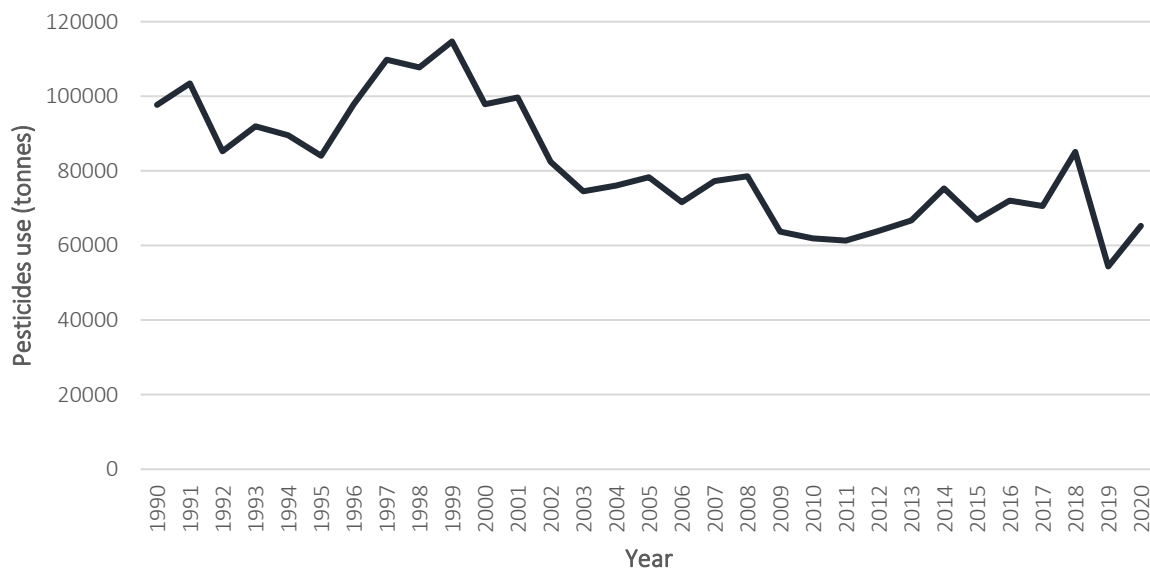


Figure 2. Pesticides use (tonnes) in France from 1990-2020 (Source: FAOSTAT)

1.2 Over 150 years of pesticides' regulations in France

Where pesticides use increased over time, also did their concerns about the impact on public health and the environment. Hence, this required the French government to establish control measures on the use and sales of pesticides. In this sub-chapter, I provide an overview of the emergence of national and international regulations to control pesticides in France, which is synthesised in Figure 3. Like the use of pesticides, also their regulation dates back from the mid-19th century. Already in 1846, the French government implemented a decree that forbid the use of arsenic compounds in agriculture. However, the Ministry of Agriculture did not enforce this law for a long time. As I illustrate in this chapter, the control of pesticides use has always been about the trade-offs between agricultural efficiency and the impact on public health.

²¹https://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_consumption_of_pesticides#Analysis_at_EU_and_country_level; visited on 02.01.23

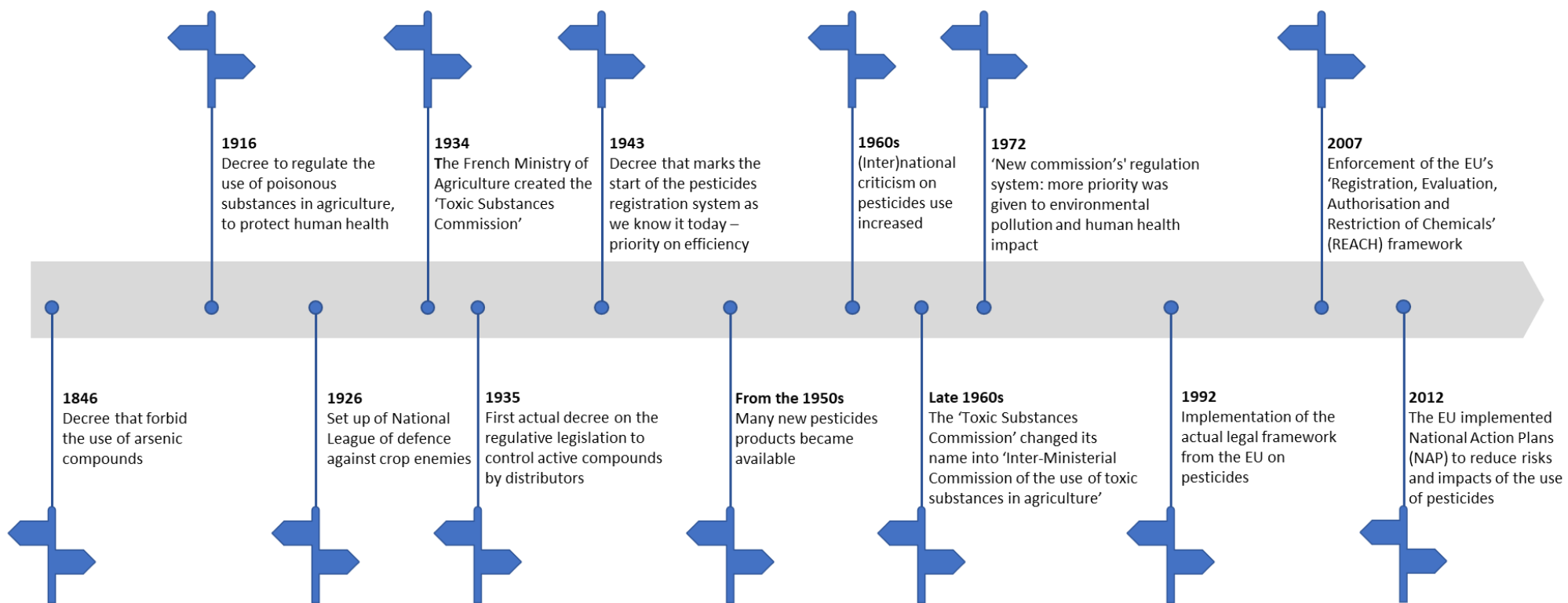


Figure 3. An overview of over 150 years of pesticides' regulations in France

Chapter 1. Setting the scene of the O-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

1.2.1 The first government decrees and regulations on chemical pesticides

To regulate the use of poisonous substances in agriculture, in 1916 the French government implemented a decree on 'the importation, sale, holding and use of poisonous substances' (Jas, 2007). In the interwar period that followed, the regulations that aimed at protecting public health received resistance and did not seem to be enforced. For instance, Jas (2007) explains how opponents of the legislation, such as French entomologists, phytopathologists and phytopharmacists set up a 'National League of defence against crop enemies' in 1926. These opponents even requested for easing the rules for the chemical control of pests, which was not granted by the French government. They also lobbied for stronger regulative legislation for chemical pest control, to prove efficiency of the pesticides.

As a response to these requests, in 1934, the French Ministry of Agriculture created the 'Toxic Substances Commission'. Even though the commissions' activity remained rather limited until the Second World War, they aimed to register pesticides' substances and protect public health from pesticides' hazards. However, the commission and its members were largely linked to the 'National League against crop enemies'. The first actual decree on the regulative legislation for effective use of chemical pesticides was released by the government in 1935, to control active compounds by distributors (Jas, 2007). According to Jas (2007) this decree implied that "*distributors had to indicate the name, origin and title in active compounds, as well as the nature and chemical compounds contained in the substances they produced*"(p.375).

The French government was in favour of chemical crop protection and promoted pesticides use, but they also continued to study the effectiveness of pesticides. Especially during and after the Second World War, focus had been on achieving efficient crop protection with the use of chemical pesticides, and less on protecting public health. And thus, the focus remained largely on ensuring the effectiveness of pesticides (Jas, 2007). Eventually, this resulted in a government decree in 1943, which marks the start of the pesticides registration system as we know it today (Jas, 2007; Levain et al., 2015). According to Jas (2007), this decree requires "*manufacturers to obtain government authorisation prior to marketing any phytopharmaceutical products, and forbidding the sale of any products that had not been granted such authorisation*" (p.376). However, the aim of the decree was not just to guarantee the effectiveness of pesticides, it was combined with the aim to protect public health in line with the earlier work from the 'toxic substances commission'.

1.2.2 The French pesticides registration system

Hence, the decree of 1943 can be considered as the first pesticides' registration system in France, as it required authorisation of pesticides' substances prior to marketing. It was constructed to

Chapter 1. Setting the scene of the O-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

combine two aims: protecting human health and ensuring the efficiency of pesticides. However, there were still some limitations to its implementation and enforcement, as the main focus remained on the efficiency of pesticides. First of all, according to Jas (2007), it was the task of the 'toxic substances commission' to examine the pesticides' substances. The author states: *"the commission tested the efficiency of each product but not the related health hazards. The Toxic Substances Commission was only consulted when previously unknown substances were used in compounds"* (p.376). Second, the commission members came mainly from the pesticides industry, agriculture manufacture companies and the Ministry of Agriculture – the Ministry of Health was not even involved and the number of toxicologists was limited (Jas, 2007).

Third, many new pesticides became available from the early 1950s onwards, such as DDT and TEPP (Fourche, 2004; Levain et al., 2015). The three main chemical compounds after World War II (WWII) are: organochlorines (or organic hydrocarbons), organophosphates, and neonicotinoides (Levain et al., 2015). This did not only put pressure on the French registration system, it also evoked criticism. Although many requests for pesticides substances were not authorised, the main criteria remained the pesticides' efficiency. According to Jas (2007): *"Where proof of efficiency was provided refusal was unlikely, even when health hazards were acknowledged"* (p. 377).

Fourth, even though in a limited number, toxicologists took part in the 'toxic substance commission'. They were involved to study the acute and chronic toxicity of pesticides, and did find health risks related to various pesticides substances. Even though toxicologists were well aware of the chronic health risks, pesticides regulations remained to be based on acute toxicity (Jas, 2007). In addition, as Jas (2007) illustrates, their work was rather guided as they were 'compelled to find a way of enabling the use of pesticides'. At the time, one of the main toxicologists involved was René Truhaut. He managed to partly overcome this regulation issue by using international frameworks (e.g., from the WHO), through integrating indicators such as 'daily acceptable intake'. However, priority remained on the efficiency for crop production and such indicators still allowed a limited amount of residues on food products. Jas (2007) highlighted in this regard: *"whether or not priority was given to public health by Ministry of Agriculture representatives depended on two types of situation: either public health hazards were potentially highly visible or no major agricultural interests were at stake"* (p.379).

Registration as the main paradigm of pesticides regulation in France

In 1963, Carson published the book 'Silent Spring'. It was well received in France, but also caused discussions, especially by major actors involved in chemical crop protection (e.g., pesticide industry, ministry of agriculture, scientists). They believed that their national regulation system was

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

rigorous and that the case which Carson described was probably true for the USA, but not for the French context (Jas, 2007; Levain et al., 2015). Carson called for a shift from the pesticide paradigm towards biological control. However, in France, even some experts from this field of biological control were not only positive about this demand. According to Levain et al. (2005) *“They stated that the use of pesticides was necessary and that the main problem lied in the lack of competence of the government services in charge of controlling their good use”* (p. 12). Later in the 1960s national and international criticism on the use of pesticides increased, because of its effect on human health and the environment. According to Wezel et al. (2009):

In general, the environmental movements in the 1960s often emerged as a consequence of the unexpected impacts of industrialised agriculture after the Green Revolution. Researchers with narrow focus on short-term yields and economic returns considered environmental and social factors to be externalities. Public policies rarely considered the environmental impact of agriculture, nor the social consequences of a uni-dimensional rural development focussed on production and economics. This environmentalism was primarily concerned with the impacts of toxic substances, in particular pesticides, on the environment. Other non-agricultural topics of these environmental movements included industrial pollution, nature conservation, and distribution of benefits (p. 505).

The French Ministry of Agriculture continued to ‘hide’ behind their ‘rigorous’ regulation system that, according to them, involved careful analysis of toxic substances, testing, documentation etc. (Jas, 2007; Levain et al., 2015). However, the pressure of opponents of pesticides did lead to changes: in the late 1960s the ‘Toxic Substances Commission’ changed its name into ‘Inter-Ministerial Commission of the use of toxic substances in agriculture’. This name was chosen as - beyond just the Ministry of Agriculture - representatives from the Ministry of hygiene became members as well (Jas, 2007). It was not until 1972 when the ‘new commission’s’ regulation system was implemented, that more priority was given to environmental pollution and human health impact. Although this revision did not prevent an increase in registered pesticides.

From the 1970s onwards, legal frameworks on national and international level concerning pesticides’ development, production, commercialisation and use changed. For instance, in 1960 the French government implemented the law for agricultural orientation.²² In its revision of 1980, France was one of the first countries in the world to recognise ‘organic farming’ as an ‘official’ form of agriculture, as it states [*translated from French*]: *“agricultural products that do not use synthetic chemicals, known as ‘organic farming’”* (Loi n° 80-502 du 4 juillet 1980 d’orientation agricole - Article 14).

²² Loi d’Orientation Agricole

Chapter 1. Setting the scene of the O-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

As a result of studies into the health impacts of pesticides, various pesticides are considered dangerous today as it can cause various cancers and neurological diseases. This is not just about public health, but also about professional pathology related to pesticide use, which re-gained interest. There was already a large interest in the 1950s and 1960s on the impacts of pesticides on farmers health, but it lost momentum in the 1970s (Jas, 2010). However, still today, registration remains the main paradigm of pesticide regulation in France. The government remains stuck between pressure from society and lobbies from the pesticides industry (Jas, 2007; Levain et al., 2015).

1.2.3 International frameworks to regulate pesticides use

Over time, the use of pesticides was increasing drastically and so were concerns about health risks and the environment. At the international level, frameworks were developed to provide guidance to national governments to regulate the use of pesticides. For instance, as a response to provide legal guidance to governments, FAO adopted in 1985 the 'The International Code of Conduct on the Distribution and Use of Pesticides'. These regulatory guidelines promoted 'effective pesticide management and adequate protection of the environment and public health' (FAO, 2015).

At the EU level, regulatory policies for pesticides were launched. To better harmonise pesticides' regulation among countries, the EU came up with a regulatory regime. This regime also aimed to harmonise the European food product market. First directives were initiated by the EU already in 1976, which were revised in 1986 and 1990. These directives put a limit on residues doses on food products. However, the actual legal framework from the EU on pesticides dates from 1992, known as EU Directive 91/414/EEC.²³ This is the current legal pesticide framework of the EU, which evaluates the substances (active ingredients) of pesticides, which also includes the amendment on maximum residue levels on food products.²⁴

Since 2003, the European Food Safety Authority (AFSA) has conducted the related risk assessment. After an active compound has been authorised by the EU, a member state is allowed to authorise pesticides that contain these cleared active ingredients (Ansell, 2008). Authorised active ingredients and products are reviewed regularly – authorisation is valid for maximum 10-15 years. Therefore, the EU evaluates and approves these active ingredients, but the member states authorise the actual commercialisation of the pesticides' products by companies.²⁵ These pesticides have to

²³ Council Directive 91/414/EEC concerning the placing of plant protection products on the market

²⁴ REGULATION (EC) NO 396/2005 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC

²⁵ https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_approval-factsheet.pdf; visited on 23.11.22

contain at least one authorised active ingredient.²⁶ It is thus possible that the EU does not authorise an active substance that is eventually still commercialised in a pesticides' product in a member state.

At the French National level, this authorisation used to be done by the 'Toxic Substances Commission' (which later became the 'Inter-Ministerial Commission'), as discussed in the previous section. In 2006, this authorisation responsibility was given to the French Agency for Food, Environmental and Occupational Health & Safety (AFSSA²⁷). This transfer was part of a larger inter-ministerial plan by the Ministry of Agriculture, the Ministry of Ecology, the Ministry of Health, and the Ministry of Competition, Consumer Affairs and Fraud Prevention, to reduce pesticides related risks (CROPPP, n.d.; Jas, 2010). In 2010, AFSSA merged with the French Agency for Environmental and Occupational Health and Safety (AFSSET²⁸) – which together became the French Agency for Food, Environmental and Occupational Health & Safety (ANSES²⁹). Together with the Ministry of Agriculture, the Ministry of Ecology and the Ministry of Consumer Affairs, this agency is also under the responsibility of the Ministry of Labour.

Additional EU regulatory programmes

Although less pesticides products were authorised because of the EU pesticide directive, pesticides use in the EU did not decline. Therefore, the EU came up with two additional EU regulatory programmes:

1) **REACH** – The Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) was enforced in 2007, through the regulation (EC) No 1907/2006.³⁰ It aims to 'improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances'.³¹ This is done by the four processes of REACH, namely the Registration, Evaluation, Authorisation and Restriction of chemicals. REACH also aims to 'enhance innovation and competitiveness of the EU chemicals industry'. In this way, the EU hopes to gather and share more information about the risks on public health and the environment by commercialised pesticides, which used to be quite limited. The responsibility of this regulation lies within the pesticides industry, as manufacturers are obliged to find information on the active substances themselves. They need to enter this data into an EU database, which is managed by a special created

²⁶ https://ec.europa.eu/food/plant/pesticides/authorisation_of_ppp_en; visited on 23.11.22

²⁷ *Agence française de sécurité sanitaire des aliments*

²⁸ *Agence française de sécurité sanitaire de l'environnement et du travail*

²⁹ *Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail*

³⁰ REGULATION (EC) No 1907/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency

³¹ https://ec.europa.eu/environment/chemicals/reach/reach_en.htm; visited on 02.01.23

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

agency: European Chemical Agency (ECHA). ECHA also coordinates the REACH regulation process within the EU. Currently, the REACH framework is being revised, under the Chemicals Strategy for Sustainability.³²

2) **National Action Plans** – The EU aims to achieve a Sustainable Use of Pesticides through its Directive 2009/128/EC.³³ This Directive is reinforced in order to ‘establish[ing] a framework for Community action to achieve the sustainable use of pesticides’. This directive has been implemented through so called ‘National Action Plans’ (NAP) since 2012. Through these NAPs, the EU required member states to implement actions to reduce risks and impacts of the use of pesticides.³⁴ France implemented its NAP through its so called ‘Ecophyto II plan’. The plan aimed to reduce pesticides use in France between 2015-2020 with 25%, and by 2025 with 50%. Ecophyto II is the follow up policy programme of the French Ecophyto plan, which was initially launched in 2008 to reduce pesticides use by 50% over a ten-year period. When pesticides use showed to have increased instead at the mid-term evaluation, Ecophyto II (Lapierre et al., 2019) was developed in the context of the EU NAP. I further discuss this Ecophyto plan in section 1.3.3.

However, as the EU commissioned report on the implementation of the directive highlights, the NAPs have been poorly implemented among member states (Guteland, 2019; European Commission, 2020b). According to the rapporteur, the NAPs lacked ‘quantitative objectives, targets, measurements and timetables’ according to the rapporteur. Initially, France was the only country that had implemented a NAP with an ‘high-level measurable target’ to reduce pesticides use (Guteland, 2019). The latest report on the NAP implementation showed that also Germany and Denmark have set such ambitious targets (European Commission, 2020b). In addition, the NAPs should be revised every five years. After five years France was one of the two countries who actually did this (Guteland, 2019).

Finally, on the EU level, the Common Agriculture Policy (CAP) (2014-2020) promotes sustainable use of chemical plant protection products (PPP). The EU claims to do this through the measures described in Box 2.³⁵ In the most recent reforms of the CAP (2023-2017), CAP strategic plans to be implemented by member states have to be in line with the EU’s strategies set out in the Green

³²https://ec.europa.eu/environment/chemicals/reach/reach_revision_chemical_strategy_en.htm; visited on 02.01.23

³³ DIRECTIVE 2009/128/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides

³⁴ https://food.ec.europa.eu/plants/pesticides/sustainable-use-pesticides/main-actions_en; visited on 02.01.23

³⁵ https://ec.europa.eu/info/food-farming-fisheries/sustainability-and-natural-resources/biodiversity-and-land-use/pesticides_en; visited on 23.11.22

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

Deal. Specifically, this is about the 'farm to fork' and 'EU biodiversity' strategies.³⁶ These strategies aim to reduce use, risks and dependency on pesticides, as a revision of the Directive on the Sustainable Use of Pesticides. Through these strategies, the commission has set the ambition to (European Commission, 2020a): *"reduce by 50% the use and risk of chemical pesticides by 2030 and reduce by 50% the use of the more hazardous pesticides by 2030"*.

Box 2. Promotion of sustainable use of chemical plant protection products in the Common Agriculture Policy (CAP) (2014-2020)

- Most direct payments to farmers are no longer linked to production, reducing the incentive to produce more than is needed and to intensify the use of pesticides;
- "Green" direct payments are given to farmers for agricultural practices that are beneficial for the climate and the environment;
- Under so called cross-compliance rules, farmers can lose part of their payments if they do not respect the requirements of EU law related to environment, climate change, the good agricultural condition of land, human, animal and plant health standards and animal welfare. This includes the conditions for use of pesticides;
- In the specific case of fruits and vegetables, at least 10% of spending in the operational programmes must be on environmental actions that go beyond mandatory environmental standards;
- Agri-environmental measures are designed to reduce the risks of environmental degradation and enhance the sustainability of agro-ecosystems;
- Farm advisory systems have to inform farmers about conditions under cross-compliance, green direct payments, issues related to the water framework directive and the sustainable use of pesticides directive.

1.2.4 Authorisation and withdrawal of pesticides in France

Considering the regulatory systems as discussed in the previous sections, what is the situation today in France? Figure 4 shows the comparison of authorised active substances between EU countries in 2020. With 343 active substances, France has authorised the most of the EU. Figure 5³⁷ shows the evolution of authorisation and withdrawal of pesticides in France since the early 1940s – the start of the government decree on pesticides and thereby the regulation system – until 2019.

By using the data on withdrawal and authorisation, I could also analyse the cumulative amount of pesticides authorised for the French market over time. Figure 5 illustrates that for the first 40 years, pesticides were solely authorised, there was no withdrawal of pesticides from the market. The first pesticides were withdrawn in the mid-1980s. The highest number of pesticides authorised on

³⁶ https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/new-cap-2023-27/key-reforms-new-cap_en#agreenerpolicy; visited on 02.01.23

³⁷ Only those pesticides products with an indicated 1st authorization date are included in this analysis

the market was reached in the late 1980s and early 1990s (around 5400 products). It was not long after this point when the number of pesticide authorisation per year started to decrease as well as the total (cumulative) number of authorised pesticides, while the withdrawal of pesticides increased. It is notable that this evolution took place around the same time of the implementation of the EU's legal framework on pesticide regulation in 1992.

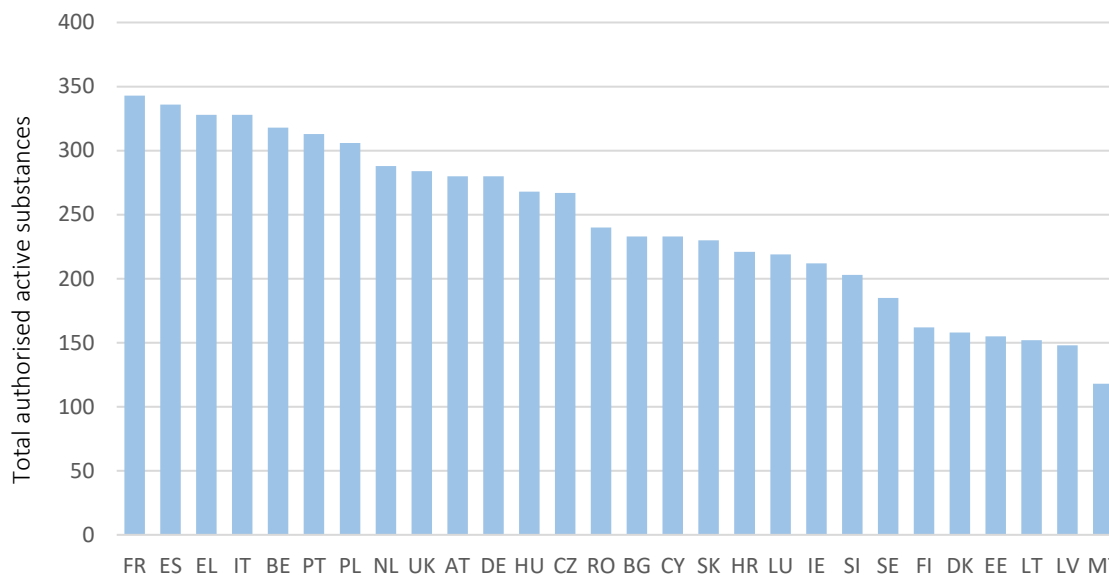


Figure 4. Total authorised active substances in 2020 per EU country (Source: EU Pesticides database, 2020)

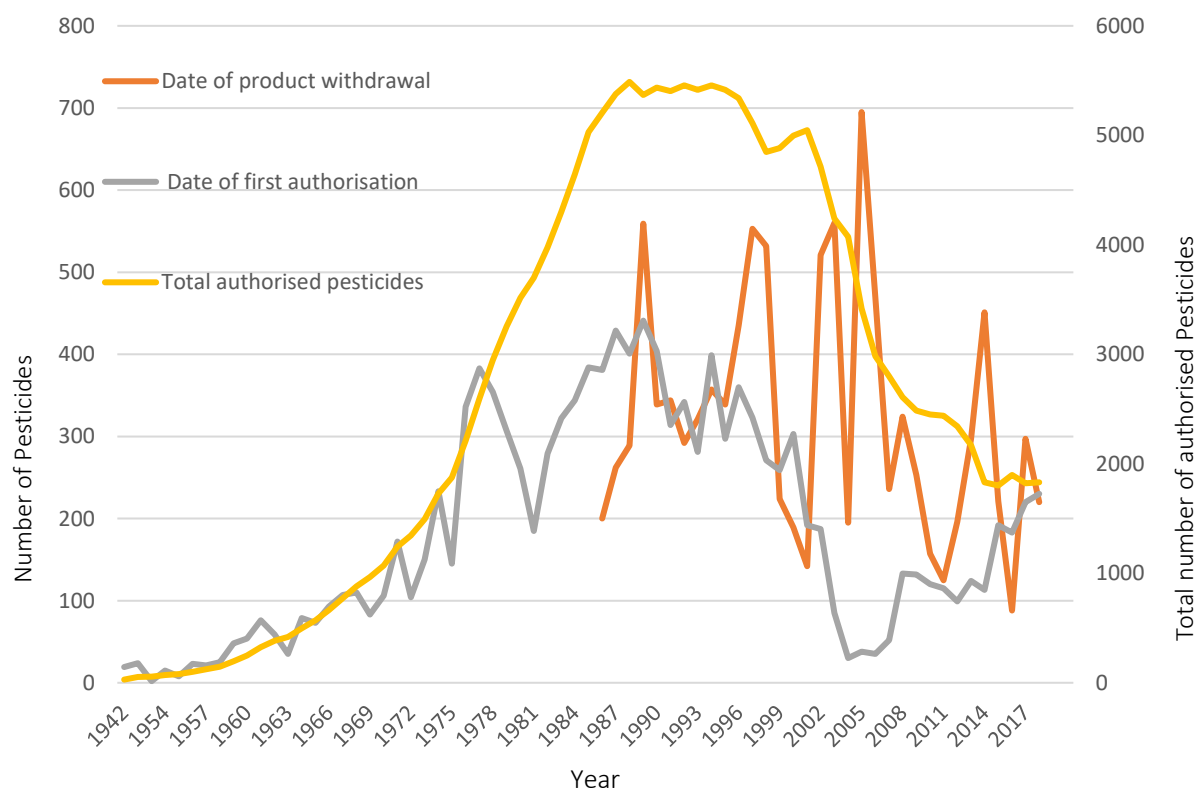


Figure 5. Evolution of the authorisation and withdrawal of Pesticides in France (including total number of authorised pesticides) (source: E-Phy and Database French government (data.gouv.fr))

Chapter 1. Setting the scene of the O-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

An analysis into the active substances of the pesticides over time reveals that pesticides, especially in the 1980s and 1990s, contain often the same active substance, but in other doses (based on the E-phy database³⁸). This means that there were many pesticides available on the market consisting of different doses of the same substances. Later on, in the 2000s and 2010s the diversity of active substances increased. This could indicate that pesticides became more targeting to specific pests. This might also be a possible explanation why the number of pesticides on the market decreased, while pesticides sales increased.

Nevertheless, from 2006 onwards the number of pesticides authorisation increased again, up until today. This is a particular moment in time, considering that it was in this period that the first French 'Ecophyto plan' was launched (I further discuss this in sub-chapter 1.3), which aimed to drastically reduce the use of pesticides. It was as well the moment in which pesticide authorisation became the responsibility of AFFSA. However, an analysis into the types of pesticides that have been authorised after 2006 in France is summarised in Table 1. The percentage of products that are suitable for organic production, biocontrol, or with a bee label increased also in the period after 2006.

The French government has also put in place a law in 2014 that allows the marketing of certain pesticides products for a maximum of 120 days in case of plant protection emergencies in the country. This list of products is published on their website.³⁹

Table 1. Mentions added to the chemical plant protection products (PPP) in the French regulation system (source: e-phy database and database French government: data.gouv.fr)

Mentions of PPP	% of PPP after 2006	% of PPP before 2006
Suitable for use in organic farming	8.7%	0.9%
Authorised for use in gardens	7.2%	8.3%
Biocontrol list	13.3%	1.2%
Low risk product article 47	1.4%	0.0%
Organic amateur production	3.0%	0.2%
Bee mention	1.1%	0.1%

1.3 R&I activities and strategies on (the reduction of) pesticides

In the previous sub-chapter, I illustrated the evolution of the regulatory framework on pesticides sales in France. This highlighted the efforts of the French government to control pesticides use: to ensure the efficacy of pesticides' products, but also to consider their impact on public health and the environment. However, I have also highlighted how pesticides use increased over time (sub-chapter 1.1). In this story, in which I describe how we arrived today at the implementation of the R&I

³⁸ <https://ephy.anses.fr/>

³⁹ <https://agriculture.gouv.fr/produits-phytopharmaceutiques-autorisations-de-mise-sur-le-marche-dune-duree-maximale-de-120-jours>

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

programme PPR-CPA to eradicate pesticides, beyond the pesticides' regulations, there is also a history to highlight around R&I efforts. In the early years of chemical pesticides development in France (late 19th century), mainly entomologists, phytopathologists and phytopharmacists from research departments of the French Ministry of Agriculture were working on this. Also discussions around the public health impact of pesticides already emerged, as French hygienists occupied themselves with the toxicity of chemicals on human health, especially the long-term effects of arsenic insecticides (Jas, 2007).

In the early 20th century, and mainly in the interwar period, this discussion got stronger. Toxicologists from the pharmaceutical industry requested that toxicity of pesticides should be carefully studied (Jas, 2007). As Jas (2007) argues, "*toxicologists were competing with scientists working in agronomical research institutes for control of the new merging scientific discipline of phytopharmacy*" (p.372). Such discussions on health effects are reflected in the evolution of the research field around pesticides. For instance, since the 1980s more epidemiological and pathological research was conducted on the health effects of pesticides, such as cancers and neurological diseases (INSERM, 2013). From the 1990s onwards, French medical research got more involved in questions around the effects of pesticides, specifically about the effects of repetitive exposure to pesticides as well the effects from small doses (Jas, 2010).

As can be read on their website, the French National Research Institute for Agriculture, Food and Environment (INRAE) has emphasised its research efforts on pesticides in the past decades, largely commissioned by the Ministry of Agriculture and the Environment.⁴⁰ INRAE highlights their work to establish an 'inventory of international scientific knowledge on Pesticides, agriculture and the environment' in 2005. In addition, they mention their work on the harmful impact of agricultural practices on biodiversity, as well as their interdisciplinary work on agroecology since the 2010s.

Hence, in this sub-chapter, I illustrate the history of R&I activities and strategies about pesticides in France. I describe this through four sections. The first two sections provide a broad overview of R&I activities about pesticides in France. This is not just about risk, safety and impacts of pesticides, but also about the development and efficacy. The third and fourth sections describe two recent R&I programmes to specifically reduce pesticides use in France:

- Ecophyto plan: the French NAP on the sustainable use of pesticides;
- PPR-CPA: the French mission-oriented research program, as a response to Ecophyto for reinforcing R&I efforts to reduce pesticides use.

⁴⁰ <https://www.inrae.fr/en/news/what-new-options-are-available-facilitate-end-pesticides>

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

1.3.1 Research strategies in agricultural policy

As I highlighted in section 1.2.2, in 1960 the French government implemented the law for agricultural orientation (*loi d'orientation Agricole*), which has been revised in 1962, 1980, 1995, 1999 and 2006. I looked into the R&I strategies in the revisions of this law from 1980-2006, and the evolution over time, which I summarised in Box 3. This provides a first indication of R&I focus in agriculture supported by the French government.

In the 1980 version, 'health' or the 'environment' are not mentioned. Research policy seemed to have focussed mainly on economic aspects of agriculture and the increase in productivity and competitiveness of the agricultural system (including the agri-industry around it). We can see a change only 15 years later in the revised version of 1995. Research programmes are supported to conduct research in the field of health and environmental protection related to agriculture. In 1999, 'research' became part of the Rural Code, specifically in the article on 'Agricultural and veterinary research' (Article L830). This article was revised for the first time in 2006, even though these two periods only show limited changes. The main difference between both periods is the additional focus on biomass from 2006 onwards. Although competitiveness and productivity are still the first aspect to be mentioned, there is a clear priority put on sustainability, health and environmental protection as well as risk management in agriculture.

The Article L830 that is currently in place dates from 2014, whereby the 'Rural Code' changed its name to 'Rural and Maritime Fisheries Code'. The main difference with the versions of the Article from 1999 and 2006 is that the focus is not just on 'fundamental research' anymore. The 2014 version mentions: 'the development of fundamental research, applied research and technological innovation'.

Box 3. Overview of Articles on research of the law on agricultural orientation from 1980-2014 (Source: legifrance.gouv.fr)

1980 (Article 2) [translated from French^{III}]:

A policy of education, permanent training, research and development with the following priority objectives:

- increasing the productivity and competitiveness of agriculture, agri-food and agro-energy industries;
- greater independence, by reducing the costs of intermediate production factors and imported raw materials;
- forecasting and analysing technological, economic and structural developments and defining the conditions for adapting to new data.

1995 (Article 2) [translated from French^{IV}]:

Agreements concluded within the framework of a recognised interbranch organisation may be extended, for a specified period, in whole or in part, by the competent administrative authority, where they seek, by means of standard contracts, annual agreements and common measures in accordance with the general interest and compatible with the rules of the common agricultural policy, to promote:

- carrying out applied research, experimentation and development programmes, particularly **in the fields of product quality and the protection of health and the environment**;
- the coherence of the actions carried out in the field of agricultural research, experimentation and development, in liaison with the National Association for Agricultural Development.

2006 – revision from 1999 (Article 138 - code rural Article L830-I: Recherche agronomique et vétérinaire) [translated from French]:

Agricultural and veterinary research contributes to the development and competitiveness of the agricultural sector and the agricultural product processing sector. It responds as a priority to the imperatives of **sustainable management of rural areas, the development of biomass, the safety and quality of food products and the preservation of the world's natural resources. It is based on the development of fundamental research.**

It is carried out in public bodies with research missions and in higher education institutions. Technical institutes and centres linked to professions and technological innovation centres meeting the conditions set by decree contribute to it. Companies in the agricultural sector and the processing of agricultural products may also participate. The Minister of Agriculture, jointly with the Minister responsible for research or, where appropriate, with other interested Ministers, supervises these public bodies carrying out research tasks.

The Minister for Agriculture ensures the coordination of agronomic and veterinary research activities and ensures that they are adapted to the objectives of agricultural policy.

The public research bodies provide the public authorities with expert advice, particularly in the fields of public health and environmental protection. In this capacity, they contribute **to the identification and evaluation of risks in terms of the health safety of agricultural products and the protection of natural resources and environments.**

The evaluation of agronomic and veterinary research is based on periodic assessment procedures covering staff, teams, programmes and results.

1.3.2 The French research environment on pesticides

To further explore research efforts in France on pesticides, and its evolution over time, I analysed the research ecosystem around this topic. By using the Cortext Manager platform (Breucker et al., 2016),⁴¹ I did a scientometric analysis to explore the research ecosystem on pesticides in France. For the first analysis, I used the Scopus database and searched for “pesticides” AND “France”, which gave 1515 results from 1960-2019. I conducted a lexical analysis of this database by uploading it to Cortext Manager. For this lexical analysis, I extracted the top 500 used terms in the title, keywords and abstracts of each publication. This analysis⁴² allows me to study the evolution of pesticide research in France over time. Figure 6 shows a co-word analysis of the research publications between 1960 and

⁴¹ www.cortext.net

⁴² The more detailed methodology of this analysis can be found in Chapter 3

Chapter 1. Setting the scene of the O-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

2019. Each node (triangle) represents one the most frequent used terms in these publications, and the weight of the line between two nodes indicates the frequency of two terms appearing in the same publication. It resulted in nine clusters, which can be considered as different research communities.

Figure 7 to Figure 12 show this same co-word map six times, each map represents a period of 10 years which is indicated in the top. I divided the database in these periods of 10 years (per decade⁴³), to discover the evolution of pesticides research in France over time. These are heatmaps, which indicate what terms mostly appear in each period. The darker red the term or cluster, the more those terms or clusters appeared in that specific period. This resulted in the following analysis.

In the first decade, the 1960s, most research focussed on the chemical compounds of pesticides, and on pesticides' residues. Research efforts were about the pesticides' residues in human fat as well as in food. It should be noted, though, that the number of publications found in this period is very limited. In the 1970s, an even stronger emphasises had been on research on pesticides residues, both in human tissues as well as on food. This research on pesticides' residues on food products refers to vegetables, but also largely to animal-based food products such as milk and meat. Hence, together with the research from the 1960s, these decades demonstrate the research efforts in France on the impacts of pesticides on public health.

In the 1980s, we can see that research activities are more diversified. There is still a strong focus on the impacts of pesticides on public health, but also research on the environmental impacts of pesticides gains more attention. On the one hand, research on health impacts appears to start focussing on risk assessments and regulatory aspects (see red cluster in the middle-right). On the other hand, the research on environmental impacts shows to be largely about water pollution, and methods to conduct such types of research (e.g., chromatography). This period also highlights the upcoming research on insect pests in two particular fields: 1) management strategies for pest control (e.g., natural pest management); and 2) research on pesticides' resistance of insects.

The fourth decade, the 1990s, illustrates strong research emphases on water pollution (and related research methods) and waste water treatment. This is particularly related to surface water and drinking water. Also risks related to pesticides' exposure are largely studied in this period. Such research is for instance about the risks of pesticides exposure on farm workers, with a particular focus on cancer diseases. This is in line with what I already illustrated in the introduction of this sub-chapter, based on the research by INSERM (2013) and Jas (2010). [*Text continues after the figures on the following pages*].

⁴³ It should be noted that the first document papers I found in this particular database are from 1960

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

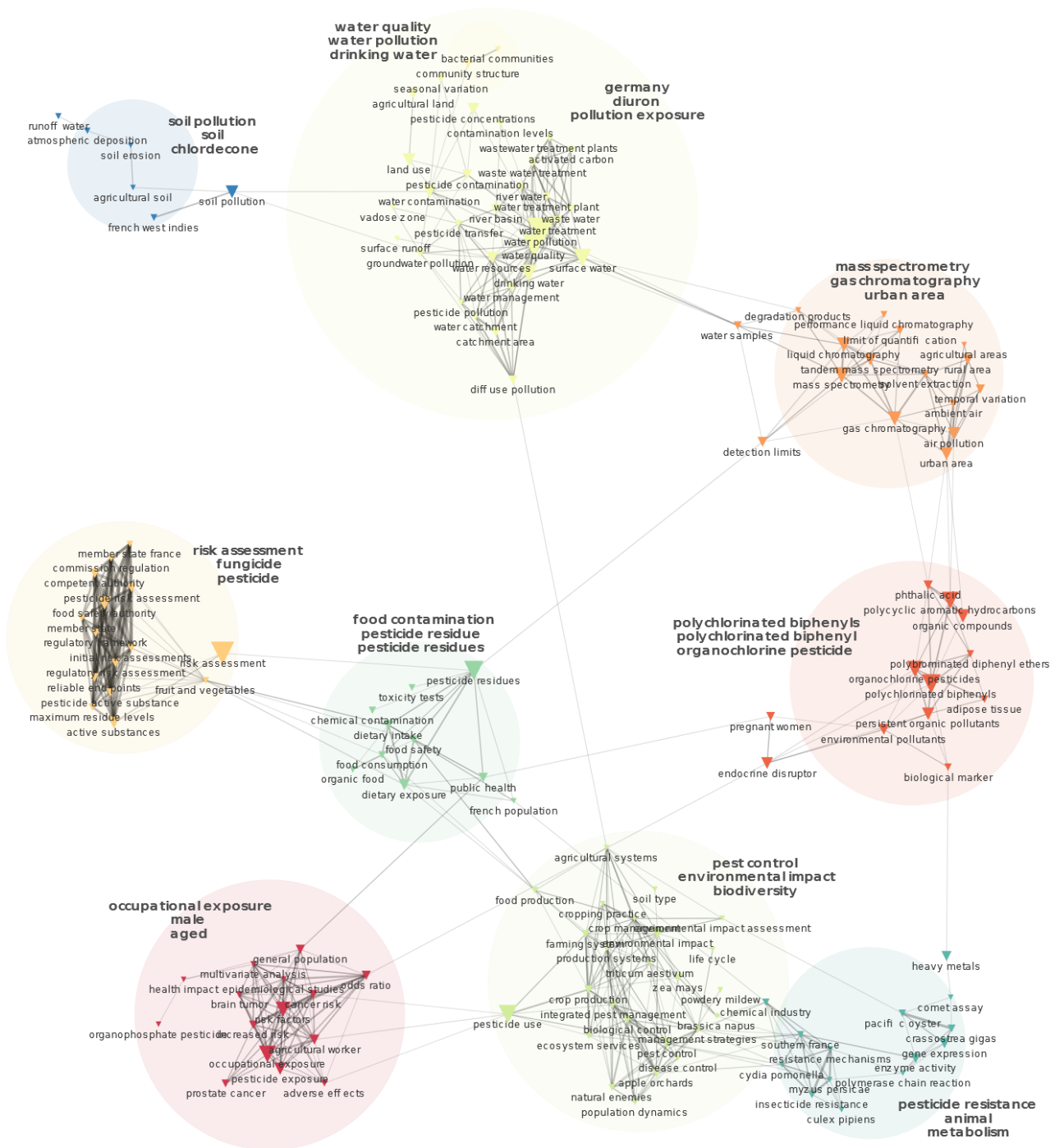


Figure 6. Clusters of the most frequent associated terms in Pesticides Research in France (1965-2019) – performed by using Cortext Manager

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

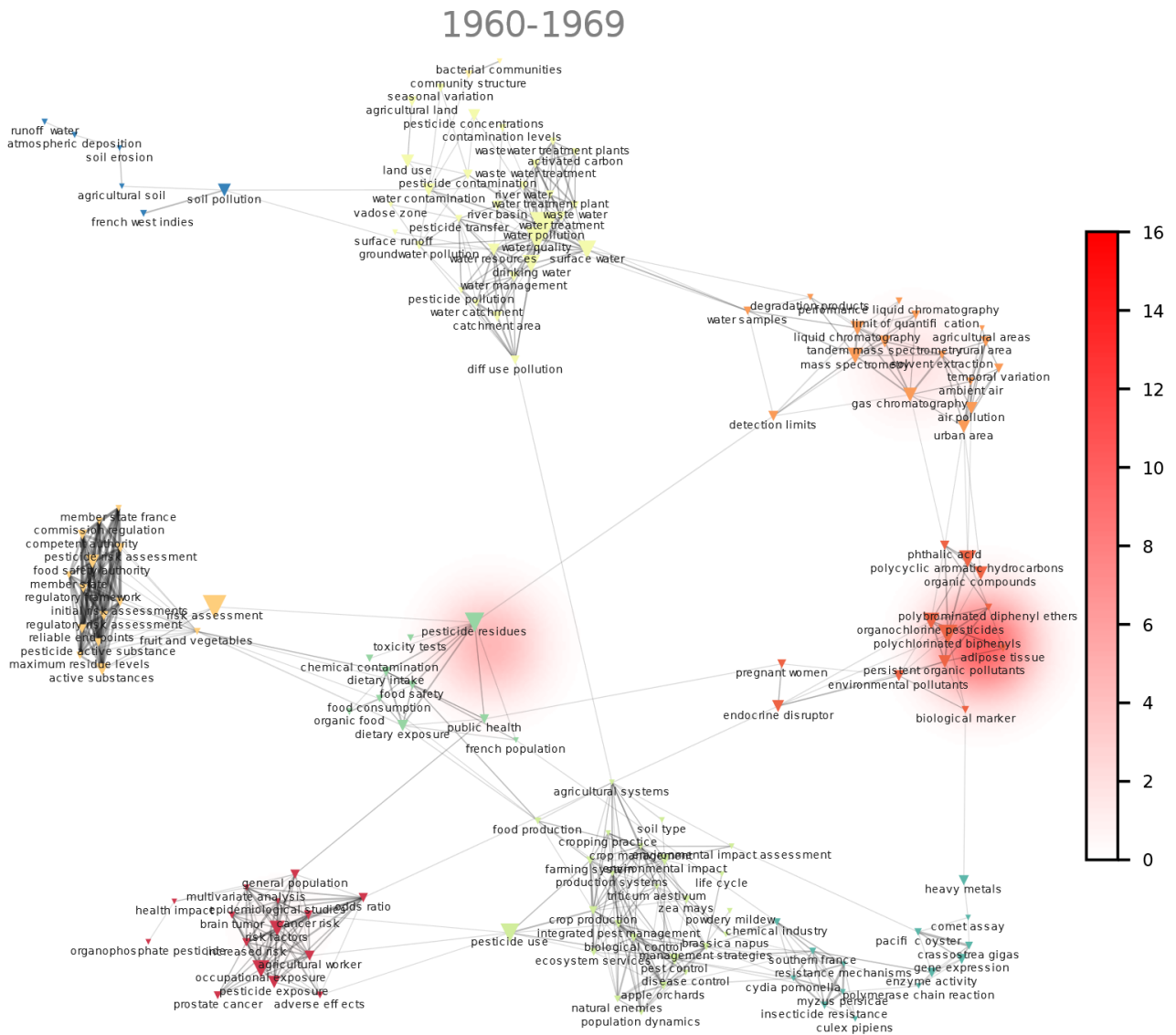


Figure 7. Heatmap highlighting the focus of the French pesticides research ecosystem in the period 1960-1969; The darker red the term or cluster, the more those terms or clusters appeared in this period – Performed by using Cortex Manager

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

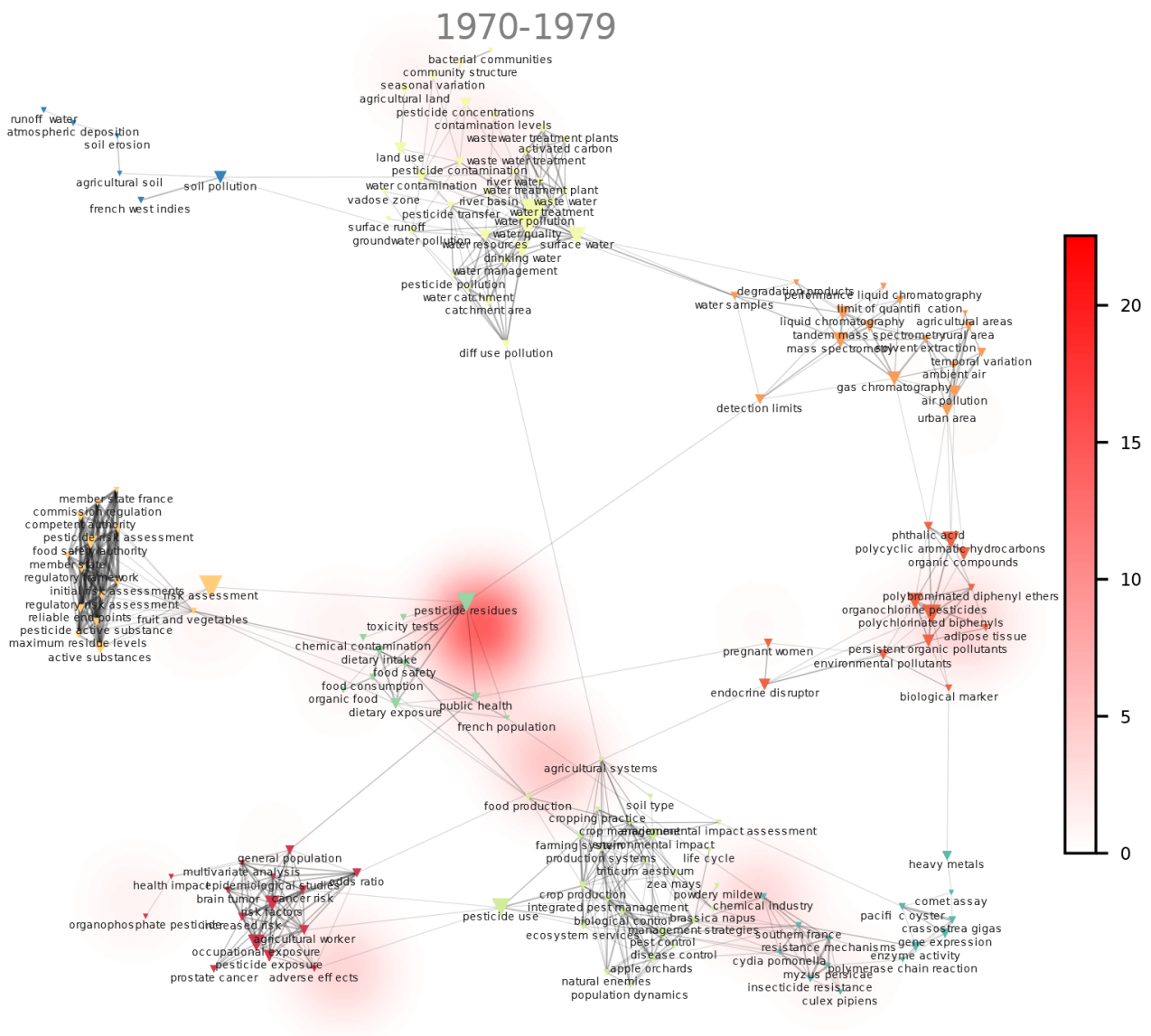


Figure 8. Heatmap highlighting the focus of the French pesticides research ecosystem in the period 1970-1979; The darker red the term or cluster, the more those terms or clusters appeared in this period – Performed by using Cortext Manager

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

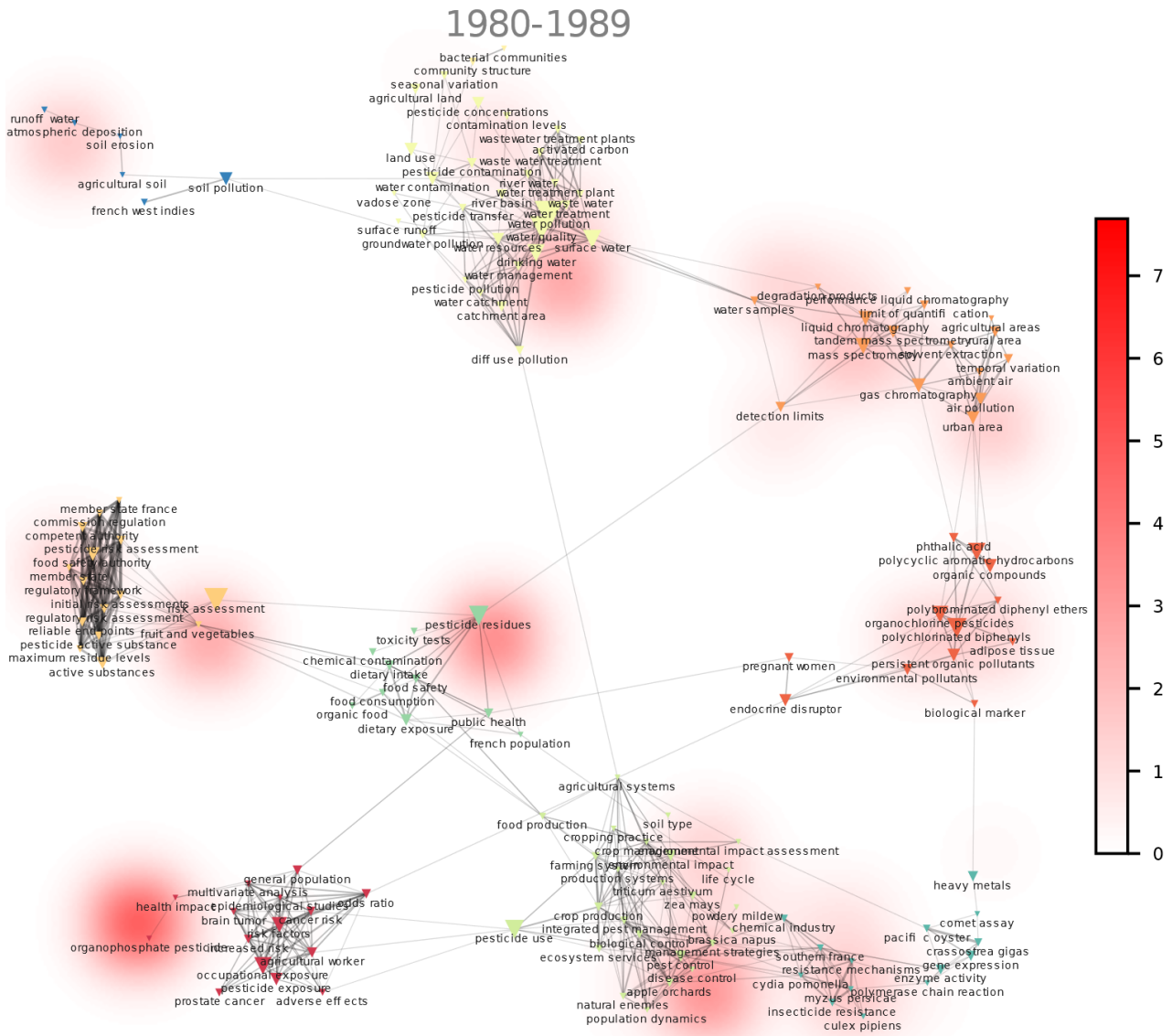


Figure 9. Heatmap highlighting the focus of the French pesticides research ecosystem in the period 1980-1989; The darker red the term or cluster, the more those terms or clusters appeared in this period – Performed by using Cortext Manager

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

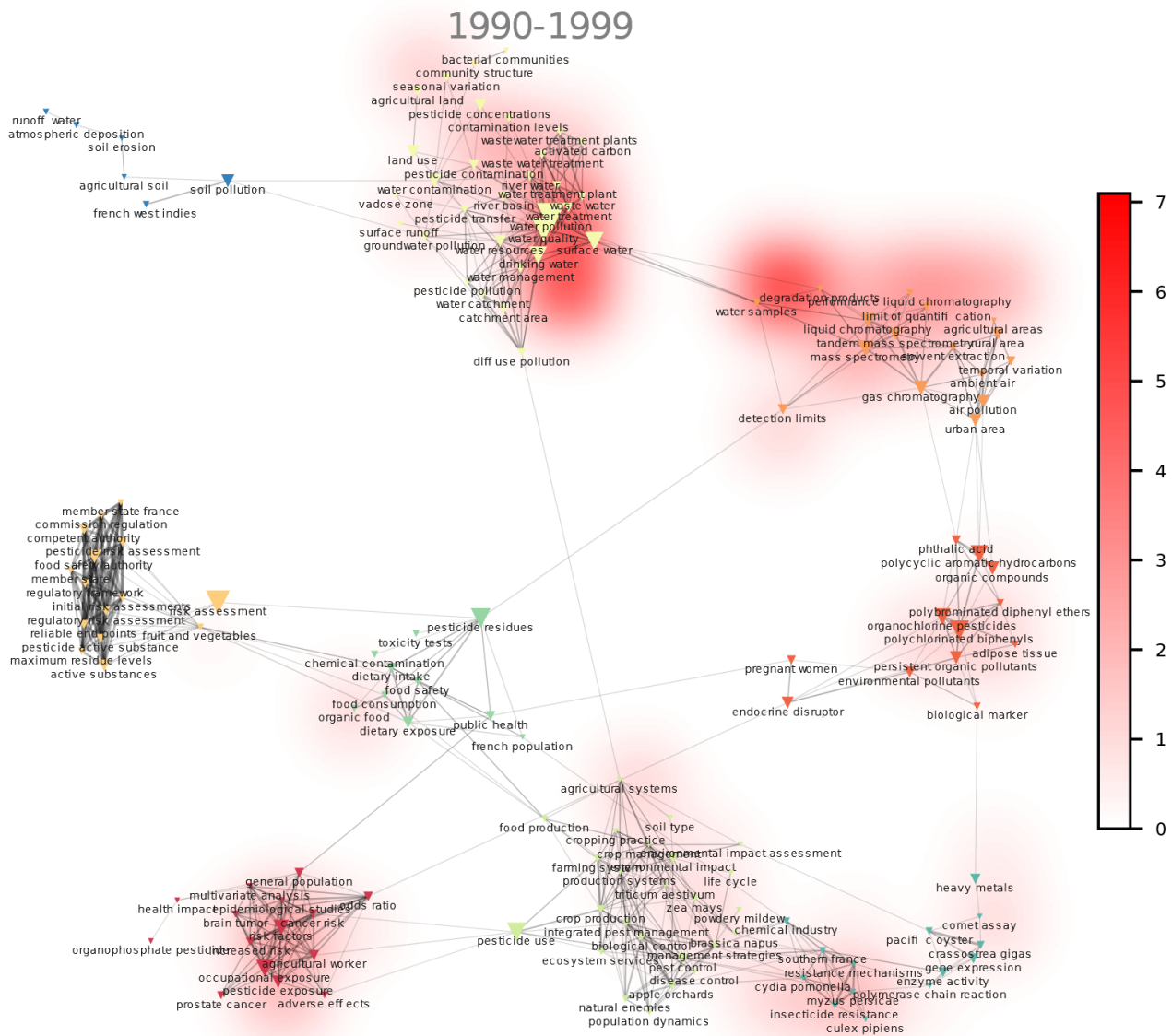


Figure 10. Heatmap highlighting the focus of the French pesticides research ecosystem in the period 1990-1999; The darker red the term or cluster, the more those terms or clusters appeared in this period – Performed by using Cortext Manager

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

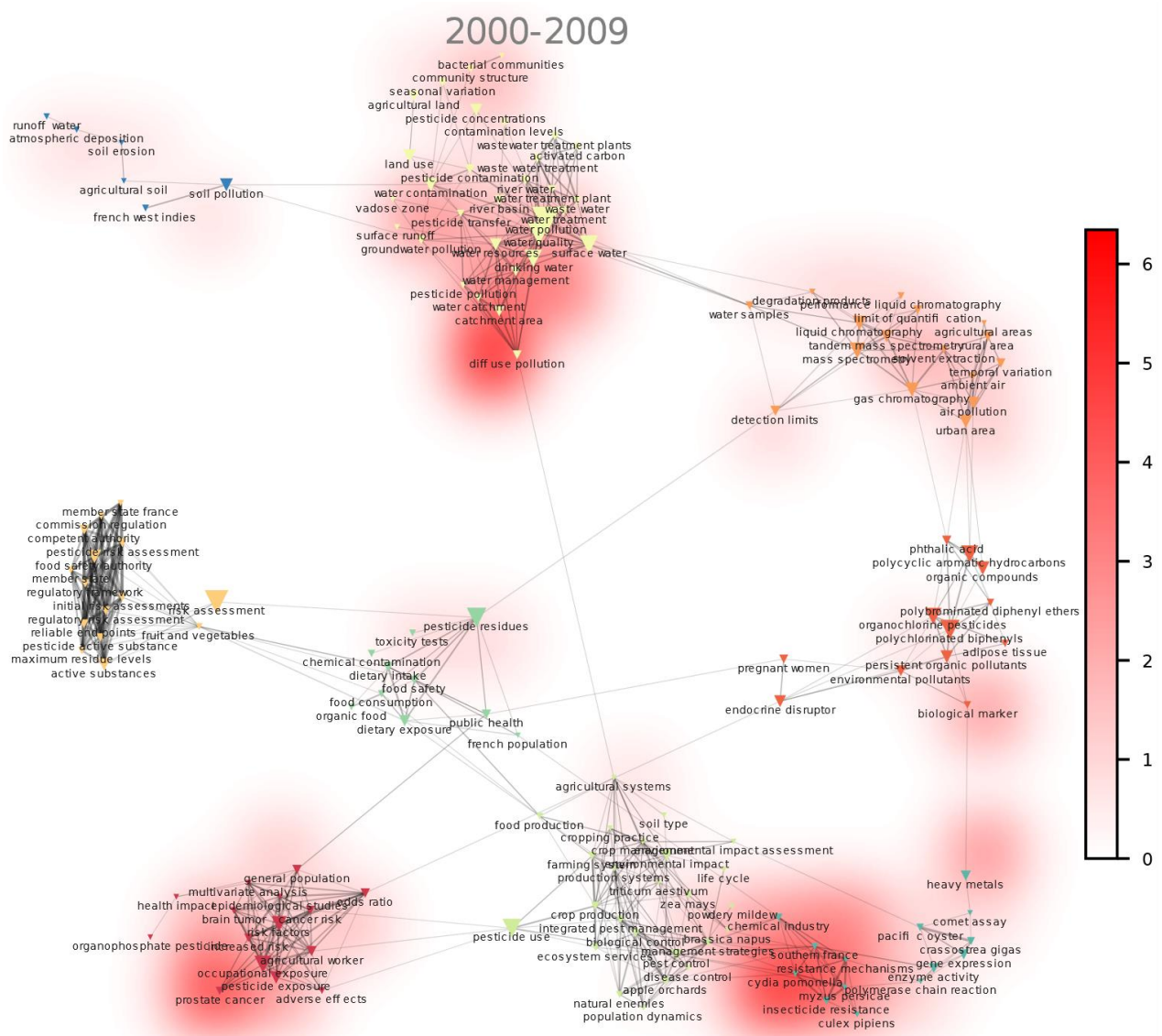


Figure 11. Heatmap highlighting the focus of the French pesticides research ecosystem in the period 2000-2009; The darker red the term or cluster, the more those terms or clusters appeared in this period - – Performed by using Cortext Manager

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

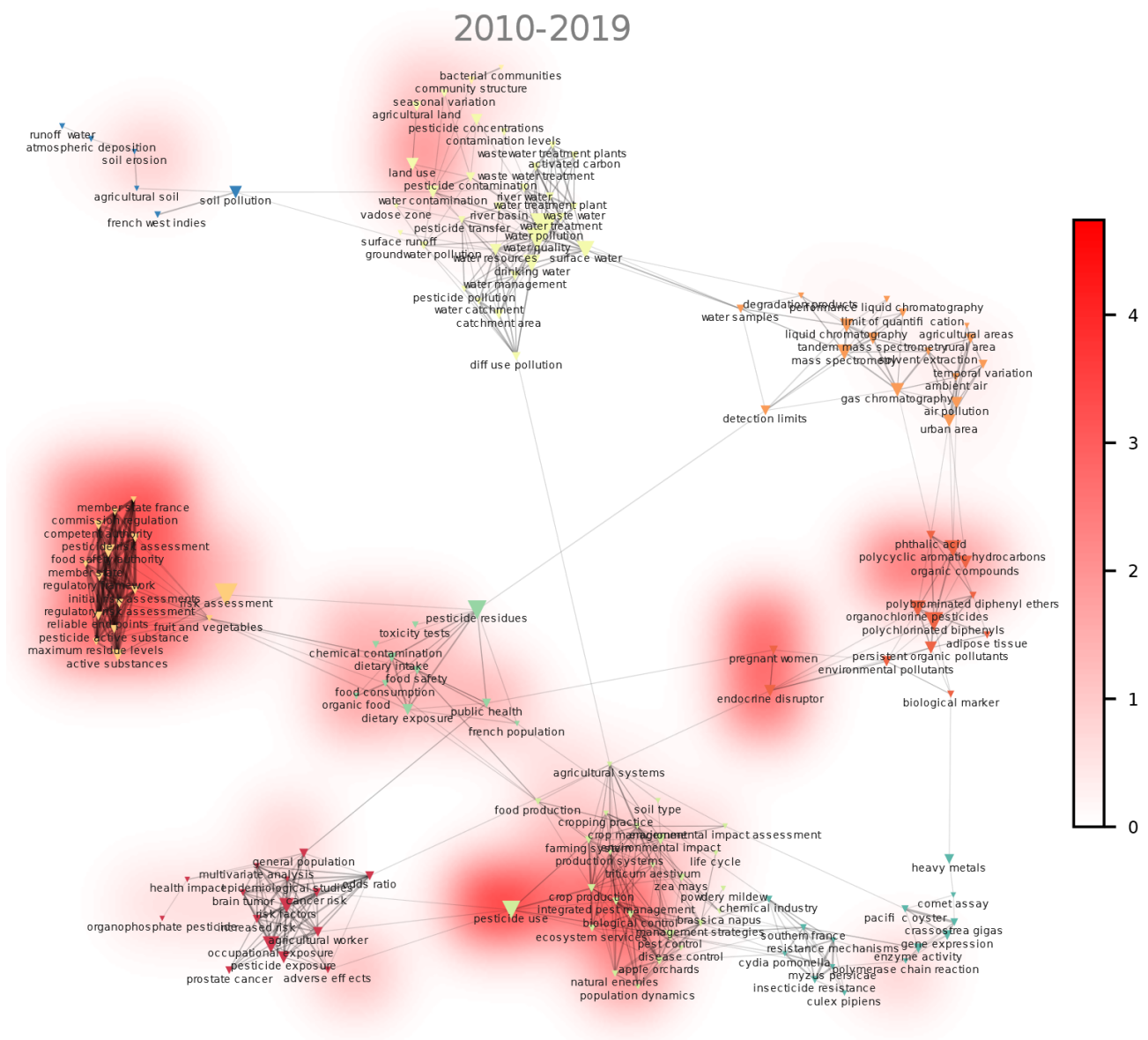


Figure 12. Heatmap highlighting the focus of the French pesticides research ecosystem in the period 2010-2017; The darker red the term or cluster, the more those terms or clusters appeared in this period -- Performed by using Cortext Manager

Chapter 1. Setting the scene of the O-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

Research on pesticides in the 2000s seemed to have reinforced the studies of the 1990s. There shows to be a strong emphasis on water pollution, which now extended to include catchment areas, the diffusion of pollution through water ways, and soil and groundwater pollution (through water runoff). On the level of public health, research largely continued to focus on pesticides' exposure and cancer risks (prostate cancer). This period is also marked by its research efforts on insect resistance.

The final decade, the 2010s, highlights a remarkable evolution of research efforts to a strong focus on the health impacts of pesticides and research into alternative pest management. Hence, this period is characterised by research emphasis in two particular fields. First, there is a strong focus on food products, such as food safety, residues on food, toxicity studies and organic food. Related to this field are the regulatory frameworks that are studied in this regard (yellow cluster in the middle-left). These studies are for instance about pesticides risk assessment, maximum residue levels, regulatory risk assessment, food safety authority and the French efforts as an EU member state. This might be related to the implementation of the REACH framework in 2007 by the EU as well as the implementation of the NAP, as I discussed in section 1.2.3. The second research field is about alternative pest management, such as integrated pest management, biocontrol, natural enemies and ecosystem services. Considering that this is also the period of the Ecophyto plan, which includes research efforts on the reduction of pesticides, this evolution is a potential result of its implementation.

1.3.3 The Ecophyto plan: the French National Action Plan on the sustainable use of pesticides

As discussed in section 1.2.3, in its strategy to sustainably use pesticides, the EU required its member states to come up with a 'National Action Plan' (NAP). Through the NAP, the EU aims to promote the implementation of pesticide reducing practices on national level. Until recent, France was one of the few countries that had implemented a NAP that actually targeted reduction of pesticides use (Guteland, 2019): namely, the 'Ecophyto II plan'. However, as I discussed, Ecophyto II is the follow up of the initial 'Ecophyto plan'. This initial policy plan, over the ten-year period 2008-2018, aimed at reducing chemical pesticides use in France with 50% (Lapierre et al., 2019). The Ecophyto plan, established by the French Ministry of Agriculture, was a response to the commitments, which came out of the national 'Grenelle de l'environnement' in 2007 (Zahm, 2011). This was a multi-actor forum with participants from (local) governments, organisations/associations and the private sector, to discuss French national policy efforts for the coming five-years to support environmental and sustainable development.

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

Ecophyto was implemented on different levels in France. At national level, the Ecophyto plan was managed by 1) the National Monitoring committee, chaired by the Ministry of Food, Agriculture and Fisheries, to manage the operational and financial implementation of the policy plan; and 2) an expert committee, consisting of actors, to support the implementation. At regional level, there is a regional monitoring committee put in place to gather actors at regional level. This committee interacts with 'technical groups' that are implemented on regional level (e.g., a technical group on water quality). Various actions were implemented, of which the largest are: 1) A national pest monitoring system (BSV – Surveillance biologique); 2) a farmers' network to provide technical assistance for pesticide transition and experimentation/demonstration (called DEPHY); 3) training and certification for farmers and other professional about the use of pesticides (Certiphyto – this certificate is obligatory if you want to use, produce or market pesticides products); 4) an online platform on Integrated Pest Management (Ecophyto Pic); 5) a specific part of the Ecophyto policy plan was dedicated to R&I activities (Luccioni, 2011; Guichard et al., 2017; Lamichhane et al., 2019; Lapierre et al., 2019).

Three main indicators were selected to monitor the pesticide reduction: 1) quantity of active ingredients (QAI; 2) Number of unit doses (NUD); 3) Indicator of frequency of treatment (IFT) (Guichard et al., 2017; Hossard et al., 2017). To support the objective of a reduction in pesticide use, the French government presented three laws (MAAF, 2015):

Law No 2014-1170 on the future of agriculture, food and forestry of 13 October 2014 promotes agro-ecological systems² and establishes several innovative schemes, notably the implementation of the trial use of certificates for low plant protection product use, and a plant-centred pharmacovigilance mechanism.

The law of 6 February 2014, known as the Labbé Law, prohibits the sale of plant protection products to private individuals and restricts the use of these products in planted spaces, forests and promenades under the management of public authorities. Article 68 of Law No 2015-992 of 17 August 2015 on energy transition for green growth extends these restrictions on use to public highways and brings the date of application forward to 1 January 2017 for local authorities and other public stakeholders.

Furthermore, the government has removed certain derogations for the aerial application of plant protection products under the Order of 19 September 2014.

Already early on in the Ecophyto plan, various actors expressed their concerns on this ambitious plan (Guichard et al., 2017). A mid-term evaluation conducted in 2013, showed that pesticides use and sales did not decrease in this period, but its use rather increased instead (Hossard et al., 2017) (Figure 2). Guichard et al. (2017) analysed the limited success of the Ecophyto plan. According to the authors, the main challenges of the Ecophyto plan are socio-technical lock-ins and

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

the lack of systems thinking: if one wants to decrease pesticide use, there is a need for alternative farm practices other than the pesticide use. There is a need of unlocking the 'business as usual', which can only be done by including all actors along the agri-food value chain.

Therefore, it was argued that reducing pesticides use needs a systemic vision, which considers the interlinkages among all actors. Guichard et al. (2017) argue that Ecophyto did not do this: [translated from French^{vi}]: *“essentially targeting farmers and R&D, it did not include anything to encourage breeders, commodity chains, processors, supermarkets or consumers to change their strategies and practices”* (p.10). However, as both Guichard et al. (2017) and Lamichhane et al. (2019) emphasise, likewise there are success stories from Ecophyto. Initiatives towards a switch from chemical pesticides to alternative practices came from farmer and advisor networks. Various groups consisting of farmers and agricultural advisors have been formed (including through the DEPHY initiative). Participating farms in this network have decreased their pesticides use by 18%, while in general pesticides use has increased in this period in France (Stokstad, 2018). According to Guichard et al. (2017) this [translated from French^{vii}] *“calls for a rethinking of farmers' access to knowledge and the organisation of agricultural development”* (p.10).

R&I played a large role in the Ecophyto plan to transform pest management systems. Already in the early phase of Ecophyto, it was observed that current knowledge and R&I available on this topic were not sufficient to respond to its objectives. Most of previous R&I have been dominated by chemical pest management (Ricci, 2015; Lamichhane et al., 2019). Ricci (2015) argued [translated from French^{viii}]:

Stakeholders agree that research and innovation have an essential contribution to make to this transformation of crop protection, but this requires a renewal of priorities and methods to meet the new needs that have emerged as a result of Ecophyto : the need to explore previously neglected fields of knowledge (such as the link between cropping systems and pests or between biodiversity and natural regulation, but also the socio-economic dimension of change and the role of public policies); the need to strengthen the scientific and methodological framework on which the plan's major systems are based (epidemic-surveillance, Dephy networks, etc.); the need to re-examine, in the context of the change in practices promoted by the plan, issues related to control methods (such as innovation in biocontrol, pesticide resistance or the evolution of agricultural equipment) (p.158).

As a response, starting from 2011, an R&I axis was reinforced through the Ecophyto plan, to support R&I initiatives, which respond better to the objectives of Ecophyto (Ricci, 2015; Lamichhane et al., 2019). Lamichhane et al. (2019) explained that an expert panel was set up in this context with the following objectives:

Chapter 1. Setting the scene of the O-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

(i) identifying priorities to develop an Ecophyto scientific research program, (ii) mobilising and facilitating scientific communities around these priorities, through their delegation into pre-existent or new calls for research proposals which integrated the priorities in their objectives, and (iii) assessing the results produced and contributing to their dissemination, finalisation and appropriation by end user (pp. 6-7).

The full Ecophyto research program⁴⁴ presented eight thematic research priorities to promote a transition from chemical to low-input crop protection systems (see Box 4). These eight themes relate to three main strategic research questions, on the transition from chemical to natural pest control, that respond to the Ecophyto plan (Ricci, 2015).

Box 4. Eight thematic research priorities of the Ecophyto plan

1. Strategic question 1 and related themes

What changes need to be made compared to the conventional agricultural system based on chemical pest control?

- a. How to reduce agricultural dependency on pesticides?

Theme II - Design and development of integrated crop protection solutions

Theme III - Diversification of control methods: 1. cultivated genetic material; 2. Biocontrol

- b. How to better assess pest risks?

Theme I - Biological monitoring of the territory: from observation to decision-making

- c. How to limit the impact of pesticides?

Theme III - Diversification of control methods: 3. Development and combination of tools in precision agriculture

Theme VII - From uses to impacts: indicators

Theme VIII - Agricultural Pesticide Exposure and Human Health Effects

2. Strategic question 2 and related themes

What processes (concerning the behaviour of actors and the role of public policies) should be implemented to achieve this transition?

Theme V - Socio-economic dimensions of transitions

Theme VI - Public policy incentives and their mobilization

3. Strategic question 3 and related themes

How can we anticipate future developments and assess the sustainability of alternative plant health management models?

Theme IV - Sustainability of the effectiveness of control methods and robustness of cropping systems.

⁴⁴ https://ecophytopic.fr/sites/default/files/Programme_scientifique.VF_.pdf

The Ecophyto II plan (2015-2025)

As in the mid-term evaluation of Ecophyto the objectives were not met, in 2015 a revised plan was presented: Ecophyto II. The plan contained again a ten-year objective to reduce pesticides use by 50% in 2025. However, this time this objective was planned in two timeframes: 25% reduction in pesticides use by 2020 and a 50% reduction in pesticides use by 2025. Various actions from Ecophyto I were reinforced and consolidated (MAAF, 2015). Ecophyto II also built further upon the R&I initiatives of Ecophyto I, and aimed to scale up such activities. As illustrated in Box 5, the R&I programme of Ecophyto II consists of three main actions (MAAF, 2015).

Box 5. Three mains R&I actions of the Ecophyto II plan

- **Action 1:** Establish a national research and innovation strategy
 - Guide and support research with a view to promoting integrated pest management; limit dependence on plant protection products; reduce the risks and impacts linked to the use of those products; identify and address socio-technical and economic barriers to a shift in practices and support changes in practices and sectors.
 - Expand multidisciplinary research on the environmental and health risks and impacts of air, soil and water pollution linked to plant protection products.
 - Develop research to support the prohibition of the use of plant protection products in gardens, planted spaces and infrastructure.
 - Improve links between basic research, finalised research projects and innovation across all areas affected by the plan and promote research networking with stakeholders
- **Action 2:** Initiate, guide and coordinate research projects to promote a multi-disciplinary approach and cooperation between all parties
- **Action 3:** Take affirmative actions for promotion and transfer

In 2017, '*les États généraux de l'alimentation*' (EGA) were organised by the French president Macron and the Prime Minister Philippe. The EGA assembles all actors from the agri-food sector to discuss economically, environmentally and socially sustainable agrifood systems. One of the outcomes of the meeting was a draft action plan on chemical plant protection products, including an agricultural system less dependent on pesticides, and a ban on glyphosate. To capture this outcome, the Ecophyto II plan was adapted into the Ecophyto II+ plan in 2018.

Specifically, for the three actions on R&I of Ecophyto II, various revisions have been made in Ecophyto II+. First, to better coordinate R&I activities, an inter-ministerial scientific advisory committee was set up. Also, the R&I activities had a specific focus to support the reduction, and eventually elimination, of glyphosate inputs. Regarding the three R&I actions, the main changes are summarised in Box 6.

Box 6. Three R&I actions of the Ecophyto II + plan

- **Action 1:** Establish a national research and innovation strategy: This will be better based on critical reflections of knowledge already obtained through previous R&I efforts ('sustainable alternatives, the impacts on health and the environment, including biodiversity, based on a range of research projects and the financing of research into plant protection products'). Also, there will be more focus on protection and (the effect of) exposure to pesticides. In addition, R&I efforts should consider the practical implications of farmers.
- **Action 2:** Initiate, guide and coordinate research projects to promote a multidisciplinary approach and cooperation between all parties: R&I activities in France will be more actively aligned with European research programmes:
Research initiatives in which France plays a leading role will be enhanced, in particular drawing up the European strategic research agenda on reinforcing research into alternatives to plant protection products, the combined and cumulative effects of plant protection products and taking these effects into account in health and environmental risk assessments, as well as on integrated protection and its implementation.
- **Action 3:** Take affirmative actions for the mobilisation of knowledge and references, utilisation and transfer: In Ecophyto II+ more emphasis is put on the interaction with stakeholders, by actively including civil society actors, businesses, and public policy leaders.

1.3.4 Investing in the future: the PPR-CPA

Around the same period as the implementation of the Ecophyto plan, the French government also officially launched the 'Programme investissements d'avenir' (PIA) in 2010. This programme aims for structural reformations while increasing economic growth and employment rates - mainly through R&I projects - in four priority areas (République Française, 2015):

1. Research and higher education
2. Industries and SMEs
3. Sustainable development
4. Digital economy

Up to today, three specific PIA's (PIA 1 - 2010; PIA 2 - 2014; PIA 3 - 2017) have been implemented. These are subdivided into missions, multiple programmes and actions (République Française, 2015). PIA 3 was officially launched in 2017 – it is a programme with a particular large focus on (the valorisation of) R&I activities. In contrast to PIA 1 and 2, PIA 3 is not structured by domain, yet it is implemented from large-scale research projects to innovation activities and business

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

developments. Along the projects, a specific focus is put in place on environmentally sustainable development (Commissariat Général à l'investissement, 2016). Table 2 gives an overview of the three priority areas, nine objectives and specific actions (Extracted from: Commissariat Général à l'investissement, 2016).

Priority Research Programmes (PPR)

This thesis is conducted in the context of Objective 2 of PIA 3, specifically in the action 'Priority Research Programmes' (PPR) (Table 2: Priority area 1, objective 2 – circled in green). The PPR aims to consolidate French research efforts. As the French Government describes (République Française, 2020): *"The research themes identified must concern large-scale, highly structuring and long-term programmes that meet two conditions: to focus on major socio-economic or societal issues and to enable the emergence or strengthening of French leadership."*

Table 2. PIA 3: three priority areas and nine objectives

Objectives	Actions
Priority 1 – Support the progress in teaching and research	
Objective 1 – Developing pedagogical innovation	"Territories of pedagogical innovation" in school education New courses on universities
Objective 2 – Amplify research programmes	Priority Research programmes Structuring equipment for research
Objective 3 – Integrating research and higher education	Support for Major Research Universities Constitution of University Research Schools
Objective 4 – Open up new management methods on universities	Experimental creation of "academic and research societies"
Priority 2 – Research valorisation	
Objective 5 – Promoting territories of innovation and demonstrators	New innovation ecosystem Highly ambitious demonstrators and territories of innovation Accelerate the development high-performative innovation ecosystems
Objective 6 – Facilitating the appropriation of innovation	Integration of SATTs, incubators and accelerators Frontier Venture National Post-Maturation Fund
Priority 3 – Accelerate the modernisation of enterprises	
Objective 7 – Support innovation	Support collaborative innovation Accompaniment and transformation of sectors (industrial solutions)
Objective 8 – Support the 'industry of the future'	Industries of the future Adaptation and qualification of the workforce
Objective 9 – Accelerate the growth of SMEs and ETIs	Innovation competition National Seed Fund 2 (Fonds national d'amorçage 2) Multi-cap-growth 2 (Multi-cap-croissance 2) Funds for the internationalisation of SMEs Major Challenges (support for equity capital transactions outside the norm)

Four PPRs have been launched (République Française, 2020):

- *Make our planet great again* – two project calls were published in 2017 and in 2018 in line with the 2015 agreement on climate change.
- *Interdisciplinary Institutes on Artificial Intelligence*
- PPR ‘growing and protecting crops differently’ (PPR-CPA⁴⁵)
- PPR on high performance sports

Hence, this dissertation is about the research conducted within the PPR-CPA, a programme that was launched in 2019. As discussed, Ecophyto was already implemented in 2008 with the aim to reduce the use of pesticides. With this PPR-CPA, the French government aims to reinforce research activities that support the transition to sustainable agricultural system with a reduced use of pesticides.⁴⁶ The Ministry of Higher Education, Research and Innovation and the General Secretariat for Investment launched this programme with the objective to support R&I in studying alternative solutions to eradicate the use of pesticides in France (Jacquet et al., 2019). Hence, the programme builds upon an ambitious mission: a 0-pesticides agricultural future in France by 2040. The French National Research Institute for Agriculture, Food and Environment (INRAE) is in charge of the scientific management and animation of the programme. The national research agency (ANR) manages the ‘selection, contracting and monitoring’ of the funded research projects.⁴⁷ The programme is subdivided into various activities (Jacquet et al., 2019):

- A prospective study on “an European agriculture without pesticides”;
- A call for research projects with a maximum of 6 years;⁴⁸
- A real-time assessment of the impact of the PPR will be conducted. This will consist of an assessment of the real-time ‘impact pathway’ [ASIRPA RT];
- Synthesis of scientific knowledge on pesticides and alternative practices;
- International symposia.

This means that the programme embeds a unique implementation of foresight exercises, research operations and impact analysis, while they are normally decoupled from one another. Impact assessment for instance, takes often place after the research programme has been finished. These

⁴⁵ Le Programme Prioritaire de Recherche « Cultiver et Protéger Autrement » (PPR-CPA)

⁴⁶ <http://daaf.reunion.agriculture.gouv.fr/Appel-a-projets-Cultiver-et>; accessed on 23.11.22

⁴⁷ <https://anr.fr/fr/detail/call/cultiver-et-protoger-autrement-cpa-appel-a-projets-2019/>; visited on 22.02.23

⁴⁸ Eventually, ten research projects are funded. I will elaborate on these projects in Chapter 3: the methodology

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

activities have been integrated in this programme with the aim to increase the reflexivity into the design and implementation of research and innovation towards zero pesticides.

Hence, this thesis is conducted in the context of the real-time impact assessment of the PPR-CPA, which is implemented by ASIRPA RT on both programme and project level (see General Introduction and Chapter 3 – Methodology). On project level, the focus is on impact analysis in real-time for each individual project. The aims of the activities on the programme level are also to emphasise real-time impact analysis, based on programme level visions to articulate the programme mission with the research done at the project level, to have a global overview of the visions of the projects and find synergies, to coordinate (exchange between) the projects, and to generalise the impacts generated by the projects. The implementation of ASIRPA RT was emphasised as follows by the PPR-CPA (Jacquet et al., 2019) [*translated from French*^{ix}]:

Its primary objective is to improve ongoing learning. It is complementary to foresight activities and is based on the identification of scientific results and their possible initial effects, as well as on the monitoring of changes in the programme environment. The evaluation will thus both measure the impacts of the programme and assist in its governance (p.85).

Hence, the ASIRPA RT approach is included in the programme as a means to support researchers in considering their contributions to pesticide eradication and the societal impacts that this eradication could bring.

1.3.5 Current controversies and public discussions about the reduction of pesticides use

In the light of current controversies and public discussions, this strong demand for research to contribute to the reduction of pesticides, and particularly the assessment of societal impacts of their use, is not surprising. I highlight here two recent events that help to contextualise the emphasis on societal impacts within the PPR-CPA. First, it is about the discussions that were evoked after the mid-term evaluation of Ecophyto in 2013. As I emphasised in section 1.3.3, at this mid-term evaluation it became clear that pesticides use had actually increased instead of decreased. However, the former Minister of Agriculture, Food and Forestry – Stéphane Le Foll – had initially presented a decline in pesticides use in his announcement at the annual meeting of the National Steering and Monitoring Committee (CNOS) of Ecophyto in December 2013. Stéphane Foucart (2013), a journalist of the French national newspaper 'Le Monde' explained why he accused the Minister of a false announcement of this data. The author argues that it was based on outdated data.

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

As Foucart (2013) explains, to index the use of pesticides, Le Foll used the 'Number of Dose Units' (NODU). Based on this, Le Foll indexed a decline of pesticides use in France of 5.7% between 2011 and 2012. The NODU is calculated based on the data collection by the Ministry of Agriculture on national pesticides sales. As Foucart illustrates, pesticides distributors have to declare their sales by 31 March, and the data on which Le Foll's announcement was made dates from 30 June. However, many of these sales data are not declared by the end of March, but way later. In addition, these sales numbers are allowed to be adjusted or corrected for another three years.

Instead, the journalists of Le Monde found in November 2013 an increase in the so-called diffused pollution fee (in French called: *la redevance pour pollutions diffuses - RPD*). Therefore, the author gets to the conclusion [translated from French^x]: *"It seems impossible that the NODU has decreased with an increase in the amount of pesticides used. The benchmark is therefore more likely to have increased between 2011 and 2012."*

In any case, the sales and use of pesticides had increased in the years before. As a response, already early in November 2013 – hence before the announcement of Minister Le Foll – 'politicians, scientists and leader of associations' launched the 'Montpellier Call' (Benkimoun, 2013). They stressed for a reduction or even the eradication of pesticides, to reduce the environmental and health risks caused by pesticides use. This was a response to the failed Ecophyto plan, which had up until that day not shown a decrease in the use of pesticides. The call was based on various scientific efforts, such as the 30-years inventory work of the National Institute for Health and Medical Research (INSERM) on the harmful impacts of pesticides on human health, as well as the work of INRAE on the negative impacts of pesticides on bee populations, and their work on the benefits of agroecological practices (Benkimoun, 2013).

More recently, a group of 260 scientists in France responded to the launch of the PPR-CPA in 2019. Where they acknowledge the efforts of the French Government to reduce pesticides with their ambitious zero pesticides mission, they argued that the programme lacked the work on societal impacts. A group of these scientists wrote an opinion paper in 'Le Monde', in which they critiqued the PPR-CPA, stating [translated from French^{xii}]: *"This scheme is designed to develop agronomic and technological alternatives to pesticides and then deploy them to farmers. But work on the impacts of pesticides on human and environmental health and the costs to society are excluded from the calls for projects"*.

The scientists stress for a need to calculate all societal costs of pesticides to society, the hidden as well as the more visible ones. This requires multidisciplinary and participatory responses from research according to the authors, as they emphasise [translated from French^{xiii}]: *"The analysis of the*

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

effects and impacts of pesticides must be carried out by public research, in complete independence and transparency, in the service of citizens and in the name of the common good of the preservation of nature and its ecosystems.”

These examples highlight some of the recent public debates going on in France, which stress the demand for a strong reduction in the use of pesticides as well as the need to emphasise societal impacts of (a reduction in) the use of pesticides.

Conclusion

To conclude this chapter, today, France remains one of largest consumers of pesticides in Europe. Previous concerted efforts of the French government to reduce the use of pesticides have failed, such as the Ecophyto plan that actually showed an increase in the use of pesticides in this period of time instead. By reinforcing research efforts, the French governments aims to radically reduce the pesticides use through the PPR-CPA, in which researchers are assigned to study alternative solutions to pesticides. But why did the French government focus on such a radical programme? I illustrated a socio-historical overview and evolution from the start of the use of pesticides in France, to today's thesis topic on the PPR-CPA: a research programme with an ambitious mission to eradicate pesticides by 2040.

France has a long history of pesticides use as well as with trying to control or even ban (certain substances of) pesticides. I showed this through the regulatory frameworks and (an evolution of) R&I strategies in France. Already in 1916, the Government tried to protect human health with a decree, but this was barely enforced. Throughout the 1920s, the need to prove the efficiency of pesticides remained dominant in their regulation. Not much changed in the 1930s, even though the 'Toxic Substances Commission' was created. To increase food production during and after WWII, pesticides efficiency remained key, but the launched decree in 1943 can be seen as the start the of registration system as we know today in which human health played a (minor) role too. However, the main actors involved came from the industry and the ministry of agriculture.

In the 1960s, (public) pressure increased with concerns over the impact of pesticides use on human health and the environment. However, the Ministry of Agriculture continued to 'hide' behind their 'rigorous' regulation system. This changed towards the end of the 1960s, when the Ministry of Hygiene started to get involved too in the 'Toxic Substances Commission', which implemented a new regulation system where more priority was given to health and environmental impacts. Over the years, more national and international frameworks developed for the regulation of pesticides substances. Also, research efforts on pesticides evolved over time with more emphasises on health and environmental impacts. And since the past decades we find research as part of more radical

Chapter 1. Setting the scene of the 0-pesticides mission: The Socio-historical context of 150 years of pesticide use, regulation, and research in France

programmes, such as the Ecophyto plan and the PPR-CPA. However, even today, the trade-offs between crop production levels and the negative impacts of pesticides use remain largely present.

So, pesticides use remained the dominant model of pest management in French agriculture in the 20th century, and the eradication of pesticides seems to be limited by socio-technical system lock-ins. Hence the apparent need to direct research to find alternative solutions to pesticides by actually aiming for a systems' change. In an attempt of the PPR-CPA to responsabilise the researchers, various animation activities are implemented on the programme level. The PPR-CPA aims to increase the researchers' capacity to overcome systemic lock-ins through a mix of forward looking, retrospective and real-time actions. In the next chapter, I review the literature on responsible research, and I present my conceptual framework how I studied the responsibility of the PPR-CPA researchers for the mission.

Chapter 2

Responsibility of Researchers for the O-
pesticides Mission

Chapter 2. Responsibility of Researchers for the 0-pesticides Mission

The PPR-CPA is an ambitious mission-oriented research programme, launched as a response to societal challenges, which are the result of intensive pesticides use in French agriculture. The PPR-CPA programme has included the ASIRPA RT approach as a means of accompanying the researchers to envision their contributions to the eradication of pesticides and the societal impacts that such eradication might bring (see Box 1 in the Introduction Chapter). Contributing to this societal mission requires the researchers take on responsibility to the mission through their alternative solution to pesticides. In this thesis, I explore how the ASIRPA RT approach – as a type of formative evaluation – encourages PPR-CPA researchers to assume the responsibility for contributing to the eradication of pesticides in society with the alternative solutions. Hence, it asks the researchers to (re-)envision the associations between their research projects on alternative solutions and a society without pesticides.

Throughout the thesis, I explore this through the notion of ‘responsible translation’ I developed. Responsible translation describes the process of translating visions of alternative solutions into those of a society that eradicates pesticides with these solutions. The process is based on the researchers’ visions of change of a future society without pesticides to which they aim to contribute with their research projects on alternative solutions. In other words, the researchers’ visions of societal change, and the responsibility they assume in this regard. To understand what it means for the researchers to take on responsibility in the responsible translation process of this societal mission, in this chapter I elaborate on the notion of ‘responsibility’ in research. I discuss the state-of-the-art literature on responsibility in research and innovation, and I identify the limitations of the knowledge base on responsible research to which my thesis contributes.

I highlight how to understand responsibility of researchers, the evolution of scholarly interest in this notion, and how we arrived today at two stabilised forms of knowledge in the EU’s policy and academic contexts. In particular since the end of WWII, the notion of responsibility in research has been of scholarly interest, starting first with notions of research ethics. Over time, it developed into a relational understanding of how science and society interact in complex ways and co-produce each other. Today one of the most widely known and used concepts is that of the EU’s policy approach Responsible Research and Innovation ‘RRI’, which was institutionalised in the past decade in the EU’s framework of societal challenges. However, the institutionalisation and implementation of RRI also reveals the challenges to responsabilise researchers for societal goals. For instance, a dichotomy is found between directing research to societal goals and research activities that are driven by market

dynamics. Also, efforts to responsabilise researchers are often implemented as supplement to R&I activities.

This thesis contributes to this state-of-the-art literature by arguing that we are in a new era of responsible research in which we ask researchers to contribute to ambitious societal missions. I present my conceptual framework of how I approached the responsibility of the PPR-CPA researchers for contributing to a societal mission through their research, when they participated in the ASIRPA RT activities. First of all, I mobilise the Sociology of Expectations to bring in the researchers' visions of society without pesticides. This literature teaches us that expectations are performative. However, the researchers' expectations of the contributions of the alternative solutions they study to this particular mission are not yet performative. Instead, it requires the researchers to envision the performance of the expected contributions of the alternative solutions that are being studied in the PPR-CPA to a future society without pesticides. I bring in an Actor Network Theory (ANT) perspective, to study the performance of expectations through associations in heterogeneous networks. I build upon the four-dimensional framework of Responsible Innovation (RI) by Stilgoe et al. (2013) to understand the construction of the envisioned networks.

I subdivided this chapter into two sub-chapters. In the first sub-chapter (2.1), I discuss the state-of-the-art literature on responsibility in research and innovation. In the second sub-chapter (2.2), I present my conceptual framework of how I approached the responsibility of the PPR-CPA researchers in this mission-oriented context.

2.1 The notion of responsibility in research and innovation

In this thesis, I explore the responsibility researchers take on in a French mission-oriented research programme, and particular the role of formative evaluation in this regard. In this first sub-chapter, I discuss the scholarly interest, emergence and evolvement of responsibility in research. For long, the notion of responsibility in research has been studied and debated by scholars, but this interest increased over time, specifically after WWII, in relation to research ethics. Today there are two widely used, stabilised forms of knowledge on responsibility: Responsible Research and Innovation (RRI) and Responsible Innovation (RI), which go beyond questions of ethical and moral responsibility, but highlight a relational understanding of how science and society interact in complex ways. Through three sections in this sub-chapter, I explore how we arrived today at these stabilised notions of responsibility in R&I, but also how these are still challenged in their implementation. I argue that I contribute to this literature, by analysing how ASIRPA RT – as a formative evaluation approach – supports the responsibility of the PPR-CPA researchers for the 0-pesticides mission.

In the first section (2.1.1), I highlight the evolvement of responsibility in research and technology over time. I first explore what is meant by ‘responsibility’, before I deepen what scholars have studied and discussed about the notion in the context of research, technology and innovation. In the second section (2.1.2), I discuss the emergence and development of RRI in the EU’s policy context, and RI in the academic context. This highlights how these notions of responsibility appeared as a response to strengthen associations between science and society. In the third and final section (section 2.1.3), I further deepen the implementation and institutionalisation of RRI in the EU’s H2020 framework programme. I particular focus on the challenges and barriers that are found in this regard. I finalise the sub-chapter with some concluding remarks.

2.1.1 Responsibility of Researchers

Responsibility has been of interest by classical sociologists such as Weber, Durkheim and Habermas. These scholars have mainly been occupied with ethics and moral responsibility, especially in the way individuals act. For instance, Max Weber (1946) defines the ‘ethics of responsibility’ in terms of morally correct action, i.e., s/he who acts has to take on responsibility for the consequences of this action. But, what does it mean to be or act responsible? ‘Responsibility’ is a broad term and has different meanings in different contexts. To understand these dimensions of responsibility, scholars have been building upon the work of Hart (1968). The philosopher of law framed different concepts of responsibility in the context of criminal law and politics. Take for instance the following quote from Vincent (2010),⁴⁹ which embeds different conceptual understandings of responsibility through the story of Captain Smith:

(1) Smith had always been an exceedingly responsible person, (2) and as captain of the ship he was responsible for the safety of his passengers and crew. But on his last voyage he drank himself into a stupor, (3) and he was responsible for the loss of his ship and many lives. (4) Smith’s defence attorney argued that the alcohol and his transient depression were responsible for his misconduct, (5) but the prosecution’s medical experts confirmed that he was fully responsible when he started drinking since he was not suffering from depression at that time. (6) Smith should take responsibility for his victims’ families’ losses, but his employer will probably be held responsible for them as Smith is insolvent and uninsured (p. 16).

Based on this quote and the work of Hart, Vincent (2010) distinguishes six conceptual understanding of responsibility:

1. **Virtue responsibility** refers to an actor who has a good character and has been acting in ‘right’ way, with good and dependable intentions.

⁴⁹ The original quote is extracted from Hart (1986), I took the modified version by Vincent (2010).

2. **Role responsibility** refers to duties an actor has, which can be multiple or can be conflicting duties passed on by different actors.
3. **Outcome responsibility** refers to the responsibility an actor has for the results of their actions, and might be blame for.
4. **Causal responsibility** refers to responsibility of an actor when an outcome or action is caused or conditioned by something else or another situation.
5. **Capacity responsibility** refers to the (non-)mental capacity of an actor to act in a responsible way.
6. **Liability responsibility** refers to who is hold responsible for a certain situation, and how that actor is facing the consequences to set things right.

Based on this distinguishing of responsibility by Vincent (2010), Arnaldi & Gorgoni (2016) conceptualise the notion of 'responsibilisation'. As the authors argue, the six concepts of responsibility show two particular dimensions: 1) active and passive forms of responsibility and 2) retrospective and prospective forms. First, the active form is about the assumption of responsibility by an actor, while the passive form is about an actor who is being held responsible. The second forms refer to a temporal element of responsibility. The retrospective form is about the past, and largely related to passive responsibility, through *ex post* analysis or 'backward-looking'. In contrast, the prospective form is about the future, it is more related to active responsibility through *ex ante* analysis or 'forward-looking'. The authors emphasise about this active prospective responsibility:

Prospective Responsibility is forward-looking, future-oriented, and essentially linked to the dimensions of assumption and exercise of responsibility, connected with the ideas of performing roles and tasks both by complying with the duties associated to them, but also going beyond what is mandated and when the contents of duties and tasks cannot be established in advance (p. 6).

It is through this active understanding of prospective responsibility that Arnaldi & Gorgoni (2016) define 'responsibilisation' as follows:

That is actors' capacity of self-commitment towards some goals which are not mandated by rules (legal or of other sort). This is an eminently ethical feature, both at the individual and at the organisational level. "Responsibilisation – namely expecting and assuming the reflexive moral capacities of various social actors – is the practical link that connects the ideal-typical scheme of governance to actual practices on the ground (p.6).

The authors perceive responsibilisation as a 'governance strategy', for actors to assume 'ex-ante responsibility for their action'. This requires that actors are aware of their responsibilisation (Dorbeck-Jung & Shelley-Egan, 2013) and that they voluntarily assume responsibilities and perform those (Arnaldi & Gorgoni, 2016). Hence, strategies for responsibilisation aim at the ex-ante

assumption of responsibility by actors in their commitment to societal goals (Dorbeck-Jung & Shelley-Egan, 2013; Arnaldi & Gorgoni, 2016). While this literature provides a good understanding of the notion of responsibility, in this thesis I further explore how to apply this in a mission-oriented context as well as the role of formative evaluation to support the assumption of responsibility by researchers.

Evolving paradigms of responsibility in science and technology

Science, very since it first existed, has had important effects in matters that lie outside the purview of pure science. Men of science have differed as to their responsibility for such effects. Some have said that the function of the scientist in society is to supply knowledge, and that the need not concern himself with the use to which this knowledge is put. I do not think that this view is tenable, especially in our age. The scientist is also a citizen; and citizens who have any special skills have a public duty to see, as far as they can, that their skill is utilised in accordance with the public interest. Historically, the functions of the scientist in public life have generally been recognised.

(Russell 1960, p.1)

As the quote above shows, responsibility of researchers for impacting society has already for long been a topic of discussion by sociologists. As Douglas (2003) argues, we expect researchers to be 'generally capable moral agents'. However, as the author argues, the moral responsibility of researchers relates to their professional context: *"There are two general bases for moral responsibilities in modern life: there are the general moral responsibilities that each of us holds as humans/full moral agents and there are the role responsibilities that arise from our taking on particular positions in society"* (p.60). Since science is important and valuable for society, the question is about what is expected from researchers in their role as scientists? Some general expectations in the scientific sphere are, for instance: the honest reporting of results, sharing outcomes, considering results or evidence of other – maybe conflicting – research(ers), and following standards of scientific research.

The grand issue Douglas points to is whether role responsibilities can exceed general responsibilities researchers have as human beings. The Free of Science movement in the 1940s would argue not, as researchers should be free to produce knowledge. But, as Douglas argues in contrast, what if that knowledge negatively impacts society? She argues: *"Contrary to the traditional view, role responsibilities do not, and cannot, trump the general responsibilities scientists have as human moral agents"* (p.60). As I highlight in this section, such reflections on the ethics of research have been of interest in academia for decades.

After WWII, particularly from the 1960s onwards, the scholarly interest in the notion of responsibility in research grew significantly. This rise is seen as a consequence of the use of the atomic

bomb at the end of WWII, and the questioning of research ethics and moral responsibility in this regard (Strydom, 1999; Douglas, 2003; Temri, 2008). According to Strydom (1999) *“the sociological interest in responsibility received a boost from the crisis of conscience experienced by physicists, chemists, biologists and sociologists due to the bombing of Japan, the proliferation of chemical and biological weapons, and the exposure of Project Camelot respectively”* (p.65). Over time the understanding of responsibility evolved in line with changing societal challenges such as increasing negative impact of human on the planet, the arrival of ‘new social movements’ and public opinions in this regard, and rising discussions around risk societies (Strydom, 1999).

Based on the work of Ewald (1993), Arnaldi & Gorgoni (2016) distinguish three paradigms of responsibility, which highlights how the notion evolved over time. First, the authors describe the ‘paradigm of fault’, which refers to ‘faulty causation’ of an actor. It is about a ‘traditional’ understanding of ethical, moral and/or legal responsibility and embeds a form of liability. Second, the ‘paradigm of risk’ is largely linked to technology-society, going beyond an individual level of responsibility. It disconnects ‘responsibility from those of action, author and fault’, but is rather about anticipating the negative consequences of science and technology through risk management. Third, the ‘paradigm of safety’ is based on ‘precaution’. The authors argue: *“This development was consequent to the perceived inadequacy of the two previous paradigms to cope with the problems set by the evolution of science and technology, as they both presuppose either an identifiable author (fault) or some reliable data (risk) to assign responsibilities”* (p.8). Precaution does not focus on liability (paradigm of fault) or risk management (paradigm of risk), but rather about responsibility of actors in this regard.

Eventually, as I will illustrate in this chapter, the notion of responsibility developed from ethics into more complex understandings of how science and society cannot be considered independent from one another, but rather interact and co-produce each other.

Moral and ethical responsibility of researchers

The philosophers Hans Jonas and Karl-Otto Apel are considered as two of the main founders of ethics in science and technology. In ‘The Imperative of Responsibility – In Search of an Ethics for the Technological Age’, Jonas (1984) analyses (emerging) technology and the impacts on society. He emphasises how technology and society are interwoven and cannot be considered in separation. Similarly, Apel (1973), in ‘The Apriori of the Communication Community and the Foundations of Ethics: The Problem of a Rational Foundation of Ethics in the Scientific Age’ emphasises the consequences of technology in society and the responsibility for ‘global problems’, particularly through theory of communication. In his analysis of the work of both Apel and Jonas, Strydom (1999) argues:

Both authors start from the thesis that the promise of modern science-based technology gave rise to a completely new and unprecedented situation when it turned into its opposite: a threat and danger or risk not only to nature and hence human survival, but even to the very nature of human beings. [...] Both authors agree, secondly, that the universal, global and irreversible features of the new situation confront humankind today with a moral challenge that requires a novel ethics of responsibility (p.66).

Hence, both philosophers reflect on technological societies, and thereby the impact of science and technology on human beings. As Strydom outlines, their focus on ethical responsibility emphasises a link between risk and responsibility in two ways. First, the focus on the impacts or consequences of technology on society are perceived from the point of view of 'risk'. Assumption of responsibility to be considered in this regard is about the potential negative consequences of technology on society, such as the situation with chemical weapons. Second, they consider the impacts of science and technology on a macro-level of society. Karl-Otto Apel (1987) for instance talks about 'macroethics of responsibility', in his thesis on 'The Problem of a Macroethic of Responsibility to the Future in the Crisis of Technological Civilisation'. Strydom argues in this regard:

What they achieved, in the first instance, was to demonstrate that a shift has occurred from the traditional emphasis on individual responsibility, which sociologists like Durkheim, Weber, Parsons and even Habermas took for granted, to a new conception of collective or co-responsibility. Secondly, Jonas and Apel in effect established a link between "risk" and "responsibility", and thus gave expression to a conceptual pair which plays a key role in the societal semantics of our time (p.66).

Strydom discusses the emergence of the concept of co-responsibility, relevant for contemporary society. Rather than what Jonas calls 'collective responsibility', Strydom builds upon Apel's 'co-responsibility', which is centred around communication and discourse. Strydom illustrates that co-responsibility is about the assumption of responsibility by a community of humans who are concerned by a certain risk and asked for support, to "equally bear co-responsibility for the observed consequences and side-effects of collective activity" (p.68).

Hence, ethical or moral responsibility refers largely to the assumption of responsibility to avoid negative consequences of the implementation of science and technology in society (Arnaldi & Gorgoni, 2016). In this regard, Douglas (2003) emphasises the moral responsibility of science, by questioning 'the tensions between autonomy and responsibility'. The author argues that scientists have the moral responsibility to consider the positive and negative societal impacts or consequences of their research. She finds the idea that scientists should be developing knowledge about the world has been for long an argument why scientists should not have to 'worry' about impacts in society untrue. Instead, Douglas argues that the responsibilities of researchers should be structured around

their role to 'find the truth' as she questions "*whether this responsibility, this goal, obliterates other responsibilities scientists have as human beings and capable moral agents*" (p.63).

The author provides two reasons. First, the creation of knowledge and exploring the truth about the world we live in does not exceed other values that society holds. Second, the societal consequences of science and technology go beyond the implementation of scientific knowledge. Douglas argues: "*Outsiders to science cannot control a piece of research's epistemic and ethical impact after the research is complete*" (p.64). While the implementation of technology might be controllable by other actors, this does not count for scientific knowledge. The author concludes:

While the search for truth is not a transcendent good, it still is a good. When considering both intended and unintended consequences of one's work, the development of knowledge is an important and worthy goal for scientists but it must be weighed against other goods, including basic human rights, quality (p.66).

Today, in the mission-oriented context of the PPR-CPA, we are in another situation of responsibility. The researchers are not asked to consider the societal impacts of their research in this way of ethical responsibility. Instead, they are supported to reflect on more complex understandings of how science and society interact, and their research projects are funded to contribute to solving a problem in society caused by another actors (pesticides). It is about a notion of responsibility that goes beyond ethical and moral responsibility, but about the responsibility of contributing to a mission.

Frameworks for responsibility in science and technology

As over time the question of responsibility in science and technology became more pressing, particularly for the negative consequences of its implementation in society, frameworks and approaches appeared to deal with this. We can especially mark the current period, in which society is facing major challenges caused by human impacts, by a new era of responsibility where researchers are required to rethink the relations between their research and society in mission-oriented contexts. This means that the notion of responsibility developed, and got implemented, into more complex understandings of interactions between science and society. Two well-known and stabilised discourses of responsibility in R&I today are the Responsible Research and Innovation (RRI) approach and Responsible Innovation (RI). Even though they largely emerged in the 2010s in different contexts – RRI in the European Union's (EU)⁵⁰ policy context and RI in the academic context – they both aim at coupling R&I activities with societal challenges. There is no consensus on a clear distinction between both notions and are often used interchangeably (Jakobsen et al., 2019).

⁵⁰ Randles et al., (Forthcoming) argue that responsible research and innovation was also an academic term – before it emerged in the policy context of the European Commission.

Particular through RRI as a policy approach, the EU demonstrates its efforts to better align research to societal challenges. Its emergence follows a period of controversy in the early 2000s around genetic engineering and mad cow disease, where citizens placed pressure on public policy and scientists to become more responsive to societal needs and interests. However, RRI was institutionalised in the EU only in the H2020 framework program, which also introduced funding calls in response to seven domains of societal challenges. The development of RRI and RI in their political and academic context is based on decades of research, discourses and approaches, which discuss the relations between science, technology and society. I will discuss three main foundations: 1) Technology Assessment (e.g., Zwart et al., 2014; van Lente et al., 2017); 2) The ELSA or ELSI programme of emerging science and technology (e.g., Chadwick & Zwart, 2013); and 3) Anticipation governance of emerging technologies (e.g., Barben et al., 2008; Owen, Pansera, et al., 2021).

First, Technology Assessment (TA) dates from the 1960s, particularly in the USA. It focusses on the implication of (emerging) technologies and the assessment of the consequences for society (Banta, 2009). Initially, it was mainly implemented for policy makers 'to compensate or prevent anticipated negative impacts of technology', and still today it is used for decision making around technologies (Grunwald, 2011). Also in Europe, it became a dominant approach in the governance of science and technology, particularly before the 1990s (Zwart et al., 2014). However, this assessment was often conducted by (engineering) experts in science and technology. As Zwart et al. (2014) argue:

It pretended to be neutral, but nonetheless seemed to convey an instrumentalist vision on both society and technology, seeing technologies as tools that could enable us to solve certain problems, depending on the circumstances. Gradually, the idea emerged that the concept of expertise should be broadened and that societal expertise (represented by future users) should be involved in this process (p.7).

In addition, according to Guston & Sarewitz (2002) the initial TA "was limited to advising society, or certain segments thereof, about how best to respond to the consequences of developing technologies and technological systems" (p.96). Hence, over the years, this field has evolved towards, for example, Real-Time TA and constructive TA (CTA) (e.g., Schot & Rip, 1997; Guston & Sarewitz, 2002; Hellström, 2003; Stilgoe et al., 2013; Bauer et al., 2021; Shanley, 2021). For instance, instead of focussing on the assessment of science and technology, CTA concentrates larger on technology 'design, development, and implementation' by integrating and co-evolving with a larger set of actors (Schot & Rip, 1997). In addition, real-time TA aims to "anticipate how research and research-based technologies will interact with social systems"(pp.94-95) (Guston & Sarewitz, 2002). Since initial TA was considered rather technology-centred, as a response, other efforts developed as well, such as the ELSA/ELSI approach (Zwart et al., 2014).

Hence, second, ELSI (USA) or ELSA (Europe) stands for Ethical, Legal and Social Aspects/Implications of emerging science and technology, and has its roots in the human genome projects. ELSA and ELSI are ethical programmes to support the anticipation of the societal implications of emerging science and technologies, and are largely implemented in the field of biotechnology and nanotechnology (Chadwick & Zwart, 2013). ELSI was developed by the federal government of the USA in 1988, and official launched in 1990, as an ethical policy tool to anticipate negative consequence of biotech research (Fisher, 2005). ELSA appeared in 1994 in the EU's fourth Framework Programme as a label 'to frame societal issues and to finance research, stakeholder dialogues, education and other activities to address them'. The programme was largely implemented in the EU between 2002-2012 (Zwart et al., 2014). However, both programmes are also criticised. ELSI got assessed as being an inefficient policy tool (Fisher, 2005). In addition, according to Forsberg (2014), research funded within the ELSA programme – natural science research – was conducted in isolation from for instance industries, and implemented as an 'add-on' to research.

Third, anticipatory governance of emerging technologies (mainly nanotechnology) (Barben et al., 2008; Stilgoe et al., 2013; Owen, Pansera, et al., 2021) is a field that distinguishes itself from previous fields, mainly ELSI, as it is characterised by 'forward-looking, engagement-oriented, and results-seeking' research (Barben et al., 2008). Anticipatory governance is defined as *"a broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible"* (Guston, 2008, 2014). Barben et al. (2008) emphasise that anticipatory governance *"comprises the ability of a variety of lay and expert stakeholders [...], to collectively imagine, critique, and thereby shape the issues presented by technologies before they become reified in particular ways"* (pp. 992-993). The authors provide three components of anticipatory governance: foresight, engagement, and integration.

While RI and RRI are considered rather complementary to anticipatory governance (Conley, 2020), they are responses to shortcomings in TA and ELSA. van Lente et al. (2017) provide two roles that RRI addresses and are found rather lacking in TA; Namely, the 'role of normativity' and 'the role of stakeholders'. The authors stress the 'orientational failure' of TA, while RRI – through its institutionalisation in the framework of grand societal challenges – *"could be interpreted as an urge to include normative concerns about the societal goals of innovation"* (p.260). In addition, according to Grunwald (2011), RRI embeds stronger 'ethical reflection'. In contrast to ELSA, RRI gives greater prominence to 'socio-economic benefits' as well as collaboration with other societal actors, in particular with private and industrial partners (Zwart et al., 2014).

In this section, I have explained how notions of responsibility in research and technology have evolved over time from questions around research ethics and moral responsibility, to more complex questions of how science and society interact through the notions of RI and RRI (in the following section, I elaborate on the more detailed emergence and development of both notions). However, as I argue, today we are in a new era of responsibility, which requires researchers to rethink the relations between their research and society in mission-oriented contexts. It is no more about the negative consequence of research and technology on society, but instead, it is about actively contributing to complex socio-technical system changes, which the mission represents. How to navigate research activities in that direction is understudied.

2.1.2 Emergence and development of RRI and RI: responding to societal challenges

While both discourses of RI and RRI are building upon decades of research about the relations between science and society, both established as stabilised ‘notions of responsibility’ in the early 2010s in the academic and EU R&I policy contexts. Even though RRI and RI are connected and often not differentiated in the literature, they do represent different discourses, different levels of intervention, and emerged in different contexts (Stilgoe et al., 2013; Owen & Pansera, 2019; Wiarda et al., 2021). The study by Wiarda et al. (2021), who conducted a RRI ‘Reference Publication Year Spectroscopy’ (RPYS), highlighted that it was Robinson (2009) who used both terms for the first time in the same article. The author aimed to capture *“the notions of responsible development, responsible innovation and including the notion that this umbrella term covers research, product development and embedment”* (p.1223).

The notion of RRI emerged in the EU’s policy context through the framework programmes, and represents a ‘science policy framework’ (e.g., Owen and Pansera 2019; Owen, von Schomberg, and Macnaghten 2021). In contrast, RI emerged in the academic context, and represented a more scientific concept. In their review of both approaches, Owen and Pansera (2019) argued:

‘Responsible Innovation’ (hereafter RI) and ‘Responsible Research and Innovation’ (hereafter RRI) are two linked discourses that have emerged in parallel over the last decade which challenge the epistemological norms and practices concerning the production and valorisation of scientific knowledge. [...] Both discourses ‘sediment over’ (Randles, 2017)⁵¹ and at times variously intersect with, reinforce or challenge existing de facto narratives and norms of responsibility as these relate to scientific research, development and innovation (e.g., those relating to academic conduct and research integrity) (p.26).

⁵¹ The authors refer to: Randles, S. (2017). Deepening ‘Deep Institutionalisation’. JERRI Deliverable 2.1.

Hence, despite their different contexts in which they emerged, RRI and RI both aim for coupling R&I activities with societal challenges. In 2011, Von Schomberg⁵² gave the following definition of RRI in a report he edited for the EC:

Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society).

Embedded in a policy context, this definition is still widely used today to describe RRI (Owen, von Schomberg, et al., 2021). Stilgoe, Owen, and Macnaghten (2013) provided a definition of RI, which emerged in the academic context. While it is building upon the definition of RRI from Schomberg, it is defined in a broader way emphasising the future context of societal challenges: *“Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present”* (p.1570).

In the past decade, there has been numerous discussions going on and literature published on the concepts, emergence and definitions of RI and RRI (e.g., Stilgoe et al., 2013; Rip, 2014, 2016; de Saille, 2015; Owen & Pansera, 2019; Robinson et al., 2020; Shanley, 2021; Randles et al., 2022). Particular RRI, as a policy concept, has been criticised for the lack of a clear and broadly accepted definition yet (e.g., Salles et al., 2018; Fraaije & Flipse, 2019; Griessler et al., 2023). Recently, we see various literatures emerging that describe, for instance, the historical processes around the development of R(R)I and its evolution over time (Rip, 2014; Shelley-Egan et al., 2018; Owen & Pansera, 2019; Owen, von Schomberg, et al., 2021; Shanley, 2021; Randles et al., 2022). As the bodies of literature are rather large, mapping exercises have been conducted both on academic literature as well as on policy documents (e.g., de Saille, 2015; Timmermans, 2017; Wiarda et al., 2021) and also criticisms and challenges are largely discussed (e.g., Blok & Lemmens, 2015; de Hoop et al., 2016; Tabarés et al., 2022; Griessler et al., 2023).

How RRI emerged as a policy approach in the EU: science-society relations

The appearance of RRI in the EU policy context dates back to 2011, with the definition provided by Von Schomberg (2011) (see earlier this page). Even though reflections on the associations between science and society have been going on for decades, the preliminary emergence of RRI in the EU is traced back to early 21st century. According to Owen, von Schomberg, et al. (2021), it was in the period of the fifth Framework Programme (FP5 1998-2002) when the European Commission (EC)

⁵² René vom Schomberg was the Directorate General for Research and Innovation at that time

published a white paper highlighting concerns about the disintegrating relationship of 'democratic institutions with European citizens'. The authors emphasised:

Citizens were increasingly distrustful of institutions, expertise and politics, or simply not interested in them at all. This included the institution of science. Reeling from scientific crises that included BSE, foot and mouth disease, dioxins in poultry and GM, this was an issue the EC felt it had to address (p.218).

Hence, in that period, society was facing crises and public trust in science declined. As a response, the EC urged for higher involvement of citizens in science (Owen, von Schomberg, et al., 2021). In addition, R&I activities needed to better respond to challenges in society (Owen et al., 2012). And thus, it highlights a demand for R&I to rethink associations between science and society. In 2012, Owen et al. published a paper in which they described 'three emergent features of RRI discourse at an EU policy level' that highlights this rethinking about the roles of science and society in R&I processes:

1. **Science for society:** R&I to respond to societal challenges
2. **Science with society:** R&I to be responsive to society (e.g., to set direction)
3. **Reframing responsibility:** rethinking responsibilities and roles by other actors (e.g., funders, policy makers, innovators)

Such reflections about science-society associations also became visible throughout the development of the EU framework programmes for R&I FP6 (2002-2006), FP7 (2007-2013) and FP8 (H2020: 2014-2020). These three FP umbrellas, showed an evolution of a specific call about science-society relations from 'Science and Society', through 'Science in Society', to 'Science with and for Society'. To start, FP6 included a call titled 'Science and Society' (SAS),⁵³ with the objective of better connecting science and actors in society. The call was set up around three axes, of which the second axe was 'Responsible research and application of science and technology', which was defined as follows:⁵³

The aim is to ensure that rapidly advancing progress in science is in harmony with the ethical values of all Europeans. Activities will promote "responsible research" in Europe, in which the requirements for investigative freedom are better reconciled with social and environmental responsibilities in the development and application of science and technology.

⁵³ <https://cordis.europa.eu/programme/id/FP6-SOCIETY>; Visited 14.10.22

In the following FP7, this call evolved from SaS to ‘Science in Society’ (SIS). The benefit of research to citizens, industries and SMEs was specified, as well as a particular attention to science-policy dialogues was given. The programme’s objective was defined as follows:⁵⁴

‘Science in Society’ aims to bridge the gap between science professionals and those without a formal science education and to promote a taste for scientific culture in the public at large. Some of the initiatives, therefore, are aimed at triggering the curiosity of young people for science and at reinforcing science education at all levels.

In the same period as the SiS program, the ‘Lund declaration’ came out of a conference on R&I in Lund in 2009. This declaration states the priorities for R&I in the EU and its member countries in responding to grand challenges society is facing⁵⁵: *“The European Knowledge Society must tackle these through the best analysis, powerful actions and increased resources. Challenges must turn into sustainable solutions in areas such as global warming, tightening supplies of energy, water and food, ageing societies, public health, pandemics and security”.*

Hence, this period was characterised by demands to bridge the gap between science and society. In particular, R&I was called for its role and responsibility to contribute in overcoming societal challenges. Despite these efforts and demands, RRI did not get institutionalised until the H2020 framework programme (FP8). It was in this FP that RRI became the overarching framework for implementing R&I programmes. Specific RRI actions were demanded in a call which now evolved to ‘Science with and for Society’ (SWaFS), which aimed to⁵⁶: *“build effective cooperation between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility”.*

As for the SWaFS call, H2020 introduced funding calls in response to seven domains of societal challenges. According to Owen, von Schomberg, et al. (2021) : *“Horizon 2020 had an ambition to bring private, public and civil society stakeholders together to address grand challenges through research and innovation” (p.221).* As the authors argue, projects in the FP7 SaS call largely focussed on the connection between ‘science’ and ‘society’- particularly emphasising research. Therefore, ‘innovation’ was brought into ‘RRI’. In this context, at the EU’s Competitiveness Council meeting in 2014, RRI was characterised as follows⁵⁷:

⁵⁴ <https://cordis.europa.eu/programme/id/FP7-SIS>; Visited 14.10.22

⁵⁵ <https://cordis.europa.eu/article/id/31013-swedish-presidency-research-must-focus-on-grand-challenges>; Visited 14.10.22

⁵⁶ European Commission, European Research Executive Agency, Opening science up to society, Publications Office, 2021; Accessed 17.11.22

⁵⁷ <https://www.horizon-europe.gouv.fr/social-innovations-enablers-security-solutions-and-increased-security-perception-25775#r1>; Accessed 17.11. 22

Responsible Research and Innovation is a process for better aligning research and innovation with the values, needs and expectations of society. It implies close cooperation between all stakeholders in various strands comprising: science education, definition of research agendas, access to research results and the application of new knowledge in full compliance with gender and ethics considerations.

In the third work programme of H2020 (2018-2020), the SWaFS call started to specifically focus on ‘open science’. Carlos Moedas, commissioner at DG Research and Innovation since 2015, identified three priorities in this regard – known as the 3Os: Open Innovation, Open Science and Open to the world (Owen, von Schomberg, et al., 2021). As described in the SWaFS call 2018-2020:⁵⁸ “Asymmetries still exist in the ability of individuals to interact with and access science, creating inequalities in scientific and innovation outcomes and an ever more pressing need to promote responsible research and innovation”. The 3Os are expected to emphasise and promote RRI actions by actively engaging citizens (citizens science) and other actors (multi-stakeholder approaches) through various activities.

This process highlights how the EU, through the R&I framework programmes, has put a conscious effort towards responsibility in R&I efforts in the past decade. In particular, it highlights the EU’s expectations of research to contribute in tackling societal challenges, as well as to engage societal actors in R&I processes.

How RI emerged as an academic field: aligning science, innovation and society

RI emerged in parallel to RRI, but in an academic context. According to Rip (2016) this body of literature discusses responsible R&I at ‘the level of research performing and research funding organisations’. RI emerged in scientific literature around the same time as RRI, in the 2010s, but is based on decades of scientific discussions on the relation between science, technology and society and the responsibility of research in this regard – as elaborated in section 2.1.1 (Genus & Stirling, 2018; Owen & Pansera, 2019; Owen, Pansera, et al., 2021). The widely used definition is provided by Stilgoe et al. (2013), who defined RI as “*taking care of the future through collective stewardship of science and innovation in the present*” (p.1570). These authors developed a four-dimensional framework for RI: 1) Anticipation; 2) Reflexivity; 3) Inclusion; 4) responsiveness. I will further discuss these dimensions in my conceptual framework in the next sub-chapter 2.2.

It is notable that in contrast to RRI, RI does not contain the term ‘research’ in its notion. Owen & Pansera (2019) argue that this represents a response to the large historical focus on science and emerging technologies. Emphasising innovation in this notion should better align the links between

⁵⁸ https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-swfs_en.pdf; Accessed on 03.11.22

science, innovation and society (Owen & Pansera, 2019; Robinson et al., 2020). According to Owen & Pansera (2019), ‘innovation’ has been rather neglected in literature, as the authors argue:

It [red. RI], like RRI, has been largely preoccupied with (techno-visionary) science and emerging technologies, rather than innovation per se, and notably innovation involving the corporate sector. Like RRI, its intersections with innovation systems remain little explored and, associated with this, how roles and responsibilities of actors should be (re)defined and how knowledge flows and institutions should be (re)configured (p.27).

As the RI-literature emphasises - which is also central in its definition - ‘responsibility’ is strongly future oriented (Stilgoe et al., 2013; Owen & Pansera, 2019). According to Owen & Pansera (2019):

[...] innovation (and techno-visionary research leading to or aimed at this) always sits in a historical context. But it is its power to create and transform futures. [...] Acknowledging the power of innovation to create futures – and associated with these uncertainties and vulnerabilities – RI asks how we can and should meaningfully engage as a society with the futures innovation seeks to create, futures that are being created unintentionally or by design (p.28).

RI, in responding to societal challenges, aims to couple science, society and innovation, by rethinking roles and responsibilities of research, innovation and societal actors in contributions to envisioned futures.

The implementation of RRI

It has been over a decade since the emergence of RRI in EU policy context. But, how has it been implemented in R&I processes this past decade? Organised under the Italian presidency of the EU, in 2014 the ‘Rome Declaration’ resulted from the conference on ‘Science, Innovation and Society – achieving Responsible Research and Innovation’. The aim of the declaration was to encourage the implementation of RRI in European funding and research institutes. This declaration defined six keys to implement RRI in R&I activities: Engagement; Gender; Ethics; Science Education; Open Access and Governance. These six keys became a ‘synonym for RRI’ and got in this way institutionalised in the EC (Rip, 2016; Owen, von Schomberg, et al., 2021). However, the keys also caused ample debates among scholars. For instance, according to Rip (2016): *“The sixth key, ‘governance’ – a central concept for RRI in the scholarly literature, as well in some of the EU-funded projects – was deleted, reportedly because it was difficult to apply in the work programmes of Horizon 2020” (p.295).*

However, these discussions did not just focus on the RRI keys. In general, the concept and definition of RRI was not considered clear nor was it clear to many how to implement or approach it (Salles et al., 2018; Fraaije & Flipse, 2019). Significant conceptual and empirical research has been

done to better define RRI (Stahl et al., 2021). Such work is notably commissioned by the EC itself, not only for its conceptualisation, but also towards the implementation and governance of RRI. To start, the EU Expert group on Policy Indicators for RRI looked into the definition of RRI in both EU policy reports as well as in scientific literature. This expert group did not find consensus on “*what RRI exactly entails, nor about how to measure its impact*” (p.5) (Roger et al., 2015). Therefore, in 2015, they published an expert report named ‘Indicators for promoting and monitoring Responsible Research and Innovation’, in which they presented indicators for the implementation of RRI, which are based on the six keys (Roger et al., 2015). This is an example from an expert group within the EU, but over the years, the EC funded a variety of projects to support the implementation of RRI in R&I activities.

Frameworks for implementing and governing RRI

Especially in its early years – under the FP7 SiS programme - the EU initially funded four projects to develop frameworks for the implementation and governance of RRI. First, the EU funded the RES-AGORA⁵⁹ project, which aimed at developing a framework for the governance of RRI. Randles et al. (2016) developed six *de facto* narrative frameworks for governing responsible R&I activities. These six narratives are: A) Republic of Science (‘science should comply with certain guarantees, such as publicity, ethics, fraud’); B) Technological Progress: Weighing Risks and Harms as well as Benefits of New and Emerging Technologies; C) Participation Society; D) The Citizen Firm; E) Moral globalisation; F) Research and innovation with/for society. They developed a responsibility navigator based on 10 principles.⁶⁰ Second, the ‘GREAT’⁶¹ project explored RRI governance processes to inform policy makers on the implementation of RRI in R&I activities. Both these projects were funded from the same RIA call. The other two projects were CSA projects. The RESPONSIBILITY project developed a model and tool to mainstream the implementation of RRI by different stakeholders and thereby to support cooperation. Fourth, the ProGreSS project studied governance and funding models of implemented RRI on an international level. They connected international networks on RRI with European partners.

Following these four projects, within the FP7 SiS call also other projects were funded. For instance, the EU funded the RRI-Tools⁶² project which aimed at supporting ‘Training and Dissemination’ of RRI. They provide toolkits and trainings on the implementation of RRI for a variety of stakeholders. Other projects focus on RRI in specific scientific domains. However, the expert report that I mentioned above on indicators for implementing RRI was commissioned before these research

⁵⁹ <https://cordis.europa.eu/project/id/321427/reporting>; accessed on 21.10.22

⁶⁰ <http://responsibility-navigator.eu/navigator/>

⁶¹ <https://www.great-project.eu/>; accessed 21.10.22

⁶² <https://rri-tools.eu/>; accessed on 21.10.22

projects were completed. The result was that this report was based on the six keys, and not on the more complete, complex and evidence-based governance proposals of the projects.

Hence, these projects funded under the SiS programme aimed at developing frameworks for implementing and governing RRI. More recent through the H2020 program, in which RRI was institutionalised, various projects were funded to support the (further) implementation and monitoring of RRI in R&I activities. To provide a few examples, the RRI-practice⁶³ project studied 'barriers and drivers to the successful implementation of RRI'. The JERRI⁶⁴ project aimed to support 'RRI transitions', particularly by exploring RRI practices, and by asking partners to experiment with implementing RRI practices. The project NewHoRRizon⁶⁵ was funded with the objective to further integrate 'RRI in the research and innovation systems on national and international levels'. And, the MoRRI⁶⁶ project - and its successor project SUPER MoRRI - aims at 'Monitoring the evolution and benefits of Responsible Research and Innovation'. While Horizon Europe has only recently started, a group of RRI scholars and practitioners created a group for 'supporting the visibility and operationalisation of RRI in "Horizon Europe"'. This initiative is called 'RRI in Horizon Europe'⁶⁷, but it should be noted that this is not commissioned nor funded by the EU.

Similarly in the academic context, conceptual frameworks appeared, notably to contribute to developing collective meaning and definitions of RRI (Fraaije & Flipse, 2019). A widely used one is the 4-dimensional framework of RI by Stilgoe et al. (2013): Anticipation, Reflexivity, Inclusion and Responsiveness. This framework is developed with the aim for R&I processes to respond to societal challenges. Over the years, this framework has been taken up, discussed and adapted to specific contexts. For instance, in the process of the EPSRC in the UK to institutionalise RRI, they adapted it in their 'AREA' framework: Anticipate, Reflect, Engage, Act (Owen, Pansera, et al., 2021). In turn, de Saille (2022) found that this AREA-framework was missing aspects of the 6 keys on RRI from the EU. Therefore, the authors advanced the concept to 'ARIA in 6 keys', whereby the 'I' represents 'Inclusion'.

Other types of frameworks also appeared in literature, with the aim to clearer define and implement RRI. To provide a few examples, Fraaije & Flipse (2019) developed a framework based on RRI qualifiers. They developed this framework based on the analyses of RRI policy documents, EU projects proposals and scientific literature, as 'a means of shifting RRI from concept to practice'. In addition, Pacifico Silva et al. (2018) developed a framework that is specifically adapted to RRI in health

⁶³ <https://www.rri-practice.eu/>; accessed 21.10.22

⁶⁴ <https://www.jerri-project.eu/jerri/index.php>; accessed 02.02.22

⁶⁵ <https://newhorizon.eu/our-aim/>; accessed 21.10.22

⁶⁶ <https://super-morri.eu/morri-2014-2018/>; accessed on 02.11.22

⁶⁷ <https://rri-in-horizon-europe.net/about/>; accessed 21.10.22

systems around five domains: population health, health system, economic, organisational and environmental.

To conclude, in this section I shed light on the emergence of two stabilised notions of responsibility in R&I in two different contexts: RRI and RI. In particular I discussed the development of RRI as a policy approach in the EU. I illustrated how the notion of RRI was institutionalised in the EU, through an evolution in the calls under the FP6-8 from SaS, to SiS, to SWaFS, and eventually including the 3Os framework. This indicates that science and society associations are not clear: i.e., is it research with, within, in or for society? If RRI aims for R&I activities to respond to societal challenges – such as the 0-pesticides mission – the understanding of science-society associations are key.

In addition, a collective framework and definition of RRI is still missing, as Stahl et al. (2021) stressed: *“the discussion of both the definition and the operationalisation of RRI is still open”* (p.176). Hence, so far it seems that no consensus is found on the meaning of RRI. If responsible research should be aimed at contributing to societal challenges or missions, it requires a better understanding and re-definition of the science-society associations this represents. In addition, the notion of RI, does not embed the term ‘research’, as to emphasise on innovation. Previous efforts have largely focussed on science and emerging technologies (such as nanotechnology) and less on innovation. By emphasising innovation, the aim of RI is to reinforce the alignment between science, innovation and society. This highlights an ongoing debate about coupling science, innovation and society which requires further study, particularly in the context of societal missions.

2.1.3 The implementation and institutionalisation of RRI: Challenges and barriers

Despite these (funding) efforts of the EC, recent literature on RRI highlights its limitations in the operationalisation, implementation and institutionalisation as R&I policy approach (e.g., Novitzky et al., 2020; Stahl et al., 2021; Tabarés et al., 2022; Griessler et al., 2023). For instance, particular in the case of the uptake of RRI in the EU, Tabarés et al. (2022) emphasised the limitations in the implementation, institutionalisation, consistency, diffusion and irregular adoption of RRI principles. Griessler et al. (2023) argued that RRI is a fragile policy concept:

By fragility we mean that the actors championing RRI were not able to stabilise and sustain over the period of the 8th Framework Programme, Horizon 2020, (1) a clear and accepted definition of RRI, (2) the legal foundation necessary to fund a separate RRI programme, formerly called “Science with and for Society” (SwafS), as well as (3) the financial and (4) institutional resources they were able to secure in Horizon 2020 (p.16).

So, what caused these limitations in RRI? To understand this, I mobilise recent scientific literature which discusses the implementation and institutionalisation of RRI in (national) funding and

research agencies, and the lessons learned in this regard (e.g., Forsberg et al., 2018; Owen, Pansera, et al., 2021; Stahl et al., 2021; Dabars & Dwyer, 2022; Fuenfschilling et al., 2022). However, before I deepen the challenges and barriers, I first focus on the experiences of the implementation and institutionalisation of RRI principles and the analysis in this regard.

The empirical literature on the implementation and institutionalisation of RRI highlights the variety of programmes, funding agencies and research institutes and universities that are taking up RRI principles and action. I provide some examples that highlight the diverse levels of implementation, for which I identified three main streams: 1) the EU level; 2) the level of funding agencies, programmes and research councils; and 3) project level. First, on the European level, Forsberg et al. (2018) conducted a preliminary study for the ‘RRI-practice’ project, which is funded under the H2020 SWaFS programme to ‘analyse RRI related discourses and pathways to implementation’ in member countries. These analyses, and the comparison between countries is further elaborated in the book published by Wittrock et al. (2021), based on the reports of 12 member countries. The authors based their analyses on three drivers of implementation: structural, cultural and interchange related. They found that:

[...] national policies, regulatory frameworks, laws and monitoring systems are the most effective drivers for RRI, alongside dedicated pilot programmes and organisational units that provide institutional homes for experimentation, together with organisational mandates, organisational goals, guidelines, procedures and routines (pp.vi-vii).

A second stream of research focusses on funding agency or research council level. To provide a few examples, the work by Fuenfschilling et al. (2022) illustrates RI⁶⁸ in the Swedish innovation agency Vinnova; Dabars & Dwyer (2022) demonstrate ‘societal responsibility’ in the Arizona State University; and Owen, Pansera, et al. (2021) highlight RI at the Engineering and Physical Sciences Research Council (EPSRC) in the UK. To start with the latter, the EPSRC already institutionalised a framework for RI in 2013 (Owen, 2014). This was the result of a process that started in 2009, when principles similar to RI were implemented in a nanoscience call ‘to reflect on the broader social, health and environmental risks of their research and its envisaged applications’ (Owen, Pansera, et al., 2021). So far, Owen, Pansera, et al., (2021) show that the EPSRC emphasised ‘advocacy, mobilising support and developing the skills and knowledge necessary for RI implementation’.

In the case of Vinnova, the notion of ‘RRI’ is not exactly used as such. They launched a programme called ‘Norm Critical Innovation’ (NCI), which was implemented in 2014 in the programme ‘Gender and Diversity for Innovation’. According to Fuenfschilling et al. (2022), such a framework to identify ‘problematic social norms’ is important for contributing to transformative change. This change

⁶⁸ The authors do not differentiate between RI and RRI

requires understanding and challenging ‘the norms, values and belief systems’ behind it. In this sense, the authors argue that NCI could be relevant for the implementation of RRI principles, as they emphasise:

Our analysis identified the most common project activities and outputs and in so doing carved out the core characteristics of norm-critical practice, which are the identification and disruption of norms, the design of inclusive processes, the application of a socio-technical approach, the creation of knowledge-sharing networks, and advocacy. These characteristics are arguably relevant for the implementation of RI practices, which is why we argue that NCI could be seen as an important building block to foster RI principles in all kinds of innovation processes (p.23).

While most of the literature and examples are found in the European context, Dabars & Dwyer (2022) discuss the institutionalisation of RRI at Arizona State University (ASU) by operationalising the New American University and Fifth Wave models. They describe the ‘organisational reconceptualisation’ at ASU in the past two decades for its ‘societal responsibility’. Hereby they divided ‘Societal Responsibility’ from ‘Responsible Innovation’ as the authors argue that “*a commitment to the former is not necessarily sufficient for the latter to flourish*” (p.114). In addition, Randles (2017) emphasised that, this organisational change went through three phases: 1) ensuring a diversity of students; 2) the engagement of research with society; 3) research efforts to impact society by addressing societal challenges.

A third stream of empirical literature highlights implementation of RRI on the level of research projects, such as the RRI working group in the Human Brain Project (HBP) (Salles et al., 2018; Stahl et al., 2021; Ulnicane et al., 2022) or the meta-analysis of the governance of RRI in research consortia by Morrison et al. (2020). The EU-funded HBP provides an interesting case of the implementation of RRI on project level, as it embeds a specific ‘RRI team’ and implemented a subproject on ‘Ethics and Society’ for ‘identifying, reflecting upon, and managing the ethical, social, and philosophical issues raised by the project’. Examples of this subproject are the creation of the HBP Foresight lab aiming for the anticipation of ‘possible future uses and applications of HBP’, public engagements, support in ethics, and more (Stahl et al., 2021). Morrison et al. (2020) studied the implementation of RRI in European consortia through governance structures. Even though they argue for need to support RRI with ‘appropriate consortia governance mechanisms’, in practice they found that these governance structures of consortia actually provide barriers for its implementation. I will further discuss this, together with other identified challenges and barriers.

Even though the literature discussed in the previous section emphasises the importance of RRI, this literature also sheds ample light on the various challenges, barriers and shortcomings of the

implementation and institutionalisation of RRI, and potential solutions to overcome these. This highlights difficulties in aligning R&I activities with societal challenges. Even under the RRI framework, excellent or breakthrough science seems to remain the main paradigm (Jakobsen et al., 2019; Wittrock et al., 2021; Dabars & Dwyer, 2022). Such findings result in discussions on the limitations of RRI as a policy concept, as well as the challenges and barriers for its implementation and institutionalisation. In recent literature on RRI, I found two major and largely discussed, interlinked challenges: 1) the dichotomy between excellent R&I driven by market dynamics and societal goals; 2) the vision of the implementation of RRI principles as a 'supplement' to R&I activities.

The dichotomy between excellent R&I and societal goals

To start with the first challenge, the literature on RRI highlights the dichotomy between excellent R&I, and societal goals. R&I activities are still often aiming at economic growth and competition as a result of market dynamics (Jakobsen et al., 2019; Owen & Pansera, 2019; Novitzky et al., 2020; Dabars & Dwyer, 2022; Fuenfschilling et al., 2022; Tabarés et al., 2022). R&I to increase competitiveness and economic growth versus R&I to respond to societal challenges seem to contradict one another (Tabarés et al., 2022). Dabars & Dwyer (2022) argue that: *“organisations committed to discovery and innovation have a societal responsibility to recognise that outcomes of knowledge production and technological innovation are not inherently aligned with important societal goals”*.

I identified two main reasons attributed to this challenge, which both relate to the current R&I policy environment (Novitzky et al., 2020; Owen, Pansera, et al., 2021; Wittrock et al., 2021). First, it is about the framing of R&I policies. According to Novitzky et al. (2020) RRI is often seemingly in conflict with other R&I policies and funding mechanisms. The authors mention conflicting examples to societal goals, such as the focus of R&I policies on scientific excellence, economic value, technological readiness levels as well as the contradiction between mission-oriented innovation policy versus fundamental research funding. This hinders 'the emergence of specific RRI-oriented policy frames'. These conflicts between goals of R&I policies are also seen as a result of the dominant paradigm which links innovation to market creation (Owen & Pansera, 2019). Owen & Pansera (2019) argue:

And innovation systems continue to be, by and large, configured to provide an ever-increasing supply of innovative products, services and business models for the market, to stimulate markets, to create new markets and to protect and increase market share. That is not to say that innovation (and in particular social innovation) does not produce benefits for society. But, we suggest, innovation overwhelmingly remains intimately and unreflexively tied to the idea of gaining competitive advantage within the construct of the market society, while being insufficiently directed at the deepening problems facing society and our planet, which include a rapidly escalating crisis of climate change and ecological

sustainability, demographic change, inequality, geopolitical conflict and resource sustainability and insecurity (p.43).

This is problematised in a similar way by de Saille (2015), who argues that implementing RRI requires more than a change in research, it also requires change in the R&I policy context and in the way we think about R&I. The author argues in this regard:

Thus, although RRI has at times been presented as a way of protecting society and the environment from instrumental economic demands, without a concurrent paradigm shift in the way European politicians think about science and social relations, and about growth economics and the purpose of innovation, its deeper potential may become lost within policies which are designed to mould a knowledge-based economy in the image of a production-based single market (p. 163).

To provide two empirical examples, the cases of RRI studied by Owen, Pansera, et al. (2021) and Wittrock et al. (2021) highlight this type of conflicting R&I policy framing as one of the main challenges for the limited implementation of RRI. Owen, Pansera, et al. (2021) discussed the challenges and the dynamic process of the institutionalisation of RRI at the EPSRC in the UK. The UK R&I policy approaches support public funded research focussing on 'economic growth, productivity and national prosperity' through technology markets. In addition, in their comparison of the uptake of RRI in different EU member countries (RRI-PRACTICE project), Wittrock et al. (2021) highlight the division between (fundamental) research and innovation in national R&I policies. Similarly to the conclusions of Owen, Pansera, et al. (2021), the authors illustrate that the implementation of RRI – and thus the focus on societal goals – might be limited by R&I activities which mainly aim for economic growth driven by the market. Wittrock et al. (2021) emphasise:

[...] in national STI policy, there tends to be a clear distinction between pure curiosity-driven science and applied science, and in the latter between economic and societal goals. [...] a science for society policy may stimulate researchers to do independent research on particular societal goals, whereas innovation policy often is aimed at stimulating cooperation between researchers, private sector actors and the government, typically on priorities set by the market (p.ix).

The second reason I identified to cause this challenge, relates to the differences between the large scope of societal goals and the relatively small scope of research projects. This is, for instance, represented by the difficulties in aligning long-term vs short-term goals. Societal goals or missions, such as the French 0-pesticides mission, are not achievable in the short-term. However, resources and timeframes of research projects are implemented in a short timescale. Similarly, skills, expertise and competences might be lacking for complex and large scale societal challenges (e.g., Morrison et al., 2020; Owen, Pansera, et al., 2021; Wittrock et al., 2021 ; Tabarés et al., 2022).

To provide a few examples, Wittrock et al. (2021) demonstrate *"the lack of resources in the form of time, people and competence"* (p.viii) to be the major barrier of the implementation of RRI. In their study on the EPSRC, Owen, Pansera, et al. (2021) argue that the implementation of RRI competed with other priorities for both time and financial resource[s]. Morrison et al. (2020) studied the governance of research consortia for the implementation of RRI, and found that this is challenged by 'rigid terms and conditions imposed on consortia' through contracts by the funding scheme/agency. This limits the flexibility of research consortia. A final example by Tabarés et al. (2022) stresses that the implementation of RRI requires a change in practices, values, norms etc. The authors argue in this regard: *"Such changes doubtlessly require time to be effectively institutionalised. The logic of H2020 project funding, operating on short term cycles (3–5 years), ignores this reality of RRI implementation"* (p.17).

The implementation of RRI principles as a 'supplement' to R&I activities

The second major challenge to the implementation and institutionalisation of RRI is that it is an add-on or supplement to R&I activities. One of the main reasons given for this challenge describes the cultural environment within which R&I activities are embedded, such as belief systems, routines, practices, norms, values and behaviour in science (e.g., Owen & Pansera, 2019; Owen, Pansera, et al., 2021; Wittrock et al., 2021; Fuenfschilling et al., 2022; Tabarés et al., 2022). In this regard, Owen, Pansera, et al. (2021) emphasise: *"In terms of the dynamics of RI institutionalisation, our literature review highlighted first the importance of legitimacy challenges to incumbent norms and practices as creating opportunities for new discourses such as RI to gain organisational purchase"* (p.8). The legitimisation of RRI implementation requires thus a change in the dominant paradigm of (excellent) R&I (Tabarés et al., 2022).

Hence, RRI is challenged by the way it is implemented as a supplement to R&I activities, instead of a paradigm shift in the way we conduct research and innovate. This causes various issues. First, responsibility in R&I is complex (Wittrock et al., 2021). Instead of integrating RRI in complex R&I processes, RRI is often implemented as 'add-ons' to such processes (Wittrock et al., 2021; Fuenfschilling et al., 2022). Fuenfschilling et al. (2022) argue in this regard: *"RI initiatives tend to disregard the need to transform the normative underpinnings of innovation per se, replacing a growth and competition paradigm with a more socially and environmentally desirable imperative"* (p.2). Similarly, if RRI principles are implemented as 'add-ons' to innovation processes, it will insufficiently change the actual (institutional) construction of R&I processes. This might lead to limited impact of RRI after the end of a specific R&I activity (Stahl et al., 2021). Stahl et al. (2021) work on the implementation of RRI in the European HBP, and for RRI principles to become guiding in future R&I

processes. One of the main objectives of the HBP is to establish a research infrastructure in this field, and the authors argue for implementing RRI strategies.

A third issue is a potential negative perception of RRI by researchers when it is implemented as 'add-on' instead of leading to a paradigm shift in R&I processes. The institutionalisation of RRI might be challenged by such visions according to Owen, Pansera, et al. (2021):

It also surfaced in assumptions made by researchers regarding the social desirability of their research and its envisaged impacts, claims that RI may slow down or hinder innovation (Brand and Blok, 2019)⁶⁹, claims that it is irrelevant for scientific practice (Glerup et al, 2017)⁷⁰ or that it presents an additional and unnecessary bureaucratic burden (p.9).

This highlights that institutionalisation of RRI – particularly as a paradigm shift in how we do research and innovate – might be highly challenged by resistance from concerned actors. If responsibility paradigms in R&I challenges 'deeply engrained institutional and disciplinary cultures, norms, behaviours and governance arrangements (e.g., norms of scientific autonomy)', this resistance could certainly be present (Owen & Pansera, 2019).

Overcoming challenges of implementing and institutionalising RRI

How do scholar that have documented challenges to implement and institutionalise RRI envision overcoming these? For instance Novitzky et al. (2020), illustrate a 'governance failure', meaning that RRI is not implemented on a stage of a policy process, which need to be bridged:

(i) the RRI framework is still an evolving concept, the development of which hinders its proper understanding by those who are supposed to use it; (ii) such individuals have only superficial understanding of the notion for its effective exploitation; and (iii) although the RRI framework is present on the declarative, strategic policy level (scoping and subtheme general description), it wanes in funding calls (policy operationalisation) and is largely absent in evaluation criteria used in proposal assessment. Collectively, these points further suggest that applicants have little in the way of consistently aligned incentives to regard RRI as relevant in proposal design and submission. Although (i) and (ii) are primarily a matter of a lack of adequate information, awareness and training, (iii) points to limitations of European science policy efforts related to the pursuit of RRI.

Building upon this quote from Novitzky et al. (2020), I found diverse examples in literature that discuss the need for 1) evaluation or assessment frameworks; 2) the need for adequate training; 3) the support and adaptation from funding agencies and calls; 4) the governance of research. First, various authors discuss the need for assessment or evaluation frameworks for the implementation of

⁶⁹ The authors refer to: Brand, T., Blok, V., 2019. Responsible innovation in business: a critical reflection on deliberative engagement as a central governance mechanism. *J. Responsible Innov.* 6 (1), 4–24.

⁷⁰ The authors refer to: Glerup, C., Davies, S.R., Horst, M., 2017. 'Nothing really responsible goes on here': scientists' experience and practice of responsibility. *J. Responsible Innov.* 4 (3), 319–336.

RRI. This literature stresses the need for research assessment frameworks so to align RRI implementation efforts with visions of broader societal impacts of R&I activities. This is not just about the evaluation of the implementation of RRI, but also about the impacts of such activities (Jakobsen et al., 2019; Owen, Pansera, et al., 2021; Tabarés et al., 2022). Tabarés et al. (2022) argue in this regard:

[...] interchange barriers observed in different programme lines could have been overcome with the introduction of specific evaluation criteria. Forcing projects to comply not only with the RRI keys but also with its underlying integrative vision would have facilitated the implementation of the concept, adding clarity and a clear mandate about its implementation in H2020.

Second, the implementation of RRI would need adequate training and guidance and information provision to increase capacities and competencies in relation to the RRI principles (Owen & Pansera, 2019; Novitzky et al., 2020; Tabarés et al., 2022). Third, it is suggested to better embed RRI principles in funding calls, in proposal submission, and more generally in the priorities of funding agencies (Morrison et al., 2020; Novitzky et al., 2020; Tabarés et al., 2022). In line with my second point, Tabarés et al. (2022) suggest developing training on RRI as a pre-requisite to receiving EU R&I funding. Morrison et al. (2020) argue that research consortia are limited in aligning their research with RRI principles through their contracts with funding agencies. Hence, they stress that funding agencies should provide a research environment that supports the RRI principles and which ‘recognises the challenges’ of its implementation. The authors argue: *“Rather, funders must do more work to ensure their different priorities such as open data, value for money, and timely project completion are in alignment with, and ideally subordinate to, RRI”*.

Fourth, aligning R&I activities with RRI principles, requires changes in the governance of R&I. Fuenfschilling et al. (2022) studies the implementation of the so called ‘Norm Critical Innovation’ (NCI) by Vinnova in Sweden. They argue that such ‘novel ways of R&I practices’ might be seen as an opportunity to implement RRI and thereby targeting societal challenges. The authors argue in this regard:

NCI principles could be applied in all kinds of projects where the aim is to challenge existing systems and where deep-structural change is needed. System change requires a deeper understanding of the norms, values and belief systems that built them. In order to create transformative change, we need to understand and challenge the dominant mindsets.

This research by Fuenfschilling et al. (2022) highlights the importance of not implementing RRI as an ‘add-on’ to research activities, as they highlight the contribution of NCI to a change in norms and values. However, this research is not conducted in the context of a societal mission, nor does it study how it changes visions of research contributions to societal challenges.

To summarise, in this section I illustrated two major challenges causing barriers to the implementation and institutionalisation of RRI in R&I processes. Instead of a paradigm shift by envisioning new, responsible ways of R&I, such processes are still often aiming at economic growth. Hence, as scholars have demonstrated, there is a dichotomy between excellent R&I driven by market dynamics and R&I efforts that respond to societal goals. In addition, RRI is challenged as it is often implemented as an add-on or supplement to R&I activities/processes. Instead, contributing to societal goals or challenges requires finding new and responsible ways of conducting research. This requires a change in the construction of R&I activities and processes, as well as a change in embedded norms, values, practices and behaviour of researchers. Scholars have discussed possible contributions to overcome challenges of RRI in this way. To date, however, how to overcome such challenges has been under-studied or under-demonstrated.

To conclude this sub-chapter, I provided an overview of the emergence and evolution of the notion of responsibility in science, technology and innovation. Particular today the most widely known and used concept is that of the EU's policy approach 'RRI'. RRI was institutionalised in the EU only in the H2020 framework program, which also introduced funding calls in response to seven domains of societal challenges. I highlighted the emergence and development of RRI as a policy concept in the EU for rethinking science-society relations. Thereby I also shed light on how the notion is criticised and how its implementation is largely challenged. I identified four knowledge gaps in the literature to which I respond and contribute with this dissertation: 1) The lack of understanding how to support the responsibility of researchers in mission-oriented contexts; 2) the need for re-defining the associations between science and society; 3) the lack of coupling science, society and innovation; and 4) the challenges to the institutionalisation of responsible research in a mission-oriented context that need to be overcome.

This thesis contributes to this literature by arguing that we are in a new era of responsible research in which we ask researchers to assume responsibility for contributing to ambitious societal missions. Especially in the literature on RRI, scholars discussed the rethinking of associations between science and society in responding to societal challenges. These scholars emphasise that it requires a paradigm shift in how to direct and govern research and innovation in line with societal goals. To respond to the addressed knowledge gaps, in the next sub-chapter, I present the conceptual framework of my dissertation. This framework allowed me to study how ASIRPA RT supported the responsibility of the PPR-CPA researchers in (re-)directing their research towards the societal mission. This leads to an understanding how researchers contribute with other actors in society.

2.2 A concept to study responsible research for the eradication of pesticides

Building further upon the previous sub-chapter, in this thesis I show how ASIRPA RT supports responsible research in this mission-oriented PPR-CPA. Hence, in my research I explored how ASIRPA RT – as a type of formative evaluation – accompanied the PPR-CPA researchers to assume responsibility for contributing to the societal mission with their research projects. For the researchers to contribute to the 0-pesticides mission, requires them to envision how to achieve a society without pesticides would work, and how to achieve such a society with the alternative solutions that they study in their research projects. In order words, the researchers' visions of societal change, and the responsibility they assume in this regard. I developed the notion of 'responsible translation' in order to analyse the responsibility of the PPR-CPA researchers (I explain this in more detail in Chapter 3 – the Methodology).

In this sub-chapter, I present the conceptual framework that guides the analysis and interpretation of my data. I present the framework in three sections. First (section 2.2.1), I am building upon the Sociology of Expectations, which teaches us that expectations are performative. However, the researchers' expectations of the contributions of the alternative solutions they study to this particular mission are not yet performative. Therefore, second (section 2.2.2), I mobilise Actor-Network Theory to study the performance of these expectations by associating actors in envisioned heterogenous networks. Third and final (section 2.2.3), I explain how the construction of these envisioned networks are based on visions of responsibilities of researchers in their professional role in science, as well as on the expected roles and responsibilities of other actors. I build upon the four-dimensional framework of Responsible Innovation (RI) by Stilgoe et al. (2013) (anticipation, reflexivity, inclusion, responsiveness) to understand the construction of the envisioned networks.

Hence, I approach responsible research through the researchers' visions of expected contributions of the studied alternative solutions to a society without pesticides. In addition, I approach the study of the responsibility researchers assume in this regard, through how they anticipate the progressive construction of envisioned heterogenous networks in order to perform these expected contributions in real-time.

2.2.1 Future looking activities: The Sociology of Expectations as an approach to studying expected contributions to the mission

Contributing to an ambitious mission, like a society without pesticides, requires visions of how such possible futures can be achieved. Specifically, in the case of the PPR-CPA, pesticides are embedded in complex socio-technical systems, and eradicating them requires changes in society. To

contribute to the mission, researchers need to envision the 'future working world'⁷¹ without pesticides through the alternative solutions they study in their PPR-CPA projects, and the change this would represent.

Various authors have written about envisioned futures, imaginaries and how this influences change (Sovacool & Hess, 2017). There is a large body of literature on foresight exercises (e.g., Martin 1995; Porter 2010; Pietrobelli and Puppato 2016), anticipatory governance (e.g., Guston 2013), sociology of expectations (e.g., van Lente & Rip, 1998; Brown & Michael, 2003; Borup et al., 2006), Regimes of Techno-Scientific Promises (e.g., Joly 2010; Robinson et al. 2021), and socio-technical imaginaries (Jasanoff & Kim, 2009b, 2015). This literature puts a particular focus on the anticipation of R&I, by looking systematically into the future of R&I to understand their role to navigate towards and enact envisioned futures. It argues how visions are a driver for R&I activities as well as about the capacity to anticipate R&I to enact upon these visions. Such activities stress that the future and present are strongly linked: actions and choices made today can create different futures, and similarly visions about the future shape those actions and choices in the present. I identified three main aspects of future looking activities, which this body of literature explores:

1. Future looking activities help to **strategise R&I** and related R&I policies by exploring multiple future possibilities, and the role of R&I activities in contributing to achieving these futures.
2. Future looking activities can help to reflect on the **involvement of (non-)human actors** in R&I processes, as visions of the future embed expectations of how society should be constituted and act in this future state of existence.
3. Future visions can steer R&I activities through the anticipation of the **allocation of resources**, such as financial, technological, analytical and human resources.

Although the above-mentioned bodies of literature on future looking activities present frameworks for understanding R&I strategies and directionality, they embed different levels of intervention. For instance, Technology Foresight Exercises and Socio-technical Imaginaries embed visions on national level and rather emphasise R&I policy discourses. Technology Foresight Exercises represent multi-dimensional and multi-actor processes to envision possible futures of R&I. The aim is to assess R&I policy options that could support those future visions (Martin 1995; Porter 2010; Pietrobelli and Puppato 2016). Pietrobelli & Puppato (2016) explain that such foresight "*systematically*

⁷¹ I would like to thank Philippe Laredo for the insightful discussions we have had in which he explained to me his perception of the 'future working world'

embodies a set of programmes to study innovation plans and priorities to foresee, shape and direct potential future orientation of technological change” (p.118).

Socio-Technical Imaginaries envision the role of the state, and this analysis is largely based on Science and Technology policy discourses (Jasanoff & Kim, 2009b). Jasanoff and Kim (2009a) define this as follows:

Imaginaries, in this sense, at once describe attainable futures and prescribe futures that states believe ought to be attained. Such visions, and the policies built upon them, have the power to influence technological design, channel public expenditures, and justify the inclusion or exclusion of citizens with respect to the benefits of technological progress. [...] S&T policies thus provide unique sites for exploring the role of political culture and practices in stabilising particular imaginaries, as well as the resources that must be mobilised to represent technological trajectories as being in the “national interest” (pp. 120-121).

Future looking activities on a rather macro techno-scientific level, such as Anticipatory Governance and Regimes of Techno-Scientific Promises focus on the inclusion of specific technoscientific actors in technological fields such as nanotechnology. I already touched upon Anticipatory Governance in section 2.1.1, as *“a broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible”* (Guston, 2008, 2014). It is about anticipating the acceptance of new technologies by society, as Guston (2014) argues: *“anticipatory governance motivates activities designed to build subsidiary capacities in foresight, engagement, and integration”* (p.219). Regimes of Techno-scientific promises elaborate on ‘shaping expectations’ of technoscientific actors as this could lead to ‘agenda setting and action’ (Robinson et al., 2021). Joly (2010) explains that regimes are ‘stabilised sets of formal and informal rules and routines’ and techno-scientific promises are to encourage ‘investment, and the mobilisation, circulation, and accumulation of resources’.

Finally, the body of literature on the Sociology of Expectations (SoE) emphasises a rather meso-level of intervention. It focusses for instance on visions of companies or technologies, or on the level of research projects. This field of study emphasises scientific and technological developments, how expectations about the future can be performed by strategising R&I pathways. Hence, it explains how R&I activities are shaped by visions about the future (e.g., Brown et al., 2003; Borup et al., 2006; van Lente, 2012). Borup et al. (2006) argue: *“Such expectations can be seen to be fundamentally ‘generative’, they guide activities, provide structure and legitimation, attract interest and foster investment. They give definition to roles, clarify duties, offer some shared shape of what to expect and how to prepare for opportunities and risks”* (pp.285-286). This concept is widely used in innovation

studies and technology development, in fields like nanotechnology, transport and biotechnology (e.g., Borup et al., 2006; van Lente & Bakker, 2010; Alvial-Palavicino, 2016).

Many of the above-mentioned bodies of literature on future looking activities are too structural, failing to open up spaces for the consideration of specific actors' visions or agency – particularly at the level of understanding how responsible research can be put into action through funded projects. Instead, in order to be able to analyse the responsibility of researchers when they participate in a formative evaluation approach, I need to be able to follow the researchers' work and their visions. In the case of the PPR-CPA, the content of envisioned futures in the mission-oriented context is set by researchers. I thus need a framework that enables me to study the roles, and responsibilities in these roles, of researchers and other actors to perform these visions. Consequently, in the following part I explain why the SoE provides the appropriate framework for studying this.

Expectations are performative

Gordon Moore, the director of research and development (R&D) at Fairchild Semiconductor laboratory, predicted in 1965 that the production of transistors in integrated circuits (chips) that they developed would double every 1.5 years. Eventually, the prediction became true as chip manufacturers adapted their future oriented (innovation) strategies to this prediction. Manufacturers created expectations on how to achieve this prediction, and realised it by adjusting their company strategies. This situation, also known as Moore's law, illustrates how R&I activities and investments of companies are being adapted to achieve predicted or expected goals, which provides an example of a 'self-fulfilling prophecy' (van Lente & Rip, 1998; Brown et al., 2003; van Lente, 2012). 'Self-fulfilling prophecy' is a term created by Robert K. Merton. Merton (1948) defined this as follows:

The self-fulfilling prophecy is, in the beginning, a false definition of the situation evoking a new behaviour which makes the originally false conception come true. The specious validity of the self-fulfilling prophet perpetuates a reign of error. For the prophet will cite the actual course of events as proof that he was right from the very beginning (p.195).

Hence, in contrast to Moore's law, Merton envisioned self-fulfilling prophecy as the result of an initial defined situation, which was untrue. However, it became eventually reality, as actors started behaving according to the false definition. Merton described the case in which rumours were spread about an American bank in insolvency. Even though the rumours were false, people starting acting upon it and a run on the bank ensued – causing real insolvency issues.

In the case of the 0-pesticides mission, we do not start with 'a false definition', nor does it represent a prediction of a situation like in Moore's law. Instead, in the case of the PPR-CPA research we are dealing with a definition of an envisioned, and desired, future situation: future agriculture

without pesticides. Therefore, to study these visions, I am mobilising the SoE. This body of literature teaches us that expectations are performative by shaping R&I strategies and activities, by facilitating the creation of networks and interactions, and by mobilising resources (Brown & Michael, 2003). According to van Lente (2012): *“the sociology of expectations has studied how in scientific and technological developments actors continuously and explicitly refer to what is possible in the future: they draw from and add to a repertoire of images, statements and prophecies – and by doing so they contribute to a particular dynamic”* (p.772).

Hence, expectations are dynamic and performative in the sense that they are the ‘enactment of desired possible futures’ (Borup et al., 2006). Expectations are not just descriptively shaping future discourses, but they actually perform such envisioned futures: they do something (van Lente & Rip, 1998; van Lente, 2012). The SoE emphasises how R&I activities are shaped by visions of the future, and so the expectations to contribute in this regard. According to Borup et al. (2006) expectations are ‘generative’, as the authors argue:

They [red. expectations] guide activities, provide structure and legitimation, attract interest and foster investment. They give definition to roles, clarify duties, offer some shared shape of what to expect and how to prepare for opportunities and risks. Visions drive technical and scientific activity, warranting the production of measurements, calculations, material tests, pilot projects and models (pp. 285-286).

In addition, Brown et al. (2003) explain: *“expectations mobilise the future into the present. That is, they perform a real-time purpose in shaping present day arrangements across area [...] Expectations are part of the world of action: they incite, block, justify”* (p.3). Scholars describe various dynamic characteristics of the performativity of expectations, which are embodied in and influence future discourses. I will describe four characteristics that I identified: 1) multi actor; 2) knowledge and learning; 3) socio-technical structures; 4) adaptivity to new conditions.

First, expectations facilitate the coordination of networks of different actors at various scales of organisation, expectations guide interactions and expectations influence not just individuals, but society as a whole (Borup et al., 2006; Brown et al., 2003; Groves, 2013; Konrad, 2006; van Lente, 2012). Second, expectations can influence and create opportunities for dissemination of knowledge, experimentation and learning (Brown & Michael, 2003; Groves, 2013; Konrad, 2006). Third, as Borup et al. (2006) emphasise: *“expectations constitute ‘the missing link’ between the inner and outer worlds of techno-scientific knowledge communities and fields”* (p.286). Expectations connect together the technical and social world and thereby contribute to the creation of socio-technical systems (Borup et al., 2006; Konrad, 2006). Fourth, Borup et al. (2006) argue that expectations change over time and

space as they adapt to 'new conditions or emergent problems'. Thus, expectations are spatially and temporally embedded.

In the case of the PPR-CPA, the researchers are supported in navigating their visions of the constitution of a future society without pesticides, and expectations of the contribution of the alternative solutions they study to these visions. This shows that, in this case, expectations are not yet 'performative', but are to be performed to achieve the envisioned future. In the next sections, I further explain my approach to study the performance of expectations, and eventually, how this enabled me to study responsible research. In other words, to understand responsible research through the performance of a future society without pesticides.

2.2.2 An ANT Perspective to Performing Expectations

In their book chapter entitled 'Expectations in technological developments: An example of prospective structures to be filled in by agency' van Lente & Rip (1998) reason: *"expectations allocate roles for selves, others and (future) artefacts. When these roles are adopted, a new social order emerges on the basis of collective projections of the future"* (p.203). In reference to the title, they introduce the term prospective structures, which, in contrast to retrospective structures, refer to 'arrangements that do not exist yet'. With this term, the authors seek to contribute to the various attempts to overcome structure versus agency dualism. They argue that structure and agency co-evolve, as it is the structure that shapes action: *"A spiral of structure and agency is the result: social structure as the context of action, and (reinforced or transformed) social structure as the outcome of action"* (p.223).

Hence, expectations in this regard are considered social structures 'to be realised', and so, the work done in the present to establish these expected structures is based on visions of the future in order to 'exert force' and to create a new social order (van Lente & Rip, 1998). The authors argue: *"Prospective structure should be added to the ontology of the social world: i.e., a not-yet-existing structure that is to be filled in by agency, and precisely in that movement also redefining and modifying that agency"* (p.225). Hence, expectations are based on visions of possible futures and the agency 'feasible in the present' to perform these visions (Groves, 2013).

In line with van Lente and Rip's work, in the PPR-CPA, the researchers' expectations of the contributions of the alternative solutions to this particular mission are not yet performative. It is the precise role of ASIRPA RT, as a formative evaluation approach, to enable the researchers to make explicit visions of a future society without pesticides, through the expected contribution of the alternative solutions they study in their projects. This highlights the particular need for other actors in society that need to change how they act in the future to constitute such a society. Hence, this shapes

the expected roles and actions of researchers and other actors to contribute to envisioned future society – and thus it highlights the co-evolution of expectations as ‘prospective structures’ and the agency to perform these expectations.

Heterogenous networks to perform expected contributions to the eradication of pesticides

According to Borup et al. (2006) *“expectations and future orientation as an integral part of human agency have been analysed in both classical and contemporary social theory”* (p.288). In the tradition of Actor Network Theory (ANT) (e.g., Akrich & Latour, 1992; Callon, 1986; Latour, 1996a, 1996b; Law & Urry, 2004), I understand agency to be the ability of actors to act, to change and to make changes. According to Akrich & Latour (1992) actants in ANT are identified as *“whatever acts or shifts actions, action itself being defined by a list of performance through trial; from these performances are deduced a set of competences with which the actant is endowed [...] an actor is an actant endowed with a character”* (p.259). In addition, agency in ANT is described as follows by Bueger & Stockbruegger (2016):

ANT’s understanding of agency is captured in the concept of actant. [...] There are hence no intrinsic qualities that make or constitute an action, and agency is neither characterised by reflectivity nor by intentionality or the logic of teleology. Instead agency is understood as an effect or as the modification of a state of affairs. Agency in that sense is everything that has an impact and makes a difference in the world. [...] An actant can therefore not act on its own. Agency is realised through networks and in association with other actants. An actant is configured in specific networks through which an effect is being produced. A network, in other words, gives an actant shape and turns it into a concrete actor (p.8).

In ANT, agency is not just subscribed to human-, but also to non-human actors. In addition, ANT goes beyond the agency-structure dichotomy (e.g., Callon 1986; Latour 1996; Law and Urry 2004). ANT rethinks the dualism between the ‘individual’ and the ‘collective’, as, according to Callon and Law (1997): *“Divisions between human and non-human, subject and object, and agent and structure--all of the dichotomies generally mobilised to explain the collective, have disappeared”* (p.2). I follow four principles of ANT (Callon & Law, 1997): 1) the social is heterogenous in character; 2) entities are heterogeneous networks (human and non-human); 3) entities may have variable geometry, which redirects action; 4) entities are both individuals and collectives. Agency is embedded in heterogenous networks, and the way how heterogenous actors are associated in networks is called ‘assemblage’ or ‘assembling’ in ANT (Latour, 2005). The term comes from the French word ‘agencement’, which is an arrangement that produces agency through the interactions among its actors. Latour (2005) argues that the assemblage is present only as long as it is performed. Hence, it can be considered as the arrangements of performing agency (Alvial-Palavicino, 2016).

According to Trauger (2009) *“Actor-network theory offers roads out of structure/agency dialectics and proposes new possibilities for understanding structure as a network, and agency as the outcome of networking”* (p.117). Agency in an assemblage is thus not about the act of an individual actor nor of the structure, but it is the result of interactions within the heterogeneous network (Latour 2005; Alvial-Palavicino 2016). Alvial-Palavicino (2016) explains: *“agency is not just a network; instead, it stresses the capacity of these assemblages to act or operate differently in different configurations [...] the way in which the human and non-human actors are arranged explains its capacity to act in the world”* (p.143).

Hence, I study how researchers envision constructing envisioned heterogeneous networks to perform expected contributions to the constitution of a future society without pesticides, and agency as the result of interactions within the network. Consequently, the outcome of these networks – and thus the performance of expectations - changes if the networks reconfigure. In line with the argument of Latour (2005), heterogeneous networks are only performed when associations between actors are established. Hence, for the PPR-CPA researchers, it requires them to envision the construction of these heterogeneous networks to perform the expected contributions of the alternative solutions to a society without pesticides.

Associations in heterogeneous networks

To continue on the construction of heterogeneous networks, Cresswell, Worth, and Sheikh (2010) highlight that:

The central idea of ANT is to investigate and theorise about how networks come into being, to trace what associations exist, how they move, how actors are enrolled into a network, how parts of a network form a whole network and how networks achieve temporary stability (or conversely why some new connections may form networks that are unstable) (p.2).

In addition, Fox (2000) argued ‘Without power nothing is achieved’. In French post-structuralist sociology (Deleuze et al., 1987; Foucault, 1984), the term ‘power’ is found in two different contexts, which in English are both translated as power: 1) ‘Puissance’ and 2) ‘Pouvoir’. Deleuze et al. (1987) define ‘puissance’ as the capacity to affect and be affected by others. ‘Pouvoir’ is the definition that I use in my thesis, as it is the power that is actualised through associations. Hereby, I base my work on Müller (2015) who explains: *“‘pouvoir’ corresponds to ANT’s understanding of power as the formation of a common interest and single will through the translation of initially disparate entities that stabilises an actor-network”* (p.33). Hence, for the heterogeneous networks to contribute to eradicating pesticides in society, they need to produce power through their associations.

To build further upon this, Callon (1986) reasons: *“Understanding what sociologists generally call power relationships means describing the way in which actors are defined, associated and simultaneously obliged to remain faithful to their alliances”* (p.224). According to Latour (1984), the concept of power is often mistaken in social sciences as power is not the cause, but the consequence of collective action. For Latour (e.g., 2005), assemblages or networks consist of actors with different power capacities. However, the power of the network is not the mere power capacity of individual actors, but power (as in the capacity to form a common interest and single will) results from the associations between actors.

In the *‘Powers of Association’* Latour (1984) describes two models of how power leads to action in networks: 1) the diffusion model and 2) the translation model. He uses these models to explain ‘the spread in time and space’ of a token ‘with an inner force similar to that of inertia in physics’ – this means that without obstacles the token will move forward in the same direction in space and time. The diffusion model explains how collective action of actors can fasten or slow down the token – but it can hardly be stopped (e.g., technological or scientific progress). As Latour describes, certain technologies spread rather easily through society. The actors that it passes do not necessarily modify the technology – they do not add power to the inner force –, but they could change the speed of the spread. Examples provided by Latour are steam engines, computers, gadgets or fashion.

The translation model is the more classical ANT understanding of associations in networks. Callon (1986) explains: *“Translation is the mechanism by which the social and natural worlds progressively take form. The result is a situation in which certain entities control others”* (p.224). The translation model helps to explain how the spread of something (the ‘token’ for Latour, it could refer to a technology or a claim) in the network depends on the actors who act in all different ways and embed agency. By the spread through the network, each actor modifies the ‘token’ a bit. Latour (1984) provides three aspects of the translation model: 1) the faithful transmission is a rarity; 2) displacement is not caused by initial impetus, but it is the consequence of the action of all actors in the network; 3) all actors in the network do ‘something’ in the network beyond just resisting or transmitting – they shape it according to their own situation. The heterogenous actors in the network are thus not just blocking or facilitating, but they modify or shape it.

According to Cresswell, Worth, and Sheikh (2010): *“thus inherent to ANT is a move away from the idea that technology impacts on humans as an external force, to the view that technology emerged from social interests (e.g., economic, professional) and that it thus has the potential to shape social interactions”* (p.2). In going beyond excellent science, this means that the PPR-CPA researchers have to (re)think the actors they require for the alternative solutions they study, actually enable the

contribution to the eradication of pesticides; i.e. to perform the expected contributions to the mission by associating actors in envisioned heterogenous network. This is where the notion of 'responsibility' plays a key role, which I will elaborate in the next and final section of this chapter.

2.2.3 Responsibility of researchers and other actors for the expected contributions to the mission

Hence, as discussed in the previous section, for the researchers to contribute to the societal mission, it requires them to move beyond blue-sky excellent science on alternative solutions to pesticides. Instead, it requires the researchers to envision the constitution of society without pesticides and how they expect to contribute with their research projects on alternative solutions. This contribution to the mission does not solely depend on their research into alternative solutions, but also on the contribution of other actors to enable the eradication of pesticides with these solutions. Hence, towards performing these expectations, it requires the researchers to envision the construction of heterogenous networks by associating actors who they expect to contribute. It is not only the researchers who hold responsibilities for the mission, but also other actors. Consequently, the PPR-CPA researchers are supported by ASIRPA RT to (re-)imagine the associations between their research on alternative solutions and a society without pesticides. It is in this way that I approach to studying how the researchers take on responsibility for the mission: the way they assume responsibility in the construction of envisioned heterogenous networks with other actors.

Responsible research reflects an iterative process in the construction and maintenance of the heterogenous networks of researchers with other actors to perform expected contributions to the mission. In this thesis I am talking about a very first step in the responsabilisation of the PPR-CPA researchers for the mission, and thus about early visions of the researchers who are not yet largely interacting with other actors. It reflects a T_1 -phase, where the researchers had just started their research projects as well as their participation in the PPR-CPA. This means that I am also talking about a first round of expectations of the researchers of how the alternative solutions they study could be used and respond to needs in society, require the intervention of intermediaries, and need actors to be interested and enrolled. Over time, in other iterations, the construction of the networks should not be based anymore on visions of the researchers only, but should progressively become based on a more participatory process. This means that expectations of other actors need to be performed to maintain the network.

Before I discuss how I approach this first 'round' of the envisioned network construction, I further illustrate the constitution of the networks to perform expectations based on the researchers' visions. As van Lente & Rip (1998) emphasise: "*Expectations allocate roles for selves, others and*

(future) artefacts. [...] The shared expectations are structures to be realised, actor-worlds as Callon (1986) has called them. They do not yet exist, but nevertheless exert force. The mechanism by which they exert force is the script allocating roles” (p.225). This highlights that the construction of the heterogeneous networks are based on the envisioned roles for the researchers themselves as well as for other (non-)human actors for the mission. So, these networks are constructed around visions of responsibilities different actors hold in their different roles to perform the eradication of pesticides in society with the alternative solutions studied in the projects.

In line with the six dimensions of responsibility⁷² (Vincent, 2010), which I discussed in section 2.1.1, I am thus referring to a particular type of responsibility in this mission-oriented context. When in this thesis I speak about ‘responsibility’, I refer to ‘role responsibility’, which is about the duties an actor has, which can be multiple and can be passed on by different actors (Vincent, 2010). This is thus about the responsibilities the researchers hold in their professional role as well as the roles and responsibilities of other actors, with whom they must interact in the network. The expected contributions to the mission will be performed by the network when actors assume role responsibilities for the mission, which is the result of interactions among these associated actors. In this early phase (T_1) of responsible research in the PPR-CPA, these responsibilities of other actors reflect thus visions of the researchers, which is what I explore in the thesis. However, as the construction of the network reflects an iterative process, this has to become more participatory over time through the interaction of the researchers with other actors.

Hence, the envisioned networks are to perform these expected responsibilities for the mission. I approach responsible research through the way how researchers assume responsibility for the construction of these envisioned network. This is based on their visions of responsibilities of themselves and other actors, when they are accompanied through a formative evaluation approach. For understanding the progressive construction of these envisioned networks, I am building upon the work on RI by Stilgoe et al. (2013). Their work is strongly based on ‘future-oriented’ thinking as the authors argue that for R&I the ‘past and present do not provide a reasonable guide to the future’. The authors developed the widely used definition of RI as *“taking care of the future through collective stewardship of science and innovation in the present” (p.1570)* (see also section 2.1.2). Stilgoe et al.(2013) developed a framework for RI to ‘represent aspects of societal concern and interest in R&I’, while particularly emphasising innovation processes. This framework consists of four future oriented dimensions:

⁷² 1) Virtue responsibility; 2) role responsibility; 3) causal responsibility; 4) outcome responsibility; 5) liability responsibility; 6) capacity responsibility

1. **Anticipation** – this is about the directionality of R&I and how to set research agendas in that direction. The authors argue in this regard: “*Anticipation involves systematic thinking aimed at increasing resilience, while revealing new opportunities for innovation and the shaping of agendas for socially-robust risk research*” (p.1570).
2. **Reflexivity** – this is about the reflexivity of actors and institutions in the ‘moral’ directionality of R&I.
3. **Inclusion** – the inclusion or engagement of ‘the wider public’ in R&I processes, as to better respond (direct research) to their needs and challenges.
4. **Responsiveness** – this refers to the capacity of researchers to (re-)direct R&I pathways in response to societal challenges.

I build upon these four dimensions to explore how researchers’ visions enable their achievement of the mission. These networks are to perform the expected contributions of the alternative solutions they develop in their projects to a future society without pesticides. Therefore, I approach how formative evaluation encourages the researchers to assume responsibility through the four dimensions of RI – anticipation, reflexivity, inclusion and responsiveness – in the envisioned network construction. This is thus about (re-)directing their research contributions to societal goals, through the associations with other actors.

Therefore, to conclude this sub-chapter, I study how the researchers assume responsibility for contributing to the societal mission when they are accompanied by formative evaluation to envision the construction of heterogenous networks. The envisioned networks associate a heterogenous set of actors with different envisioned roles and responsibilities, to perform the expected contributions to an envisioned future society without pesticides. In this regard, responsible research at this early stage of the projects, is about how the researchers take on responsibility to perform their expected contributions (i.e., their alternative solutions) to the eradication of pesticides in society. There are two parts of this process, which are clarified through operationalised research questions:

1. Researchers’ visions of possible futures without pesticides: how do the researchers expect to contribute to the constitution of a society without pesticides with the alternative solutions, and what has to change in society to enable this contribution?
2. Researchers’ visions of the construction of heterogenous networks, which are to perform the expected contributions to envisioned ‘0-pesticides society’: how do researchers envision responsibilities for themselves and responsibilities of other actors? And how do they envision associating actors to ensure that the envisioned network will put the alternative solutions into practice in the future.

Conclusion

To conclude this chapter, I provided a literature review on responsible research and explained how I approach the responsibility of the PPR-CPA researchers when they get involved in formative evaluation. In the first sub-chapter I showed that for long, the notion of responsibility in research has been studied and debated by scholars. But this interest increased and evolved over time, specifically after WWII, in relation to research ethics. Today there are two widely used, stabilised forms of knowledge on responsibility: Responsible Research and Innovation (RRI) and Responsible Innovation (RI), which go beyond questions of ethical and moral responsibility, but highlight a relational understanding of how science and society interact in complex ways.

I argue that we are in a new era of responsibility today, which requires researchers to rethink the relations between their research and society in mission-oriented contexts. It is no longer only about the negative impacts of research and technology in society. Instead, it is about actively contributing to complex socio-technical system changes. The notions of RRI and RI aim to respond to the complex understandings of how science and society interact. For instance, previous efforts have largely focussed on science and emerging technologies (such as nanotechnology) and less on innovation. By emphasising innovation, the aim of RI is to reinforce the alignment between science, innovation and society.

However, the RRI framework, which was institutionalised in the EU's H2020 research programme, showed to be largely challenged by 1) the dichotomy between excellent R&I driven by market dynamics versus societal goals; and 2) the implementation of RRI principles as an 'supplement' to R&I activities. Instead, contributing to societal goals or challenges requires finding new and responsible ways of conducting research. This requires a change in the construction of R&I activities and processes, as well as a change in embedded norms, values, practices and behaviour of researchers. Scholars have discussed possible contributions to overcome challenges of RRI in this way. I demonstrate in this thesis the potential of formative evaluation as an approach to support researchers in envisioning possible societal futures and how to navigate research activities in that direction. In other words, the researchers' visions of societal change, and how they assume responsibility in this regard.

Therefore, I study how researchers take on responsibility for the mission when they are accompanied in envisioning the expected contributions of the alternative solutions to the eradication of pesticides in society. I approach the performance of these expectations through the construction of envisioned heterogeneous networks. At this early stage of the 0-pesticides mission, these networks are not yet performative. Instead, these heterogeneous networks are constructed through an iterative

process as researchers and other actors are progressively taking on roles and responsibilities for achieving this mission through their associations. Through ASIRPA RT as a formative evaluation approach, researchers are supported to assume responsibilities in their role as scientists in a mission-oriented project. At the early T_1 -phase, ASIPRA RT accompanies the researchers to learn in their role as researchers in this mission, and thus it reflects their first visions of the construction of the networks. In the next chapter I elaborate on the thesis' methodology, as I explain the methods I have used to collect and analyse my data in this regard.

Chapter 3

The Research Methodology: exploring the intervention of ASIRPA Real-Time for the PPR-CPA researchers

Chapter 3. The Research Methodology: exploring the intervention of ASIRPA Real-Time for the PPR-CPA researchers

In this dissertation, I explore how formative evaluation encourages researchers to take on responsibility for contributing to a societal mission through the research they are conducting. To respond to this question, I studied the case of a French research programme launched in 2019: the PPR-CPA, with the ambitious mission of eradicating pesticides by 2040. I worked with the researchers of the ten funded research projects who are encouraged to think about their contribution to the constitution of a pesticides-free society with the alternative solutions to pesticides that they study. The PPR-CPA has integrated ASIRPA Real Time (RT), a formative evaluation approach, to support researchers in this process.

Hence, more precisely, I studied the responsibility the researchers take on for the mission through the implementation of ASIPRA RT. This research methodology is embedded in an experimental set-up. The PPR-CPA provides a test-bed for the development of the ASIRPA RT tools and its implementation. My embeddedness in the ASIPRA RT approach, allowed me to study how ASIRPA RT supports the researchers to assume responsibility for the 0-pesticides mission with their research projects. I developed the concept of 'responsible translation' to explore the process from research on alternative solutions to a society that eradicates pesticides with these alternatives. As expressed in the introduction of this thesis, in this way I analyse the links between formative evaluation, the process of translation and responsibility. In this chapter, I explain how I achieved this by collecting and analysing my data in the context of the implementation of ASIRPA RT in the PPR-CPA, in order to respond to my research question.

To study this, in my research I used the qualitative research approach of 'grounded theory', through data that I collected by participant observations and semi-structured interviews. This methodological approach was founded by Glaser & Strauss (1967), and guides researchers to construct theory from data in an inductive way. Using grounded theory, means that data collection, and the analysis and conceptualisation of the data occurred simultaneously. Hence, it provided 'a way of thinking about and conceptualising data', and is specifically suitable for research where the theory to be produced is based on many conceptual relationships (Strauss & Corbin, 1994). In this regard, Strauss & Corbin (1994) elaborate:

Theoretical conceptualisation means that grounded theory researchers are interested in patterns of action and interaction between and among various types social units (i.e. "actors"). So, they are not especially interested in creating theory about individual actors as

Chapter 3. The Research Methodology: exploring the intervention of ASIRPA Real-Time for the PPR-CPA researchers

such. They are also much concerned with discovering process – not necessarily in the sense of stage or phases, but of reciprocal change in patterns of action/interaction and in relationship with changes of conditions either internal or external to the process itself.

Therefore, the grounded theory approach guided me to study how the research assume responsibility based on the empirical data which I collected through my unique access to the ASIRPA RT intervention in the PPR-CPA. In this chapter, I will elaborate on the various methodological steps I have taken in this regard. In the first sub-chapter (3.1), I describe the context of the data collection with ASIRPA RT in the PPR-CPA. I introduce my research objects: ASIRPA RT, the PPR-CPA and the 10 funded research projects. In the second sub-chapter (3.2), I illustrate how I collected my data with ASIRPA RT in two phases. In the following sub-chapter (3.3), I elaborate on the analyses of my collected data. The sub-chapter (3.4) is based on a reflexive approach fundamental to qualitative and participatory methodology, which includes a discussion of the reliability and validity of my research findings, my positionality as a researcher and a reflection about the ASIRPA RT approach.

3.1 Objects of Research: ASIRPA Real-Time in the PPR-CPA

As I conduct my PhD research in the context of the ASIRPA RT implementation in the PPR-CPA, in this first chapter I will introduce my objects of research. This provides the context of the methodology, which is further described in following sub-chapters 3.2 (data collection), 3.3 (data analyses) and 3.4 (reflexivity and researcher positionality). I divided this sub-chapter into three sections, introducing three research objects: 1) an introduction to the ASIRPA RT approach; 2) an introduction to the PPR-CPA; and 3) an introduction to the ten funded PPR-CPA projects whose researchers participated in the ASIRPA RT activities.

3.1.1 An introduction to the ASIRPA Real-Time approach

The ASIRPA approach was launched at INRAE in 2011 as an ‘*ex post* tool’ for INRAE’s research impact assessment (Joly et al., 2015). The approach mobilises the Sociology of Translation and Actor Network Theory (ANT) (Callon, 1986), to highlight the chains of translations that occur during the process of generating societal impacts. In this regard, Matt et al. (2017) emphasise “*The ASIRPA approach pays attention to the process of transformation which renders knowledge actionable by incorporating it into new products, processes, and ways of doing or governing things. It is necessary to identify systematically the chains of translations that occur during the process*” (p.209). ASIRPA builds upon the Impact Pathway (IP) framework from Douthwaite et al. (2003) and shifted it to an approach in which an IP is: “*i) multidimensional; ii) based on the involvement of networks of actors; iii) at different stages and playing a variety of roles; and vi) over a non-linear impact pathway*” (p.13) (Joly et al., 2015).

ASIRPA’s central tool is the ‘impact pathway’ (IP). The IP describes the non-linear process of how scientific knowledge is translated into impacts. This IP goes from scientific knowledge, into outputs, and through the intervention of intermediary actors and eventually translates into impacts. There are five dimensions of impacts: 1) economic; 2) health; 3) social; 4) environmental; 5) political (Matt et al., 2017; Joly et al., 2015).

The real-time approach of ASIRPA is developed based on the experiences of almost ten years of ASIRPA ex-post and over 60 case studies. ASIRPA RT is a formative evaluation tool, using an intervention research approach, with the aim of accompanying researchers to envision desired futures and to navigate research in that direction. The ASIRPA RT method is in detailed described in Matt et al., (2023). The first principles were developed in the end of 2018, and the approach was further advanced in the context of the PPR-CPA from 2019 onwards. This means that the tools and their implementation were developed and improved within the PPR-CPA as an experimental testbed. This placed me in a unique situation for the collection of data for my thesis as I not only used the ASIRPA RT approach to collect data, but I have also been involved in the ASIRPA team and contributed in the development of the tools within the PPR-CPA.

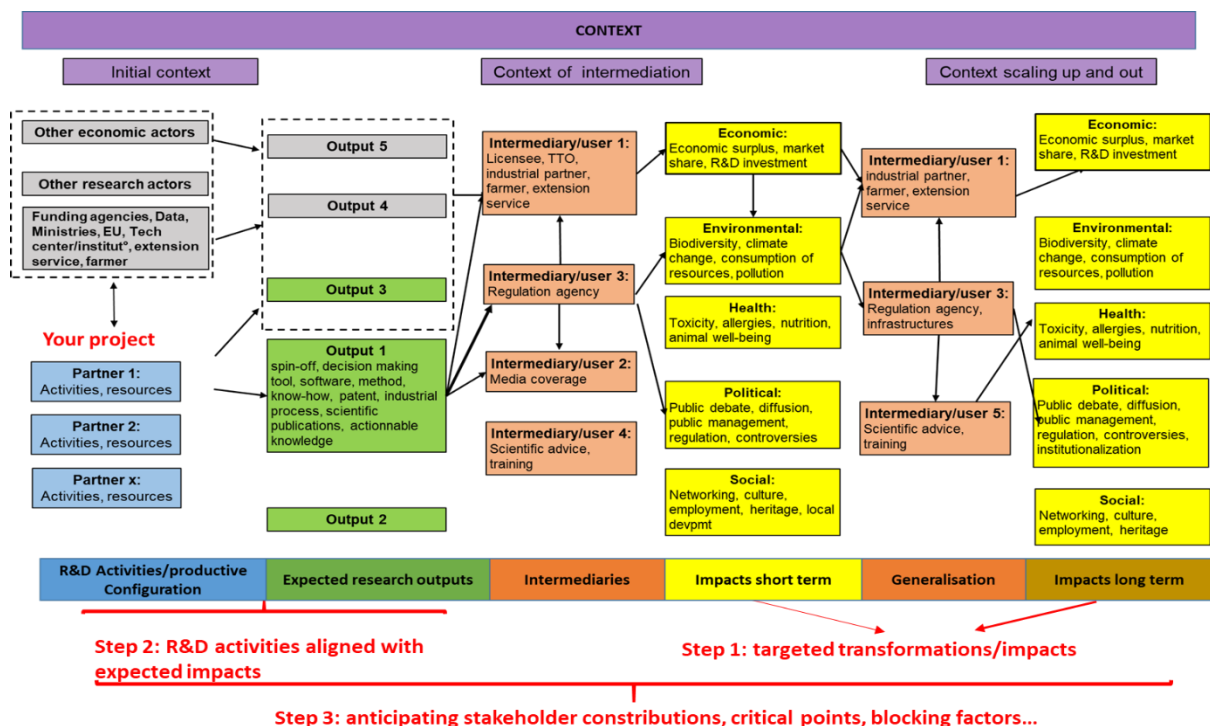


Figure 13. ASIRPA's RT Impact Pathway and the three steps in the construction

The main tool of ASIRPA RT remains the IP, which was developed for the ex-post assessment, but it is adapted to the real-time situation through three steps (Figure 13). The ASIRPA RT approach works from a retrospective reasoning. This means that the construction of an IP starts with envisioning the projects’ contribution to societal impacts and transformations. The second step is to identify the

R&I activities linked with the envisioned societal impacts and transformations, and the third step is to envision the context of intermediation (actors to involve, blocking and facilitating factors, what should be in place to achieve the envisioned impacts etc.).

The e-learning platform of INRAE hosts a Massive Open Online Course (MOOC) on ASIRPA RT, which is available to all researchers at the institute. The MOOC consists of several modules, and provides the method and tools for researchers to reflect and anticipate their envisioned societal transformations and impacts. The aim is not only to help navigating ongoing research, but also to accompany researchers in their proposal writing/project development in the frame of publicly supported mission-oriented research (ANR, Horizon Europe, etc.). The course is a self-learning tool meant for researchers to use independently and autonomously. There is a special course dedicated to the researchers of the PPR-CPA, and one for Horizon Europe projects.

3.1.2 An introduction to the PPR-CPA

The PPR-CPA provides the experimental testbed in which the ASIRPA RT tools were being developed. As discussed in previous chapters, the PPR-CPA has an ambitious mission: a French agriculture without chemical pesticides by 2040. It is an innovative research programme that is supposed to eradicate pesticides as a key input in farming systems, because of its negative impacts on society. The start of the programme was delayed because of the COVID-19 pandemic, but was eventually kicked-off in September 2020 and the official start of research activities took place in January 2021. The PPR-CPA implements activities on two levels: on the programme level and the project level. On the project level, the PPR-CPA funds 10 research projects over a duration of 6 years. On the programme level the PPR-CPA is subdivided into various activities (Jacquet et al., 2019):

- A foresight study on “a European agriculture without pesticides”;
- A real-time assessment of the impact of the PPR. This will consist of an assessment of the real-time ‘Impact Pathway’ (ASIRPA RT approach);
- Synthesis of scientific knowledge on pesticides and alternative practices;
- International symposia.

This highlights the unique combination of foresight exercises, research operations and impact assessment, while they are normally decoupled from one another. These activities have been integrated in the programme with the aim to increase reflexivity in the design and implementation of R&I for a 0-pesticides future (Jacquet et al., 2019).

Hence, this thesis research is conducted within the context of the implementation of the ASIRPA RT approach in the PPR-CPA. The ASIRPA RT approach is included in the programme as a means to support researchers in considering their contributions to pesticides eradication and the societal

impacts that this eradication could bring. ASIRPA RT intervenes on two levels in the PPR-CPA: at the programme level and the project level. This means that we worked on two different, but nested impact pathways (IP): on project level an IP for each individual project and a programme level IP. The aims of the activities on the programme level are to articulate the programme mission with the research done at the project level, to have a global overview of the visions of the projects, to find synergies and coordinate (exchange between) the projects. The intervention of the programme in relation to societal actors is to anchor the research results in the new context to generate transformations and foster the generalisation of societal impacts.

The programme level IP is based partly on the activities done at the project level and its interventions on the context. The PPR-CPA funds ten research projects over 6 years, which should go beyond scientific excellence, but contribute to the 0-pesticides mission and thereby impact society. Even though I was involved in all activities of ASIRPA RT on both levels, I specifically focus on the ten PPR-CPA projects as these represent the performing level of envisioning societal impacts.

In the report by Jacquet et al. (2019), various propositions for the PPR-CPA are presented. In this report, three large principles of action for a 0-pesticides future in France are presented: agroecology; prophylaxis and the value chains. Eventually, in the call for projects⁷³ two types of projects were demanded:

1. **Large-scale integrative projects** – which needed to integrate at least of two out of the five following themes: 1) Interaction through crop diversification (e.g., diverse cover crops, plant-plant interactions, mixtures etc.); 2) Interaction between plants and microorganisms, or between microorganisms; 3) Genetic resistance; 4) Conditions for the positive effects of diversification; 5) Pest regulation (e.g., through macro- and micro-organisms, natural substances, plant defences, etc.) and biocontrol methods. Conducting socio-economic analysis in the framework of the project is supported. **In addition, more targeted projects** on the following two themes were also demanded: 1) ‘Understanding the crop microbiome and its exploitation in plant health’; 2) ‘Understanding the current socio-economic determinants of pesticides use by farmers and the transition to pesticide-free cropping systems’.
2. **Projects aimed at epidemiosurveillance for prophylaxis** – which should aim to [*translated from French*^{xiii}]: “set up a reinforced epidemiosurveillance system based on the development of methodologies, tools and indicators that can be appropriated by farmers and agricultural development stakeholders”. These projects demanded to conduct

⁷³ <https://anr.fr/fr/detail/call/cultiver-et-protéger-autrement-appel-a-projets/>

experiments ‘in a variety of real and experimental situations of systems using few or no pesticides’.

In addition, all projects were required to consider two conditions: 1) they have to add a focus on ‘training by research’, in order to [translated from French^{xiv}]: “enable the emergence or reinforcement of the skills needed for the transformation of agricultural systems and the new jobs associated with them”; and 2) only research and higher education institutes can benefit from the funding, other actors cannot be funded through the PPR-CPA. Eventually, ten research projects were selected for funding within the PPR-CPA. They are outlined in Table 3. I will briefly present each of the ten projects in the next section.

Table 3. The ten funded PPR-CPA projects per project type

Project name	Project Type	Alternative solution to pesticides proposed
Be Creative	Integrative	Co-design pesticide-free territories (agroecology)
BEYOND	Epidemiosurveillance	New epidemiosurveillance paradigms for early pest prediction
CAP ZERO PHYTO	Integrative	Solutions to increase plant immunity levers
DEEP IMPACT	Integrative – targeted to microbiome	Increase plant microbiota interactions to improve plant resistance
FAST	Integrative – targeted to socio-economic determinants	Public actions to trigger transitions to pesticide-free agriculture
MoBiDiv	Integrative	Increase intra and inter-specific crop diversity
PheroSensor	Epidemiosurveillance	Artificial pheromone sensors to detect insect pests
SPECIFICS	Integrative	Diverse legume-rich, pesticide-free farming systems (agroecology systems)
SUCSEED	Integrative	Novel seed technologies/solutions
VITAE	Integrative	Multiple management options for agroecological transition in vineyards

3.1.3 An introduction to the ten funded PPR-CPA projects

In this section, I briefly introduce each of the ten funded PPR-CPA projects, specifically to highlight the proposed alternative solutions to pesticides they are doing research on, and the expertise of the consortia. It should be noted that only eight out of ten projects participated in the ASIRPA RT activities (I will elaborate on this in the next sub-chapter 3.2).

Be Creative: *Built pEstiCide-free agRoecosystEms At Territory leVEI*. The project aims to co-design pesticide-free territories. They build upon knowledge of agroecology and the need for systems

thinking, specifically on a territorial level. The consortium is largely constituted of researchers with expertise in ecology, agronomy and design studies. Their multidisciplinary team consists of over 15 research centres (mostly INRAE, but also AgroParisTech, AgroSup Dijon, National Natural History Museum, the Center of Research in Design), with skills in 'design research and co-design methodologies; in territorial approaches; in biotic interactions and ecosystem services and in agronomic innovations'. Together they aim to develop an *"innovative co-design approach about the transition to pesticide-free territories to think in terms of disruptive ecological, socio-economic and technical dynamics, with and for the actors of the territories"*. They identified 10 case study territories throughout France, with a diversity of farming systems with whom they will work in the project to collect data. The project has two PIs: one specialised in agronomy (in a research unit with specialists on design studies) and one specialised in design studies in agriculture research.

BEYOND: *Building epidemiological surveillance and prophylaxis with observations both near and distant.* The project aims to develop a new paradigm of epidemiosurveillance for early pest prediction. The multidisciplinary team consists of researchers in 'life sciences, mathematics, computer science, social science and economics'. The researchers are from over 10 research centres (mostly INRAE, but also CIRAD, and SupAgro) and diverse associated partners (Platform of plant health epidemiosurveillance, University of Bologna, Association for the Defence against Pests, Institute of the vine). They plan to develop a new epidemiosurveillance paradigm in three ways: 1) by integrating indicators from various sources (maps, remote sensing, smart sensors etc.) into epidemiological models for epidemiologists; 2) educate epidemiologists about including new indicators 'into their reasoning'; 3) develop decisions making tools on this new epidemiosurveillance for farmers and other stakeholders, to guide them in their decisions in managing plant health without pesticides. They work on 15 pathogen system in different crops and different types of pathogens. The PI has an interdisciplinary background related to plant pathology.

CapZeroPhyto: *Adaptation of the concept of ecological immunity to crop protection: Rosaceae and Solanaceae, two case studies.* The project does research into crop protection strategies through the combination of levers of plant immunity to support crop defence systems. The multidisciplinary consortium is mainly constituted of experts in crop production, pathogens, pest control and levers of immunity. The researchers are from a variety of research centres (mostly INRAE, but also CNRS, Université d'Angers, and Université d'Avignon et Pays du Vaucluse) and they partner with diverse agricultural support institutions (Interprofessional Technical Centre for Fruit and Vegetables, l'APREL, GRCETA de Basse Durance arborist association, Chamber of agriculture). Together they study interactions in six different plant immunity levers: 'genetic resistance, companion plants, biocontrol solutions exhibiting PRI (plant resistance induction) action, UV-C flashes, mechanical stress and

nitrogen supply'. Initially their research focusses on tomato and apple crops, and will later be extended to peach and strawberry. The former PI (at the time of proposal writing) was a researcher specialised in biomechanics. At the early stage of the project the PI changed to a researcher with expertise in crop ecology.

DEEP IMPACT: *Deciphering plant-microbiota interactions to enhance crop defences to pests.* The project studies plant microbiota interaction in order to increase plant resistance to biotic stresses. The multidisciplinary consortium is specialised in 'ecology, biology, plant genetics and mathematics'. Ten research centres partner in this project (mostly INRAE, but also CRNS and universit  Rennes 1) and they collaborate with a large variety of public and private external partners and farmer networks (ACTA, ARVALIS, Regional chamber of agriculture in Bretagne, Haute Marne et Pays de la Loire, Agro d'Oc, Coop rative Agricole Dijon, Groupe Limagrain, Association pour la Promotion d'une Agriculture Durable, Gassler SAS). They aim to "*identify, characterise and validate the microbial communities, plant communities and abiotic factors (including agricultural managements)*" in order to explain variations in resistance to several pests in rapeseed and wheat species. The PI of the project is specialised in microbiology, specifically in plant-microbiota interactions.

Fast: *Facilitate public Action to exit from peSTicides.* The project aims to study "*the effectiveness of a variety of public actions for triggering a large-scale transition to pesticide-free agriculture, and at assessing the socio-economic consequences of such a radical change*". The consortium is specialised in social sciences - mainly in different fields of economics, but also in management, sociology and law. There are also a few experts in agronomy, data management, and epidemiology present in the consortium. The funded consortium members are from 8 different research centres and 8 additional centres who do not receive funding (mainly from INRAE, but also Universit  de Poitiers, Universit  Grenoble Alpes, Montpellier SupAgro, AgroCampus Ouest, AgroParisTech). They evaluate the efficiency of public policies on European and National level and aim to come up with political and organisational solutions, which are 'directly usable by the public decision-makers and stakeholders more broadly'. The PI of the project is an economist, specialised in microeconomic impact analysis.

MoBiDiv: *Mobilising and Breeding Intra and inter-specific crop Diversity for a systemic change towards pesticide-free agriculture.* The project aims to "*produce and disseminate knowledge to boost breeding for within-field cultivated biodiversity as a major driver towards a pesticide-free agriculture*". The multidisciplinary consortium is specialised in 'genetics, agronomy, pathology, weed science, ecology, microbiology and economics and participatory approaches'. The researchers come from around 20 different research centers (mainly INRAE, but also CIRAD, GEVES, National natural history

museum, National Institute for Advanced Agronomic Studies in Montpellier, Sorbonne Université). The consortium works on 'diversification through breeding for intra- and inter-specific crop diversity on wheat and fodder species' (to support plant-plant interactions). They will 'breed, co-design and evaluate crop and variety mixtures with stakeholders', and also look at the needed socio-economic changes and reorganisation of the seed sector. The project has two PIs. The first PI is an interdisciplinary researcher in the field of population genetics and plant breeding. The second PI is specialised in creation and dissemination of innovations and has notably ample experience with ASIRPA ex-post.

PheroSensor: *Early detection of insect pests using pheromone receptor-based olfactory sensors.* The project aims to develop and evaluate innovative, artificial pheromone odor sensors to detect insect pests. The consortium has expertise in various fields such as sensory ecology, chemical sensors, biosensors, insect olfaction, population modelling, mathematics, informatics and evolutionary ecology. Six research centres are involved (INRAE, Commissariat for Atomic Energy and Alternative Energies, CNRS, Research Institute for Development, ESIEE-ESYCOM). This consortium develops sensors based on insect pheromone receptors, for three 'potentially invasive insect pests in France': the fall armyworm, cotton leafworm moths, and the red palm weevil. They will work on two types of sensors: 1) sentinel-fly-based biological sensors; and 2) physical sensors. The PI of the project is specialised in insect olfaction.

SPECIFICS: *Sustainable PEst Control In Fabaceae-rich Innovative Cropping Systems.* The project does research into the 'design and the development of pesticide-free and legume-rich cropping systems'. The multidisciplinary consortium is specialised in agronomy, genetics, pathology, entomology, ecology, economy and sociology. Over ten research centres are involved in the consortium (mainly from INRAE, but also research unit on Legumes, Plant Ecophysiology, Agroecology in Angers, IESEG business school Lille, AgroCampusOuest and AgroSupDijon). Their work on diverse legume-rich farming systems is based on agroecological principles and holds a more systemic approach, including different scales and solutions. They work for instance on 'resistant and/or resilient crops and cultivars, diversifying arable crops both in time and space, and designing agro-ecological infrastructures in farms for intensifying biological regulations and thus reducing pest and disease populations by promoting natural enemies and increasing competition against weeds'. The project has two PIs. The first PI is specialised in agronomy and genetics, the second PI is specialised in the impact of cropping systems on weed communities.

SUCSEED: *Stop the Use of pestiCides on Seeds by proposing alternatives.* The project aims to develop novel seed technologies/solutions as alternative to pesticides. The multidisciplinary

consortium has expertise in difference fields, such as seed sciences, genomics, genetics, pathology, microbial ecology, biocontrol, biomimetics, human and social sciences (like innovation studies, consumer and producer' perception and behaviour studies, and intellectual property law). Including 14 partner research institutes (mainly INRAE, but also CNRS, GEVES, Université d'Angers, Université Clermont Auvergne, AGROCAMPUS Ouest, Université Paris-Saclay, Université Paris II Panthéon-Assas, AgroParisTech Paris) they collaborate with seed companies and other actors of the seed market (UFS, IBMA France, AFAIA, Frayssinet). The consortium does research on technologies to protect seeds against seed-transmitted pathogens and damping-off by 'using natural and environmentally-friendly alternatives to pesticides'. Their research focusses on the seeds of wheat, tomato, common bean and rapeseed through three main research directions: 1) enhancing seed defences, 2) engineering seed microbiota and 3) design bio-innovative seed treatments. The PI of the project is specialised in microbial ecology, plant-microbial interactions and (meta)genomics.

VITAE: *Cultivating the grapevine without pesticides: towards agroecological wine producing socio-ecosystems.* The project does research into multiple management options for an agroecological transition in vine cultivation. The interdisciplinary consortium has expertise in biology, agroecology, oenology, and economic and social sciences. The partners are from twelve centres (mainly INRAE, but also Bourgogne Franche-Comté University and Bordeaux university) and also collaborate with the Institut Technique de la Vigne et du Vin. With a focus on grapevine, the consortium studies 'the development of biocontrol and the use of vine genetic resistance' as well as the up-scaling of management options and the barriers, incentives and drivers of agroecological transitions. The project has two PIs. The first PI is specialised in epidemiology of plant diseases, and the second PI is specialised in international marketing and strategy, foresight studies and strategic prospective studies.

3.2 The collection of data with ASIRPA Real-Time: A comparison between two phases

In this sub-chapter, I explain how I collected my data in the context of the ASIRPA RT implementation in the PPR-CPA. For the entirety of my doctoral programme I have been a member of the ASIRPA RT team. By conducting my research as part of ASIPRA RT in the PPR-CPA, I had unique access to the intervention of a formative evaluation approach to support researchers to responsabilise in a mission-oriented setting. However, as I will describe in this sub-chapter, it also represents a rather complex situation of data collection in the experimental situation of ASIRPA RT as formative evaluation approach. I have been involved as a member of the ASIRPA team on three methodological levels: 1) the development of ASIRPA RT tools, 2) the implementation of ASIRPA RT in the PPR-CPA and 3) the observation of ASIPRA.

My integration in the ASIPRA RT team enabled me to collect data to explore the support of ASIRPA RT for the PPR-CPA researchers to responsabilise, through four operational research questions (see Introduction Chapter):

1. *How did the PPR-CPA researchers envision contributing to the 0-pesticides mission by studying alternative solutions to pesticides, before they got involved in ASIRPA RT? How did these visions influence the construction of their research projects?*
2. *How did the PPR-CPA researchers expect that the alternative solutions they study in their research projects can contribute to the 0-pesticides mission, when ASIRPA RT helped them navigating their visions of societal transformations and impacts?*
3. *How did the PPR-CPA researchers envision the construction of heterogenous networks of actors to enable the eradication of pesticides with the alternative solutions they study in their research projects, when ASIRPA RT helped them navigating their visions of the intermediary context?*
4. *How have the PPR-CPA researchers' visions changed from before their involvement in ASIRPA RT to after their involvement?*

Hence, as discussed, the PPR-CPA programme has included the ASIRPA RT approach as a means of accompanying researchers to consider their contributions to pesticides eradication and the societal impacts that such eradication might bring. In this regard, for the ten funded projects it was a requirement to participate in the ASIRPA RT activities as part of the PPR-CPA. Eventually, as I want to understand how ASIRPA RT enables PPR-CPA researchers to envision their contributions to the 0-pesticides mission, I studied a change in visions between two phases: before and after the researchers' participation in ASIRPA RT. I will further elaborate on those two phases as follows:

1. **T₀-phase:** This represents the phase before the PPR-CPA researchers participated in the ASIRPA RT activities. It allowed me to analyse the researchers' envisioned contributions to the 0-pesticides mission in the construction of their projects, to obtain a baseline.
2. **T₁-phase:** This represents the first phase of the participation of the PPR-CPA researchers in ASIRPA RT – starting in February 2021. In this phase, through various activities, the projects' researchers collectively developed and discussed their first IP. This allowed me to analyse the researchers' envisioned contribution to the 0-pesticides mission when ASIRPA RT supported them in navigating their visions.

In the following two sections, I will deepen the data collection in both phases. As the T₁-phase represents the intervention phase of ASIRPA RT in the PPR-CPA, I subdivided T₁ into three parts to describe my involvement on three methodological levels as describe above: 1) development; 2)

implementation; 3) observation. In a third section, I elaborate on my data collection for the socio-historical context of pesticides use, regulation and research in France (Chapter 1).

3.2.1 Data collection in the T_0 -phase

The T_0 -phase represents the phase between the launch of the PPR-CPA and the start of the ASIRPA RT activities with the project' researchers. This means that the researchers already had in mind the 0-pesticides mission, but their visions were not navigated yet by the ASIRPA RT approach. The aim of the data collection at T_0 was to understand how the researchers expect to contribute to the 0-pesticides mission and how these visions are embedded in the construction of their projects. Data was collected in two ways: 1) through the PPR-CPA project proposals; 2) through semi-structured T_0 -interviews. Hence, the first source of data collected for the T_0 -phase were the PPR-CPA research proposals of the ten funded projects. I asked the PIs if they would share with me their accepted proposals. I received a positive response for all ten projects and they send me their proposals.

Second, all project' PIs were invited to participate in an individual T_0 -interview. Those invitations were sent out after the PPR-CPA kick-off meeting in September 2020, where the ASIRPA team also introduced themselves. This means that the PIs were already aware of the ASIRPA team, and we already saw short presentations of the ten projects by the PIs. Even though the PPR-CPA kick-off took already place in September 2020, the official start of the projects would not be until early 2021.⁷⁴ In total, I conducted 11 interviews, one for each project and two with the Be Creative project. Be Creative has two PIs, who were not available on the same day, therefore, we scheduled two dates. MoBiDiv and VITAE have two PIs, who both participated in the same interview.

The interviews took place in December 2020 and January 2021. Because of the COVID-19 pandemic all 1-hour interviews took place through the ZOOM platform, and were recorded with the consent of the interviewees. Concerning GDPR, all interviewees signed a consent form emphasising the anonymity of their data, that I used it only for the purpose of my PhD research, and that I only shared with the members of the ASIPRA team. Although I had the lead in guiding the interviews, there were always one or two members of the ASIRPA team present as well. The interviews were semi-structured, and I developed the interview protocol around four sets of questions (Adams, 2015; Patton, 2015; Kallio et al., 2016) – the full interview protocol can be found in Annex I.

1. **The PIs' visions of the projects' short-term contributions in the 0-pesticides mission, 4-5 years after the end of the projects:** what changes did they expect to contribute to, how

⁷⁴ Delays were encountered caused by the COVID-19 pandemic

did they expect their research activities could lead to these changes and what would be the potential bottlenecks and catalysts.

2. **The PIs' visions on the projects' long-term contributions to the 0-pesticides mission:** what changes did they foresee by 2050, how did they expect to contribute with their project and what should happen after the project to contribute in this regard.
3. **The construction of their project:** How and when did the ideas of the proposal emerge and how did the 0-pesticides objective influence the projects.
4. **Actors - who is expected to be important for the project:** Who they considered important for the project, to contribute to the envisioned short- and long-term visions. And, what will be their contributions to the project.

During the interviews, I took elaborate notes. After each interview, I wrote a report about my general impressions, ideas and observations of the interview. I transcribed all interview recordings either by hand or by using the NVIVO transcription software. I translated the outcomes of the T₀-phase into a table describing the expected societal transformations of each of the projects. This table was shared with the project' PIs to receive their feedback. The final version (see Annex II) fed into the first programme-level workshop, and also functioned as the starting point of the T₁-phase.

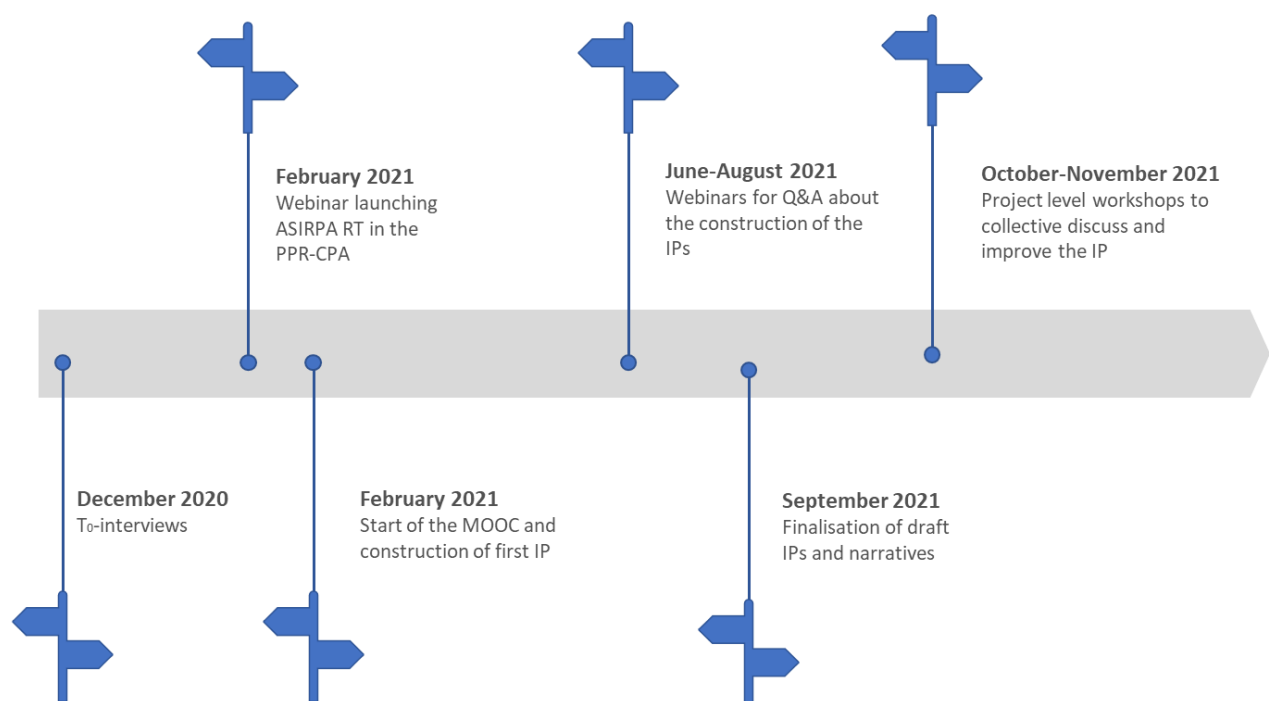


Figure 14. Timeline of the ASIRPA RT activities on project level in the PPR-CPA

Chapter 3. The Research Methodology: exploring the intervention of ASIRPA Real-Time for the PPR-CPA researchers

3.2.2 Data collection in the T₁-phase

Data collection in the T₁-phase took place in a unique and complex context: the implementation of ASIRPA RT in the PPR-CPA. I did not only observe the PPR-CPA researchers' participation in the ASIRPA RT activities and collected data through these activities, I also contributed to the development and implementation of the ASIRPA RT approach and observed the ASIRPA team in this regard. I provide an in-depth discussion of my researcher positionality in sub-chapter 3.4.

The purpose of the T₁-phase data collection was to study how the researchers' visions of their contributions to the eradication of pesticides changed when they participated in ASIRPA RT. The T₁-phase in this regard, represents the period from the start of the ASIRPA RT activities in February 2021 until the development and collective discussion of the first IP of each project in Autumn 2021. In this thesis, I focus on the ASIRPA RT activities on project level, and so I focus on this level in this section. Figure 14 presents a timeline of all activities, which I will deepen in this section. For the purpose of clarity of this section, I divided it into three parts based on my involvement in ASIRPA RT on multiple methodological levels: 1) development; 2) implementation and 3) observation.

The Development and organisation of the ASIRPA RT tools and activities

The development of the ASIRPA RT method and tools and the organisation of activities on project level at T₁ can be subdivided into three steps:

Step 1: At the start of my PhD research in November 2019, the main principles and the central tool of ASIRPA RT (the IP – see Figure 13) were already shaped by the ASIRPA team. In the first year of the PhD (2020) - before the official start of the PPR-CPA - with the ASIRPA team we further developed the RT approach. We did this through collective brainstorming, as so to have the concepts related to studying researchers' visions of societal impacts, transformations and the intermediary context clear. We particularly focussed on the communication of the approach to researchers who are not familiar with it, such as the majority of the (fundamental) researchers of the PPR-CPA.

Step 2: Right before the official start of the PPR-CPA, with the ASIRPA team we had two main goals in the development of the approach on project level. First, early February 2021, the organisation of the webinar, in which we officially launched the ASIRPA RT approach in the PPR-CPA. We presented the ASIRPA RT approach, the roadmap within the PPR-CPA, the expectations about the participation of the project' researchers and the MOOC. We particularly highlighted the importance and the relevance of ASIRPA RT for the PPR-CPA and the researchers involved. In addition, the ASIRPA team developed and launched the MOOC for the PPR-CPA projects. I was not involved in the development of this MOOC, but I provided my comments when the different modules were prepared.

Step 3: In order to collectively discuss and improve the developed IPs by the project' researchers, we organised workshops for each project in autumn 2021. Initially, we created this workshop around four parts: 1) enrich the envisioned societal transformations; 2) brainstorm on anticipating needs 3) a stakeholder analysis; and 4) develop action points.

However, after the first workshop (with Be Creative), the ASIRPA team realised that this set-up did not work as we expected at this early stage of the projects. There were two reasons for this, for which we adapted the following workshops. First, the projects were not even one year into their research and the stakeholder analysis seemed too complex and difficult at this stage. Second, more time was needed to the brainstorm about 'the anticipation of needs'. So, we split this part in two: 1) anticipating the needs; and 2) prioritising the needs (short versus long term). Eventually, in a later stage, we plan to organise a more detailed stakeholder analysis in relation to these needs.

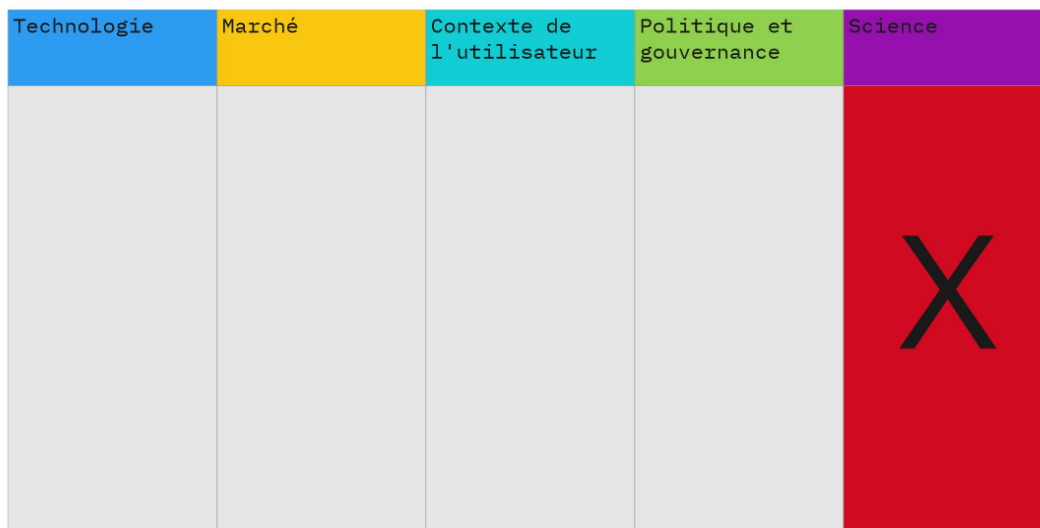


Figure 15. The ASIRPA 'STeaM UP' framework

For this brainstorm on the 'anticipation of needs' we developed a tool called 'STeaM UP'. STeaM UP stands for the following five poles: Science, Technology, Market, User context and Policy and governance (Figure 15). It represents the intermediary phase between the research activities and envisioned transformations and impacts. The aim of this tool is to brainstorm about what is necessary, for the projects to be able to contribute to the envisioned societal transformations. The development of this 'five-poles framework' is based on my analysis results of the T₀-phase, which highlighted envisioned changes in these five poles. This brainstorm was accompanied with the following question: 'what should be in place in these five poles?', which could be understood as follows:

- **Technology:** e.g., the need for (other) technologies (new ones or already existing who are not at scale yet or need to be adapted); scaling up or out from 'proof of

demonstration' to industrialisation, physical infrastructures, technical standards, tools and software, etc.

- **Market:** e.g., new or adapted market infrastructures, including standards, labels, distribution channels, contract or business models, etc.
- **User Context** (referring to a variety of users like farmers, consumers, intermediaries, industries or breeders): awareness raising, practices, capacity building, incentivising, blocking or facilitating (e.g., costs), etc.
- **Policy and governance:** e.g., new regulations, individual and collective incentives (e.g., subsidies, tax systems), etc.
- **Science:** e.g., development of science within the project and outside the project. Considering that the researchers know this part very well, we decided to focus on the other four poles.

The Implementation of the ASIRPA RT tools and activities

The data that fed into the analyses of the T₁-phase is based on two main activities: 1) the development of a first IP by the project' researchers; and 2) the collective discussion and enrichment of the first IP. In this part, I will deepen both activities, by explaining how we implemented the ASIRPA RT method and tools and how the PPR-CPA researchers participated.

First, the development of the first IP: the first webinar we organised with the ASIRPA team took place early February 2021. This webinar represents the start of the T₁-phase. We explained the ASIRPA RT approach, the implementation in the PPR-CPA and the importance in the context of the 0-pesticides mission. Also, we presented the MOOC and explained how the researchers can use it. We invited the researchers to create an 'impact team' within their projects, who are in charge of developing the first IP. At this first webinar, at least one researcher, but most often two, of all ten PPR-CPA projects were present. Table 4 provides an overview of the processes of the construction of the IPs by the eight projects who participated in ASIPRA RT.

In the period after this webinar – spring 2021 – the projects had time to participate in the MOOC and to develop a first IP. The MOOC is an autonomous online tool for the projects to work on individually, by following various modules, which guide them in the development of an IP. If the researchers had questions or difficulties they could contact us by mail or through the discussion platform of the MOOC. Various researchers used this function. Throughout spring, we noticed that researchers from some projects faced difficulties and had various questions about the construction of their IP. Therefore, we organised three extra webinars between June and August 2021. These webinars were semi-structured, where the ASIPRA team not only answered the questions of the

researchers, but the researchers also shared examples based on their various projects (both difficulties and findings/achievements). Hence, the purpose was to discuss openly the ongoing processes. It should be noted that these webinars were not recorded, but I took elaborate notes.

Table 4. Overview of the process of constructing the projects' first IP for the eight projects

Project	Process to construct the first project' IPs and the researchers involved
Be Creative	No data
BEYOND	<ul style="list-style-type: none"> The first ideas were collected during the weekly meetings: "BEYOND's Thursdays", which were led by the PI (around 12 participants). Then, the actually drafting of the IP was done by the "BEYOND Council". Four of the five members participated: 1) the PI and leader WP1 (Plant pathology); 2) Leader WP 3 (Economics); 3) Project researchers (Machine Learning); 4) Project researcher (entomology)
CapZeroPhyto	<ul style="list-style-type: none"> An initial IP was constructed by the PI (Crop Ecology) and a project researcher (Phytopathology) in collaboration with the operational manager of SUCSEED (who already worked on the IP of SUCSEED) After, workshops with other project' researchers were organised to collectively discuss. They also got help from the officer in charge of partnerships and innovation at INRAE in the field of biocontrol
FAST	<ul style="list-style-type: none"> The IP was constructed by a team consisting of: 1) the PI and leader WP 4 (Economy); 2) Leader WP 1 (Economy); 3) Leader WP 2 (Management); 4) Leader WP 3 (Economy)
MoBiDiv	<ul style="list-style-type: none"> One of the project coordinators (innovation specialist) was already familiar with ASIPRA. During the kick-off meeting she led a workshop to brainstorm on the various aspects and visions of the IP. They had 7 groups of 6 researchers, each led by a WP leader. The IP team is a group of five researchers: 1) The first PI (Genetics); 2) The second PI (Innovation); 3) One WP leader (Innovative Plant Material); 4) Project researcher (Ecology); 5) Project engineer (Breeding engineer)
PheroSensor	<ul style="list-style-type: none"> IP was constructed by the IP team, consisting of: 1) PI (Insect olfaction); 2) WP leader (research engineer chemical sensors at CEA); 3) WP leader (Mathematics and applied informatics); 4) Project researcher (Sensorial ecology)
SPECIFICS	<ul style="list-style-type: none"> The ASIPRA RT method was presented at the projects' kick-off meeting, to collectively brainstorm on some of the elements of the IP. After, the two PIs (1- agronomy and genetics, 2- weed communities) worked on drafting the IP, and later they got help from a project manager
SUCSEED	<ul style="list-style-type: none"> The first IP was drafted by the PI (microbial ecology and genomics) and the operational manager of the project. This draft IP was discussed with four WP leaders and the officer in charge of partnerships and innovation at INRAE in the field of biocontrol: 1) WP leader (Functional genomics); 2) WP leader (Genetics); 3) WP leader (Germination and seed vigour); 4) WP leader (Law)

Eventually, eight out of ten projects finished their first IP. The other two projects did not have the human resources capacity to participate in the ASIRPA activities at that stage of their research. Those eight projects who constructed the IP send it to us in various formats (mainly PowerPoint or PDF), including a narrative which explained their IP.

Second, the collective discussion and enrichment of the IP: After the researchers finished their first IP we invited them for a workshop for each individual project. The majority of the workshops took place between October and November 2021, and one exceptionally in Mars 2022. Since only eight of ten projects developed an IP, we only organised eight workshops. The workshops took place online through the ZOOM platform. We used the MIRO platform⁷⁵ for the brainstorming activities. Before the workshops, we made a call with the PI and the project manager (if the project had one) to explain them in detail the set-up of the workshops and to prepare the MIRO pages for our discussions: one MIRO page for the IP, and one MIRO page for the STeaM UP. The idea was that the discussions were led by the project' researchers themselves, and not by the ASIRPA team. The ASIRPA team was only present to provide the tools and guidance where needed. The workshops took two hours, and with the consent of all participants they were recorded and transcribed afterwards by using the NVIVO transcription software.

Table 5. Overview of the participants to the ASIPRA RT workshops per project

Project and total number of WPs	Number of participants	Tasks of the Participants
Be Creative (3 WPs)	5	2 PIs; Leaders WP 2; project manager
BEYOND (7 WPs)	9	PI; Leader WP1; Leader WP3; Leader WP5; additional researchers
CapZeroPhyto (5 WPs)	9	Roles of researchers are not specified
FAST (5 WPs)	12	PI; Leader WP1; Leaders WP2; Leaders WP3; Leaders WP4; Leaders WP5; additional researchers
MoBiDiv (6 WPs)	15	2 PIs; (task)Leaders WP3; (task)Leaders WP4; (task)Leaders WP5; (task)Leaders WP6; additional researchers
PheroSensor (4 WPs)	8	PI; Leader WP1; Leader WP2; Leader WP3; Leader WP4; additional researchers
SPECIFICS (4 WPs)	9	PI; Leader WP1; Leader WP2; Leader WP3; Leader WP4; additional researchers
SUCSEED (8 WPs)	14	PI; Leader WP1; Leader WP 4; (task)Leader WP6; (task)Leader WP7; Leader WP8; additional researchers and external partners (e.g., industrial associations)

The IPs were constructed by small groups of 2 to 5 researchers of each project. Therefore, the aim of the workshop was to gather as many of the consortia members present as possible, to enrich and develop collective visions of the projects' IPs. In general, between 5 and 15 researchers participated for each individual project, which represented the majority of the WP leaders. The participants are summarised for each project in Table 5, which provides an indicating of who's visions are represented in my dissertation.

⁷⁵ www.miro.com

In this regard, the workshop consisted of three main parts:

1. Collectively envision societal transformations and impacts, based on the first version of the IP. The PI or project manager explained the construction of the IP in about ten minutes. Based on this explanation, the other consortium members were invited to put post-its (in MIRO) about any additions or necessary changes to the envisioned transformations and impacts and discuss this collectively.
2. Collectively discuss what needs to be put in place (needs) to achieve the envisioned transformations, and how the project prioritises these needs (short vs long term). This brainstorm was based on the STeaM UP tool (see Figure 15). First, time was given for the researchers to add post-its to the framework (in MIRO). Second, the post-its were discussed and a first effort was made to prioritise the most urgent needs. The ASIRPA team members did not guide the researchers. However, in some projects the researchers faced more difficulties in this assignment, and when necessary the ASIRPA team provides some general examples such as: 'maybe you require new regulations to market your technology' or 'what would be need for farmers to access your solution'.
3. Collectively discuss the development of an action plan and the actors who needed to be involved. Due to a lack of time and the difficult assignment, we did not elaborate deeply on this part. However, we shortly discussed the importance of the action plan, and linking the envisioned needs with actors to involve. In a next step, we will go further into the development of an action plan.

As discussed in the previous part (*'the development of the ASIRPA tools'*), in the first workshop we also tried a stakeholder analysis. We removed this for the further projects as it seemed too challenging at the early stage of their research projects. Instead, we invited the researchers to reflect on linking what they considered necessary in their contribution to societal transformations (STeaM UP outcomes) to their reflections on involving actors.

After the workshop, six projects sent us updated narratives, which included the outcomes of the workshop discussions (updated transformations, impacts and the STeaM UP discussion). Eventually, for the T₁-phase I collected the following data (see also Table 6 for a complete overview per project): 1) the first IP and narratives; 2) the transcriptions of the workshop' discussion; 3) the outcomes of the STeaM UP brainstorm (post-it notes at MIRO); and 4) the updated IP and narrative. The idea of ASIRPA RT is to re-do this process of developing IPs every 18-24 months (to construct versions at T₂, T₃, etc.).

Observations during ASIRPA activities

I did two types of observations (Lofland et al., 2006) in relation to ASIRPA RT: 1) participant observations of the project researchers during their participation in the ASIRPA RT activities; and 2) observations of the ASIRPA team during both the team meetings and the animation of the activities with the participants. I took elaborate notes during these meetings and activities. Such notes were, for instance, about how the participating researchers responded to questions we posed and the discussions, if there were researchers dominating the discussions, the amount of guidance researchers required in their reflections, how the researchers interacted, and how they responded to the ASIRPA team. To conclude, Table 6 summarises the data collected for both the T₀- and the T₁-phase, for each of the ten PPR-CPA projects.

Table 6. Overview of the data collected at T₀ and T₁

PPR-CPA Projects	T ₀ Phase		T ₁ Phase				
	PPR Proposal	T ₀ interview transcription	IP	Narrative version 1	Workshop transcription	STeaM UP	Narrative Version 2
Be Creative	✓	✓	✓	✓	✓	✓	✓
BEYOND	✓	✓	✓	✓	✓	✓	✓
CapZeroPhyto	✓	✓	✓		✓	✓	
DEEP IMPACT	✓	✓					
FAST	✓	✓	✓	✓	✓	✓	✓
MoBiDiv	✓	✓	✓	✓	✓	✓	✓
PheroSensor	✓	✓	✓		✓	✓	✓
SPECIFICS	✓	✓	✓		✓	✓	
SUCSEED	✓	✓	✓	✓	✓	✓	✓
VITAE	✓	✓					

3.2.3 Data collection for the socio-historical analysis (Chapter 1)

In Chapter 1 I presented a socio-historical analysis (Payre & Pollet, 2013; Goulet, 2018) of pesticides use, regulation, and research in France. It highlights the rise of pesticides use in France, what the French government has done to control it, and why this worked or not. I have used three main methods for this chapter: 1) document analysis; 2) quantitative databases analysis; 3) scientometric analysis.

For the document analysis, I have used three main types of documents. First, I have used scientific literature on the history of pesticides in France. Second, I have explored French law and policy documents on the 'Loi n° 80-502 du 4 juillet 1980 d'orientation agricole - Article 14'. This information I extracted from the French Government website: legi.gouv.fr. It provided insights into the support of R&I activities to control the use of pesticides products. Third, I have based my analysis on policy framework and policy documents in relation to pesticides in France and EU. This is for

instance about EU regulation on pesticides registration, the EU policy efforts to reduce pesticides use, the Ecophyto plan in France and the documents on the 'Programme d'investissements d'avenir' (PIA).

Second, for the quantitative analysis based on databases, I have used various national and international databases, such as: the French E-phy database on pesticides products; the statistical database of the FAO (FAOSTAT) on pesticides use worldwide and per country; the database from the French government (data.gouv.fr) on the use and regulation of pesticides products; and the Eurostat database from the EU on pesticides sales by European countries.

Third, by using the Cortext Manager (Breucker et al., 2016), I did a scientometric analysis to explore the research ecosystem on pesticides in France. Cortext Manager is an online platform for data analysis. It provides the tools to study *"the dynamic of science, technology, innovation and knowledge production"*.⁷⁶ To prepare my database to be used in Cortext Manager, I used the Scopus database and searched for "pesticides" AND "France", which gave 1515 results from 1960-2019. It should be noted that the majority of the papers are in English. I conducted a lexical analysis of this database by uploading it to the Cortext platform. For this lexical analysis, I extracted the top 500 used terms in the title, keywords and abstracts of each publication. I cleaned this list of terms, to combine terms that are written slightly differently (e.g., capital letters) but are synonyms, and removed terms with no meaning in the context of pesticides use (e.g., 'literature review'; 'research outcomes'). With the final terms-list I conducted a co-word analysis to discover the scientific network around pesticides in French (Callon et al., 1983; Raimbault et al., 2016).

After, I divided the database in six decades. It should be noted that the number of papers per decade is not homogenous. However, this analysis allowed me to study the evolution of pesticides research in France over time. On top of the main co-word analysis (from 1960-2019) I prepared heatmaps that highlight co-word analysis for each of the six decades. The darker red a cluster is highlighted, the stronger this particular research field was present in that period.

3.3 The analyses of data: Responsible translation processes

In this third subchapter, I explain how I qualitatively analysed the collected data and how this led to my conceptualisation of the contribution of ASIRPA RT to the responsibility of the PPR-CPA researchers, by empirically exploring the processes of translation this embeds. describe this qualitative process across the following five sections. First, I explain how I inductively created the codes, which I then applied to my data. Second, I describe the analytical framework I have used to explore the process of translation. Third, I adopted abductive reasoning in the theory building part of

⁷⁶ www.cortext.net

grounded theory. And I finalise the sub-chapter by elaborating on the use and writing of the data in the empirical chapters, specifically considering the translation from French to English.

3.3.1 Inductive coding

I uploaded all collected data - documents and transcriptions - in the NVIVO⁷⁷ software, which supported me in the qualitative data analysis. What followed was an intensive coding exercise of the collected data. I developed the codes inductively (Glaser & Strauss, 1967), based on the conceptual framework.

As I adopted a grounded theory approach, I conducted the coding exercise in multiple steps. The first round of coding was done after the data collection at T₀. This allowed me to discover the major themes the projects are working on as well as the themes/concepts around societal change they were envisioning. I did the second coding exercise when I was preparing the T₁ workshops – hence, this coding was still based on data from the T₀ phase. This second coding was part of a larger meta-analysis of the ten projects, to discover structures and patterns between the projects in terms of the change in society they envision and how they envision contributing to this change. These first two coding exercises mainly fed into the development of the STeaM UP exercise as the researchers made visible the five poles of transformations they envisioned in their projects.

The third and final round of coding took place when all data was collected, thus at the end of the T₁-phase. I developed a robust code book (Annex III) based on the conceptual framework, and all patterns and topics I had discovered during the data collection and the earlier coding exercises. This led to seven categories of codes:

- Four-dimensions of RRI
- The various phases of the IP
- The five poles of the STeaM UP framework
- Expectations on the eradication of pesticides
- Stakeholder involvement in the research projects
- Responses to the participation in ASIRPA RT

During the coding exercise, I took elaborate notes to discover the first patterns. To assure the robustness of the coding exercise, together with my supervisors I discussed the interpretation of each coded item. In addition, they also coded parts of the data based on my codes and the descriptions I gave to these codes.

⁷⁷ <https://www.gsrinternational.com/nvivo-qualitative-data-analysis-software/home>

3.3.2 The responsible translation process

As explained in the Introduction Chapter, I study how formative evaluation encourages the researchers to assume responsibility in contributing to the 0-pesticides mission through a particular process of translation: 'Responsible Translation'. I developed the concept of 'responsible translation' to explore the process from research on alternative solutions to a society that eradicates pesticides with these alternatives. In this section I explain the analytical framework that I mobilised to study how the PPR-CPA researchers take on responsibility through the responsible translation process. The 'Sociology of Translation' by Callon (1986) describes the process of three researchers who aim to restock the level of Scallops in St Brieu in France. They discover a particular way of anchoring scallops used in Japan, and they want to study this way of anchoring of Scallops in France. Through four moments of the process of translation, Callon (1986) explains how they become spokesmen of the heterogenous networks their research embeds:

1. **Problematization:** *"determination of a set of actors and their identities" by the researchers, "as to establish themselves an obligatory passage point in the network of relationships" (p.204)*
2. **Interessement:** *"the group of actions by which an entity attempts to impose and stabilise the identity of the other actors it defines through its problematisation" (pp.207-208);*
3. **Enrolment:** *"the device by which a set of interrelated roles is defined and attributed to actors who accept them" (p.211);*
4. **Mobilisation:** *"ensure that supposed spokespersons for relevant collective entities are properly representative of all members of the network that are acting as a single agent" (p.196).*

In my case, I analyse the envisioned process by the PPR-CPA researchers from research on alternative solutions into a society that eradicates pesticides, through the process I developed as 'responsible translation'. This is largely inspired by the work of Callon (1986), but I adapted the analysis of this process to the societal mission of the PPR-CPA and the role of ASIPRA RT in accompanying the researchers. This is in line with my conceptual framework as discussed in Chapter 2, whereby I described how associations in heterogenous networks are to perform expected contributions to a future society without pesticides. Hence, this adaptation of the translation process concerns two conditions, namely: 1) visions of change to a future society without pesticides; and 2) the performance of expected contributions to these visions in real-time, through chains of translation in heterogenous networks.

First, differently from the case of Callon, the PPR-CPA is about an ambitious societal mission. Pesticides represent a dominant input in French agricultural systems and eradicating them requires a change in the complex socio-technical system in which pesticides use is embedded. Envisioning research contributions to a 0-pesticides future demands the consideration of the transformative change in society that would be required for this to happen: i.e. visions of the constitution of a '0-pesticides society' and how this requires actors to change how they act in the future. Second, where the case of Callon describes an ex-ante translation process, with ASIRPA RT in the PPR-CPA it is about a real-time situation and reflects visions of change to a future society without pesticides. Some actors, process and societal needs might not be known, exist or involved yet at an earlier stage of the research processes. Hence, the expected contributions of the alternative solutions to these envisioned futures are not yet performative, instead it is about the future heterogenous networks that are to perform these expectations, and their reconfiguration in real-time.

Three phases: from establishing to mobilising science-society associations in the mission-oriented context

Hence, I adapted my analysis of the responsibility of the PPR-CPA researchers through responsible translation, to these two unique conditions of the PPR-CPA case. Responsible Translation describes the process of translating visions of alternative solutions into those of a society that has used these solutions to eradicate pesticides. Responsible translation consists of three phases in envisioning 1) the establishment (through problematisation), 2) the realisation (through intersement and enrolment) and 3) the mobilisation of science-society associations in a mission-oriented context. These three phases describe the process how researchers construct envisioned heterogenous networks, by associating actors and their responsibilities. These networks are to perform the expected contributions of the alternative solutions to the envisioned future society without pesticides. The three phases are:

1. **Phase 1: Establishing science-society associations through problematisation.** This phase highlights the researchers' visions of the constitution of a '0-pesticides-society' to which they expect to contribute with the alternative solutions to pesticides they study in their research projects. This represents visions of how a 0-pesticides society is expected to benefit from the studied alternative solutions as well as what transformations are required, which requires actors in society to change to enable the eradication of pesticides through alternative solutions to the problem.
2. **Phase 2: Realising Science-Society associations through intersement and enrolment.** This phase highlights how the researchers envision and anticipate the construction of heterogenous networks to perform the expected contributions of the alternative

solutions they study to a future society without pesticides. It considers the contribution of various actors – including the researchers themselves - at different points in time, to anticipate the chains of translations that might be performed by these networks. These chains of translation in the networks will only be performed eventually when actors assume responsibility for the mission, to collectively enable the eradication of pesticides in society with the alternative solutions.

3. **Phase 3: Mobilising Science-Society Associations.** This phase highlights a change in the researchers' visions from T₀ to T₁ of the expected contributions of the alternative solutions to the eradication of pesticides in society. It highlights the constitution of each alternative solution to pesticides as a 'spokesperson' of the heterogenous networks to perform the expected contributions to the 0-pesticides mission.

The structure of the three empirical chapters that describe the T₁-phase (Chapters 5, 6 and 7) are structured around these three phases: each represent one phase. The chapters explore how the PPR-CPA researchers assume responsibility through the process of responsible translation, by empirically describing how the researchers envision establishing, realising and mobilising science-society associations in this mission-oriented context.

3.3.3 Abductive reasoning: building theory on responsible research

Eventually, my thesis contributes to academic knowledge by revealing the links between formative evaluation, responsibility, and processes of translation. I empirically analysed this through my data collection in a mission-oriented context. In making sense of my data, and the construction of theory around this, I have mobilised abductive reasoning.

In Grounded Theory, induction is often prioritised as an analytical approach to theory building, such as by Glaser & Strauss (1967). However, I follow here the approach of Timmermans & Tavory (2012), in using an abductive approach, as they argue that: *“Induction may have an important place in research, but its strength does not lie in generating new theories”* (p.170). Then, the authors emphasise about abduction: *“The Latin etymology of abduction suggests a leading away. In the context of research, abduction refers to an inferential creative process of producing new hypotheses and theories based on surprising research evidence. A researcher is led away from old to new theoretical insights”* (p.170).

In my research, I started with inductive coding and then moved to abductive reasoning for the theory building part of the grounded theory. The conceptual contribution of my thesis research builds further upon three stabilised concepts: formative evaluation, responsible research and the process of translation. By collecting my data through the ASIRPA RT approach to formative evaluation, these

three concepts fed into my data collection in the mission-oriented context of the PPR-CPA. Hence, my collected data gave new insights in these concepts in a changed context to the societal mission. This enabled me to conceptualise the contribution of ASIRPA RT to the responsibility of the PPR-CPA researchers, and build theory on the process of 'responsible translation'.

3.3.4 Using the analysed data in empirical chapters

In the writing of my empirical chapters, I used quotes from the interview and workshops with the researchers, the research proposals they wrote for the PPR-CPA, and the IP and narrative they constructed. The quotes were added to contribute and emphasise the arguments I am making. I adapted the quotes to grammatical standards, and removed wording such as hesitations like 'uhm'. Most – but not all - of the data that I collected is in French. I translated the French quotes that I use in the chapters into English, and when necessary, I double checked if the translation were correct through the DEEPL translator.⁷⁸ I indicated the translations as '*[translated from French]*' and added the original French quotes as endnotes and the end of the thesis (Annex IV).

In the thesis I use both 'I' and 'we' in the writing. Where I used 'I', it refers to my individual perspective or representation in a situation. If I use 'we', I refer to the act, perspective or representation of the ASIRPA team as a whole.

3.4 Reflexive learning in research

ASIRPA RT is a formative evaluation approach, implemented as an intervention research method. Thinking about possible 0-pesticides futures, and the contribution of research in this regard, requires a lot of reflexivity by the researchers. In this regard, the techniques of moderation for ASIRPA are key, as to be aware of objectivity and to be careful not to steer the visions of researchers. In addition, my role as a researcher is rather particular, as I have been involved in three parts: the development, implementation and observation of the ASIRPA RT tools. Therefore, in this fourth and final sub-chapter, I share reflections on my position as a researcher as well as on the ASIRPA team. In the first section, I reflect on my personal researcher positionality and illustrate how I took responsibility for my different positions as researcher and the methodological decisions I took in this regard. In the second sub-chapter, I reflect more general on ASIRPA (team). In the third section, I elaborate on my methodological decisions to ensure reliability and validity of my research findings. And finally, in the fourth section I share some reflections that the PPR-CPA researchers shared with us about their participation in ASIRPA RT.

⁷⁸ <https://www.deepl.com/translator>

3.4.1 My researcher positionality

Reflexivity on researcher positionality in social sciences is considered highly important, as to be aware of the (subjective) positions and roles a researcher adopts in their research (e.g., DeWalt & DeWalt, 2002; Gary & Holmes, 2020; Herr & Anderson, 2005; Olmos-Vega et al., 2022). Considering the various hats I have been wearing during my thesis research, and the different contexts I have been embedded in (ASIRPA team, PPR-CPA), this reflexivity is highly important for me. Therefore, in this part I elaborate on the reflexivity and the responsibility I assume in my position as a researcher in this study.

Gary & Holmes (2020) emphasise: *“Positionality is normally identified by locating the researcher about three areas: (1) the subject under investigation, (2) the research participants, and (3) the research context and process (ibid.)”*. Having this division in mind, overall, I adopted three researchers’ rationales in my PhD research:

1. **ASIRPA RT tool developer and facilitator in the PPR-CPA** - I adopted the role as a member of the ASIRPA team: I participated in the development of the ASIRPA RT methods and tools. This also includes the role as facilitator in the intervention research and observation of the participation of the PPR-CPA researchers.
2. **PhD candidate in Sociology of Science** - I adopted the role as PhD candidate in sociology: I aimed to understand processes behind envisioning transformative change in research and studied how ASIRPA’s intervention research navigated research visions of the PPR-CPA researchers.
3. **Observer of the ASIRPA team** - I adopted the role as observer of the ASIRPA team in their RT activities and tool development in the PPR-CPA.

I based the understanding of my position in these three research-rationales on the inside-outside dualism (e.g., Gary & Holmes, 2020; Herr & Anderson, 2005; Laycock Pedersen & Nikulina, 2021). This dualism is particularly important in, for instance, ethnography and action research. More specifically, I reflected upon my positionality as a researcher based on the six-level inside/outside continuum developed by Herr & Anderson (2014). They developed this continuum in the context of research positionality in ‘action research’. The authors argue that there is not just an ‘insider’ or an ‘outsider’ position, but between those there are other possible research positions: 1) Insider; 2) Insider in collaboration with other insiders; 3) Insider(s) in collaboration with outsider(s); 4) Reciprocal collaboration; 5) Outsider(s) in collaboration with insider(s); 6) Outsider(s) studies insider(s).

Considering the similarities between action research and intervention research, I based my reflections of my position as a researcher on this continuum. These insider/outsider reflections helped

me to identify how I took responsibility for my different positions as researcher and the methodological decisions I took in this regard. In my dissertation, I describe a rather particular case, as I did not only have to position myself in relation to the PPR-CPA projects, but also in relation to the ASIRPA team and activities we organised. Considering this inside-outside dualism, I have thus taken up three different positions, which I will deepen hereafter.

An outsiders' position collaborating with insiders: To start with the first position, the PPR-CPA included the ASIRPA RT approach to accompany the PPR-CPA researchers in navigating their visions of contributing to the 0-pesticides mission. Hence, with the ASIRPA team we develop and implement tools that help the researchers to contribute in eradicating pesticides. I – as a researcher part of the ASIPRA team – am an 'outsider' to this research on pesticides. For me, taking an outsider position was essential, as not to steer visions on the eradication of pesticides, but to help the researchers in navigating their research visions. A potential pitfall in this position was that I also have a scientific and professional background in Organic Agriculture and Agroecology. I took various responsibilities to ensure my outsider role to the PPR-CPA projects.

First, I was aware of the examples I gave during the various activities (such as the T_0 -interviews, or the workshops) when the researchers needed clarifications. With the ASIRPA team, we ensured to give as little as possible examples from outside their project as to not steer their visions. We tried to provide examples based on their specific projects and on situations, challenges and illustrations they had been given earlier. For instance, in the T_0 -interviews, I adapted some of the questions to situations they elaborated in their proposals. In the T_1 IP workshops, we tried to build further upon examples they already mentioned themselves earlier. Second, from the moment we started the T_0 -interviews, we constructed good relationships between the ASIRPA team members and the researchers. Some researchers indicated to be new to ASIRPA's type of reasoning. We ensured not to be judging what they had said, and that we were not speaking about 'good' or 'bad' visions of a 0-pesticides future. In addition, we also specified that we were not preparing their IPs either, but to provide them with an approach and tools to rethink their contribution to the mission. Third, in the writing of my thesis chapters, I tried as little as possible to personalise the projects and to be careful in the wording I was using to describe their visions.

Insider position: The second position reflects an insider position, considering my PhD research on the role of ASIRPA RT in navigating responsible research visions. In contrast to the previous position, it is not the 'pesticides research' or the 'PPR-CPA', which is the insider, but it is the ASIRPA team, which is the insider. As a PhD candidate, who is part of the ASIRPA team, I have thus been studying the effect of the implementation of our 'intervention'-research method in the PPR-CPA that

I am myself part of. In that sense, as an 'insider', I have thus been studying the effect my own (teams') intervention. The main issue for me in this regard was thus to ensure to be included in the ASIRPA team, but also to reflect on the implementation of the approach to limit my own influence and to ensure ample room for observations. I took various responsibilities to study the implementation of ASIRPA RT in the PPR-CPA.

First, I took active part in the ASIRPA team and in the development of the RT tools. Thereby, I could bring inputs from my PhD results as well as data requirements, and adapt the tools accordingly. Second, when I introduced myself to the participating researchers (in the T_0 -interviews, the webinars and the workshops) I presented myself as a PhD student and not just a member of the ASIRPA team. The researchers were thus aware of my position and the fact that their participation in ASIRPA RT fed into my data collection. Third, I adapted my role in the facilitation and animation during the ASIRPA activities. For instance, even though colleagues of ASIRPA were present as well during the T_0 -interviews, I was leading the questions. I kept rather close to the interview protocol, and guided or went a bit deeper into the questions when necessary. Instead, the other colleagues from ASIRPA reflected more on what had been said. In addition, during the T_1 -workshops, I did not take up a large role as animator. I mainly explained the tools (like the brainstorming on the MIRO platform), but was limited involved in the animation of the discussions. This allowed me to concentrate on observations and note taking, and it prevented me from influencing or guiding the discussion.

Insider position collaborating with insiders: Third, I have also been observing the ASIRPA team – and thus my colleagues – in the RT tool development. Considering that, I am also part of the ASIRPA team, I have thus been observing as an 'insider', other 'insiders'. There are two main reasons why this observation was key to me. First, my colleagues are experienced and knowledgeable in the ASIRPA approach, the scientific literature on which it is based and on animating participative research activities. Hence, observing them contributed to my own knowledge base, my personal development as a researcher as well as my professionalisation. Second, as I studied how ASIRPA RT supported the PPR-CPA researchers to assume responsibility for the mission, I also had to take up a critical role to our own activities. As I am studying ASIRPA RT as an 'intervention research'-experiment, it also required me to place myself as a researcher at distance from my team members, and consider the broader context of the approach. I took various responsibilities to observe the team in order to learn and to take a critical perspective.

When interacting with the ASIRPA team, I always specified from what position I was speaking: me as a member of the team, or me as a PhD student who is studying ASIRPA. This allowed also for my colleagues to understand the various roles I was adopting, but it required me to actively switch

positions within the process. Second, I observed the ASIRPA team during our internal meeting as well as during activities within the PPR-CPA. These observations were for instance about how the tools are developed, the interaction between my colleagues and participants, how they animated and participated (e.g., level of guidance) in the ASIRPA RT activities, etc. Third, I also adopted this position by observing ASIRPA in the broader context of the PPR-CPA as well as reflecting upon ASIRPA RT as the institutionalisation of RRI at INRAE. For instance, I participated in other activities of ASIRPA (e.g., the implementation in other workshops or programmes). I also followed the implementation of ASIRPA at INRAE, as well as discussions around it. This allowed me to understand what the interest is in ASIRPA and what such an approach can provide to researchers.

This complex positionality, could have caused biases if I did not properly comprehend and distinguish my roles between these three researchers' rationales. With all activities I did, I had to clearly keep in mind the research objectives and questions of my dissertation in order to not become preoccupied by the overarching questions of ASIRPA. I did this by taking on an active approach in discussing research with researchers outside the ASIRPA RT, for instance on the level of the research group or in international research communities. In addition, what helped me in particular was the co-direction of my thesis. One of the supervisors was part of the ASIPRA RT team and the other one was external to this process. This provides a rather important part of how I grounded my researchers' observations, as it gave me an 'insider' as well as an 'outsider' perception of my thesis research.

3.4.2 Reflexivity on ASIRPA RT

The ASIRPA RT tools were developed in the PPR-CPA as testbed, and is thus grounded in the experiences from this experimental implementation. Having the PPR-CPA as a testbed means that with the ASIRPA team we were 'learning by doing'. Especially in an intervention approach this can be useful by discovering empirically what concepts, activities, assignments etc. work and which ones need to be adapted.

A challenge - and major point of discussion within the team - was to find a balance in the level of guidance provided to the projects. An important aspect of ASIRPA RT is that it can be used independently by researchers. We had to explain often to the PPR-CPA researchers that it is not the ASIRPA team who is constructing nor evaluating the IPs, we are just providing the tools to navigate the researchers' visions. We used various metaphors to explain this. For instance, one, which explain how ASIRPA provides recipes in a cooking book, but it is up to projects to do the actual cooking and adapt the recipe according to their (product and cooking) preferences. To ensure our objectivity, we adapted also the techniques of moderation. For instance, the MOOC is developed in such a way to be used autonomously by researchers, and the T₁-workshops were set up with the idea that the projects

would lead the discussions themselves. Hence, it is key that ASIRPA does not steer visions or put specific ideas in the researchers' mind.

Also, we closely observed how the projects responded to the various activities, what their needs were in terms of our guidance, or about the amount of time they required. Throughout the T₁-phase, we remained in close contact with the PIs and project managers. The researchers could contact us through the discussion platform of the MOOC, and we co-organised the T₁-workshops in close contact with the PIs/project managers. Eventually, the researchers indicated their need for our involvement in their participation in ASIRPA RT. It remains thus an ongoing discussion how to guide the researchers.

In this regard, I also have some critical reflections on ASIRPA. I noticed that the PPR-CPA researchers had difficulties in understanding and appropriating the ASIRPA concepts such as societal transformations and societal impacts. As a consequence, the projects asked for a lot of guidance. However, as the tools and activities were not developed yet at the start of the PPR-CPA, we could not always quickly anticipate these requests. In addition, I believe there is some work ahead for ASIRPA to work on the communication of the concepts and approach, so that it is better understandable what the objective and processes are for researchers. I think that the experience of the PPR-CPA – notably this PhD dissertation – can feed into this task.

Also, I think that the ASIRPA team requires to be very reflexive on their moderation techniques, including an ongoing discussion on the level of guidance and intervention. I think this is crucial for the robustness of the approach. It is essential that the researchers' visions do not reflect ideas from ASIRPA members. During some of the activities, I felt that some team members were too involved in the discussion of the researchers. I believe it is our task as moderators to take a more distant approach and observe and oversee the ongoing discussions. A solution in this regard could be that ASIPRA members better identify and define their roles in these workshops, as individuals and as a team. So, reflection is needed on what roles to adopt: e.g., a role in moderating discussions? A role to guide discussions? A role to facilitate the completion of a process? A role as expert in ASIPRA IP construction? A role to help researchers? In this regard, it is also key that team members adapt their responsibilities and attitudes to fulfil these roles.

With ASIPRA we learned about the importance of good moderations of such interactive workshops and that we should not undermine this facilitating part in the further development of ASIPRA RT. I would advise the ASIPRA team to become trained in facilitation of collective intelligence. Such training can improve their awareness of their roles as facilitators and moderators, and how this can (mis)guide participants. I think that this become even more critical if ASIPRA RT starts becoming

more involved in more participatory processes. At this early stage of the PPR-CPA we only worked with researchers, but this might change over time. ASIRPA could get involved in multi-actor co-creation processes, which will push the ASIRPA team to deal with visions and interests of many more different types of actors.

3.4.3 Reliability and validity of the qualitative research

Reliability and validity are key issues in qualitative research to ensure the quality of the findings, and requires reflexivity in response to threats to qualitative research (Lincoln & Guba, 1985). According to Whitemore et al. (2001) "*Reliability referred to the stability of findings, whereas validity represented the truthfulness of findings*" (p.523). According to the authors, qualitative research needs to demonstrate: "*the truth value of multiple perspectives, the dependability of findings amid variability, the applicability of findings to broader contexts, and the freedom from bias in the research process were identified as validity issues to be addressed in the research process*" (p.524).

To ensure reliability and validity of the research findings, various methods exist. I am building upon the four techniques described by Whitemore et al. (2001): Design consideration; Data generating; Analytics; Presentation. First, for the design consideration, I have been deeply involved in ASIRPA RT. I will highlight a few key aspects in this regard. First of all, a key challenge in this thesis research is the embeddedness in the ASIRPA RT approach. At the start of this thesis the main principles and reasoning around ASIRPA RT existed, but the specific tools were further developed in the context of the PPR-CPA. Even though the PPR-CPA could be considered a testbed for the tool development, ASIRPA RT is based on the over 10 years of theoretical and empirical experiences of ASIRPA *ex post*. Second, as I explore a comparison between two phases – T_0 and T_1 – the same researchers and situations were selected for both phases to understand how ASIRPA RT supported the responsibility of the researchers. Instead of a comparison of researchers inside of the 0-pesticides mission, versus researchers outside the 0-pesticides mission (e.g., colleagues at INRAE), we decided to compare the same researchers in two phases of the same mission. Third, with ASIRPA RT we ensure a high level of researcher autonomy. We provided the approach and tools, but it was up to the researchers themselves to develop an IP and to discuss this among themselves. During the workshops, for instance, the ASIRPA RT team was critical on their own role and tried to animate and guide as little as possible. We ensure this for instance by staying in close contact with the IP and/or project managers of the PPR-CPA projects. We included them actively in the organisation and rolling out of the workshops.

Second, for the collection of the data I have used various methods. I did not rely upon only the recordings of the workshops and observations of the researchers in their participation, but I also

collected data through the IP the researchers developed and the narratives that they wrote about their IPs. For various reasons, it was key to include these different data collection methods in order to capture the visions of the researchers about the expected contributions to the mission. First of all, it overcomes issues of individual versus collective visions of researchers within the projects. The IP and narrative were mostly developed by a few researchers of the consortium. The workshops gave the opportunity to the researchers to collectively share and discuss their visions, and adapt the IP and narrative in this regard. Second, the researchers had ample time to construct their IP – over six months – which gave them time to participate in the MOOC and to more deeply reflect on their (collective) visions. The workshops were largely constructed around these developed visions, and were thus not based on individual ‘on the spot’ visions, but on the (collective) process of developing an IP. Also, I collected data for eight projects in different domains, in which a variety of researchers participated. The total number of researchers who participated in the ASIRPA RT activities was thus large and highly diverse.

Third, I used the NVIVO software to organise my data and to ensure rigour in my qualitative coding. I conducted three coding exercises at different points along the research process, as my theoretical and empirical understanding of the case evolved. The final coding included all data from T_0 and T_1 , based on a detailed codebook, which had been elaborately discussed with my thesis supervisors. In addition, to ensure the validity of the coding exercise, my supervisors did a part of the coding based on the codebook, which could be compared to my coding results.

Finally, in the presentation of the research findings, all arguments that I construct are based and underpinned by quotes and examples from the researchers. I emphasised whether the examples are based on an individual vision of a researcher (a quote of a researcher) or a collective vision (a quote from the research proposals or the IP narrative).

3.4.4 Reflections of the PPR-CPA researchers on ASIRPA RT in navigating Research visions

We need the ASIRPA team to move forward. We need a boost, we're overwhelmed with a lot of things. And so, you'll have to present and be super nice. And keep it up, that was good. But here we are, we need these reminders to move forward.

- **Workshop with Pherosensor [translated from French^{xv}]**

This quote comes from the PI of PheroSensor at the end of the ASIRPA workshop. The researcher reflected on the ASIRPA assignment to prepare a project IP, but also the need for ASIRPA RT to keep accompanying the researchers in their mission-oriented pathway. In the four empirical

chapters of this thesis (Chapters 4, 5, 6 and 7) I explored how the intervention of ASIRPA RT supported the PPR-CPA researchers in envisioning the contribution of the alternative solutions they study as part of the 0-pesticides mission. In this final section, I highlight reflections on ASIRPA RT expressed by the researchers. I do not aim to provide a deep analysis of the use of the ASIRPA RT tools, but I want to highlight some aspects on its use - such as difficulties and usefulness - which were addressed by the researchers. This will put the results as discussed in the empirical chapters in the context of the projects' participation in ASIRPA RT activities.

What is interesting is that it allowed us to really think about the actors and their role. I think it's quite interesting to see whether we have identified all the people who could be interested in the model's outputs, and I think that it's not an understatement to say that in the communication that we're going to do during the project, etc. We already have this scheme in mind and it can help us to target the paths to be taken more precisely.

- **Quote from a researcher of CapZeroPhyto during the workshop [translated from French^{xvi}]**

On this exercise it is very good. A lot of things have been said. It's going to be used to complete the existing impact pathway, as [name] said, which we're going to work on, because the idea is not to make an impact pathway for the sake of making an impact pathway, it's to use it to achieve the targeted objectives. So, we're going to integrate all of this so that we can build this action plan. The strategic plan and identify the people to contact and how to proceed to remove the obstacles identified. And we have quite a lot. So, there's still work to be done, and for that. The idea is to do it with all the stakeholders in the project. So, everyone has their own expertise. And that's it. So, I think that we will then come back to everyone with all this digested information.

- **Quote from a researcher of SUCSEED during the workshop [translated from French^{xvii}]**

These two quotes - from researchers of CapZeroPhyto and SUCSEED - illustrate that they considered the ASIRPA RT method to be a useful tool for the continuation of their project as part of the 0-pesticides mission. Especially for the identification of-, and connection to, non-academic actors, the construction of the IP is seen as a useful tool. As the researchers demonstrated, it made them reflect on who and what is needed regarding their contribution for the mission. This included reflections on whether they already have existing ideas, partners or networks that could be build further upon. For instance, the PI of PheroSensor explained during the workshop [translated from French^{xviii}]:

So, I've already taken part in a first webinar where I presented PheroSensor, in a national webinar. But there were a lot of technical phytosanitary companies. [Name] and I were invited to the webinars in the same vein, so we started to spread the word. It's just a start. I'm not saying that we've done everything we needed to, not at all. But I think that we are here, as [name] says, to identify actions. And then, I think, the role of ASIRPA is to avoid

falling asleep and staying on our academic impacts. As I was saying, we should always think in terms of power, in terms of transfer to socio-economic and political realities and so on.

This quote expresses how PheroSensor's researchers already started working on communication and outreach early on in the project, in order to interest technical companies in their sensors. At the same time, the PI expects ASIRPA RT to guide the project in this regard and to make sure they keep connecting to external actors.

However, as several of the researchers indicated, the identification of actors at this early stage of their research project is challenging. They stressed that it is too early on in the process to identify those actors that are needed, and that first results of the projects are a requirement. As a final activity in the workshops we organised with each project, we asked them to prioritize 'what needs to be in place' in their research contributions to societal transformations, and what actors would be required in this regard. To provide some examples, a researcher from SUCSEED mentioned in this regard [translated from French^{xix}]:

And indeed, the exercise is not easy to do in the sense that we are still at the beginning of the project. We don't have a lot of things that come up because we find it under the constraints of the needs that we generally find in biocontrol or in biocontrols that we find as soon as we talk about biostimulant stimulation, etc. But anyway, it will evolve too. But in any case, that will evolve too. As you said at the beginning of the meeting, it will evolve over time and it will be enriched.

In addition, PheroSensor mentioned [translated from French^{xx}]:

I think it may be too early at this stage, but it doesn't mean we can't identify it, anyway. In any case, I've been canvassing in our area. It's part of the way we do things at the AUC and we develop new technology. That's the first thing we look at, is whether we're going to be able to do it? Is anyone going to be able to produce? And because indeed, if we have a great technology, but we don't know how to produce it, because there is no channel or anything, it will necessarily be a constraint to the exploitation.

As these quotes illustrate, we found that this exercise was challenging this early in the process. These difficulties are not just about identifying actors, as the researchers show, but also to enrol these actors; What actions are necessary to involve them? What are the roles of these actors in impacting society? One of MoBiDiv's researchers reflected on the integration of actors in their IP as follows [translated from French^{xxi}]:

So, we are issuing invitations, we will have a first exchange and we have decided to try to have these meetings on an annual basis. And I think that, in the way of exchanging and getting feedback, of displaying a certain number of things, we can refine this vision of the

impact pathway and then we have to do things with the actors. So, there you have it, it's good to have the pathway, but afterwards, we have to develop it. Actions, what?

This quote highlights that the construction of the IP made them reflect on the action that are necessary to enrol actors in their project's contribution to the mission. Other projects, for instance FAST, had more issues in general to reflect on involving actors and their needs, on both short and longer term. They envision their responsibilities as researchers in political sciences rather separate from the roles of policy makers.

Finally, ASIRPA RT also made some project' researchers aware of both their expertise, as well as their non-expertise. The PPR-CPA as a programme is thereby mentioned as a building block to find synergies between expertise within the various projects. This was for instance indicated by researchers of PheroSensor. They mentioned that they do not have the expertise on Prophylaxis in their project, which would be important in combination with the field implementation of their sensors. They emphasised that in other PPR-CPA projects there is more expertise on that topic. The programme is a good way to find synergies and discuss solutions to eradicate pesticides together. Particular the ASIRPA RT activities on programme level feed into this, which are not the subject of study in my thesis (see Chapter 3 – Methodology).

Conclusion

To conclude this chapter, by conducting my research as part of ASIPRA RT in the PPR-CPA, I had unique access to the intervention of a formative evaluation approach to support researchers to responsabilise in a mission-oriented setting. This enabled me to explore the responsible translation process, and the support of ASIRPA RT as a formative evaluation to the responsibility of the PPR-CPA researchers. The PPR-CPA is a mission-oriented research programme with the ambitious goal to eradicate pesticides in France by 2040. The programme funds ten research projects that explore alternative solutions to pesticides. Specifically, the researchers of these projects are encouraged to think about their contribution to the constitution of a pesticide-free society with the alternative solutions to pesticides they study. The PPR-CPA has integrated the ASIRPA RT impact assessment approach, a formative evaluation approach, to support researchers in this process.

I compared the researchers' visions of the expected contributions of the alternative solutions they study to a society without pesticides, between a T₀-phase (before they got involved in ASIRPA RT) and a T₁-phase (after one year with ASIPRA RT). All ten projects participated in the data collection at the T₀-phase, while only eight out of the ten projects participated in ASIRPA RT activities at T₁. In my research I used the qualitative research approach of 'grounded theory', through data that I collected by participant observations and semi-structured interviews. I also had access to the responses of the

ten funded projects to the PPR-CPA project call, and the IPs, brainstorm activities and impact narratives the researchers developed through their participation in ASIPRA RT activities.

I analysed the data through inductive coding and abductive reasoning, which enabled me to explore the links between formative evaluation, responsibility, and processes of translation. I developed the notion of 'responsible translation' that I explore in the empirical chapters of my thesis. This describes the process of translating visions of alternative solutions into those of a society that has used these solutions to eradicate pesticides. This is largely inspired by the work of Callon (1986), but I adapted the analysis of this process to the societal mission of the PPR-CPA and the role of ASIPRA RT in accompanying the researchers. In envisioning 1) the establishment (through problematisation), 2) the realisation (through interessement and enrolment) and 3) the mobilisation of science-society associations in a mission-oriented context. I used this as an analytical framework to explore my T_1 data.

As I collected my data as part of the intervention of a formative evaluation approach, I elaborately reflect on my researcher positionality, on the ASIPRA RT team, as well as on the reliability and validity of my collected data. The techniques of moderation for ASIRPA are key, as to be aware of objectivity and to be careful not to steer the visions of researchers. In addition, my role as a researcher is rather particular, as I have been involved in three parts: the development, implementation and observation of the ASIRPA RT tools. I had to actively switch positions between being a PhD-researchers, and being part of the ASIPRA team.

Chapter 4

The Construction of Mission-Oriented Research: How Researchers Envision their Contribution to the 0-Pesticides Mission

Chapter 4. The Construction of Mission-Oriented Research: How Researchers Envision their Contribution to the 0-Pesticides Mission

As elaborated in Chapter 1, the PPR-CPA is a research programme with an ambitious mission: to contribute to a 0-pesticides agricultural future in France by 2040. Different from previous research programmes (such as the Ecophyto plan), it is not about a reduction in pesticides use, but it is about 'zero' use of pesticides. This requires new ways of constructing and doing research, which should contribute to this mission. The programme report stressed in this regard (Jacquet et al., 2019) [*translated from French^{xxii}*]:

This ambition therefore goes far beyond the issues underlying most of the research and applied research projects conducted to date and leads to the exploration of new fields of research. Setting such a course allows us to develop knowledge today to have tomorrow's solutions to meet society's demand for a pesticide-free agriculture. It requires a change of perspective in order to promote progress on promising scientific fronts that are new or insufficiently explored, and an evolution of scientific disciplines that integrates the new challenges and advances of other disciplines.

Hence, the ten funded projects within the PPR-CPA take part in an ambitious mission-oriented research programme. The PPR-CPA is an innovative research programme that is supposed to eradicate pesticides as a key input in farming systems, because of the harmful impacts of pesticides on society. This requires the programme, and hence the funded research projects, finding alternative solutions to pesticides, and define how they can contribute to the eradication of pesticides in society beyond scientific terms. Consequently, contributing to this societal mission requires new, responsible ways of conducting research. Specifically, the projects must reflect upon their contribution to impacting society as part of the 0-pesticides mission. The PPR-CPA has included the ASIRPA RT approach as a means to accompany researchers in navigating their visions of contributing to pesticides eradication in society.

In this chapter, I explore the PPR-CPA researchers' visions of their contributions to the 0-pesticides mission at the T_0 -phase. This represents the phase before the researchers participated in the ASIRPA RT activities (see Chapter 3). Consequently, exploring this T_0 -phase allowed me to study how the researchers envisioned their contribution to the 0-pesticides mission before their visions were navigated by ASIRPA RT. At T_0 , the majority of the PPR-CPA researchers showed to be rather unfamiliar with the ASIRPA RT approach and the related terminology used such as 'societal impacts' or 'societal transformations'. To illustrate, I extracted the following quote from the T_0 -interview with the PI of DEEP IMPACT, who positioned himself as a fundamental researcher:

This question of impact is not very familiar to me. Because for me impact is more the number of papers you publish this year. But I think it's really important to have this contribution in the PPR project. I don't know if it's a new way of doing science, but perhaps it's something that is not so much taken up on when you are working on applications. Because we are a new...it's out of my comfort zone...it's not my business as usual.

With the ASIRPA RT team, we responded by explaining the approach to him, and how we will accompany researchers in navigating their visions for the 0-pesticides mission. In turn, the DEEP IMPACT PI replied:

This is not so evident for scientists. I don't know if I gave you good answers to your questions, because this is not a classical way of thinking. Or to try to transform a research question in...with this impact, expectation, or transformation [...] but it's a new thing for me, to try to integrate the impact of the research project which are not so plentiful, also because we are on the more basic science and not so much on applied science. People on the more applied science work on things that are more evident to take in account, because you work or deal more with stakeholders or private companies who have different expectations of such project.

This quote illustrates how the researcher expresses himself to be rather unfamiliar with the terminology of ASIRPA RT at T_0 , and even questioned whether he responded in a 'correct way'. Similar reflections were given in the interviews by other PIs as well. The researchers demonstrated their visions of the expected capacity of the alternative solutions they study in their research projects to contribute to the eradication of pesticides in scientific terms. However, what we aim for with ASIRPA RT is to help directing their research towards societal goals. The researchers are encouraged to think how they expect that alternative solutions can contribute to the constitution of a pesticide-free society, which goes beyond a scientific way of knowing such a society. Hence, I illustrate in this dissertation a change in visions of the expected contributions to the mission when the researchers are supported by ASIRPA RT.

To start, in this chapter I describe the researchers' visions of the expected contributions to the mission at the T_0 -phase. I respond to the first specific research question: *How did the PPR-CPA researchers envision contributing to the 0-pesticides mission by studying alternative solutions to pesticides, before they got involved in ASIRPA RT? How did these visions influence the construction of their research projects?* I respond to this research question based on the empirical data collected through the PPR-CPA project proposals and the T_0 -interviews held with the project' PIs (see Chapter 3.2). Based on this data, I argue in this chapter that the researchers' visions at T_0 reflect renewed and ambitious research questions about alternative solutions to pesticides in their contribution to the mission. However, the envisioned contributions are shaped in a rather linear way, whereby change in

society is the result of the transfer and straightforward use of research results in society. Hence, it reflects a rather scientific way of knowing a 0-pesticides society.

To provide an example, the PI of DEEP IMPACT used the following analogy of a puzzle to describe how he envisions his project's contribution to 0-pesticides mission:

INRAE for me, and that's why I want to work at INRAE, because they think that the world of agriculture is a fascinating world. Because since the start of civilisation you have to feed the world, you have to feed civilisation, and farmers are a key player or key actor of our society. And I think to perform, and to have a contribution to that you need to have an open mind, you have to say sometimes: ok, I am a scientist, I make very good science, but sometimes I need to discuss with farmers and try to understand what their problem is, to transform their problems into scientific questions and try to see with my expertise how I could help in a specific way. But it's always like a puzzle. To have a contribution is trying to fit my piece of the puzzle - in a major puzzle which in the end will become beautiful. But my piece won't be very important if I can't integrate my piece with other pieces of the system

This quote highlights the researcher's visions of the role of his project to conduct excellent science, and the need for other actors in society in this process. At the same time, he also highlights transforming societal problems into scientific questions.

My argument of this T_0 -chapter is structured around four interlinked dimensions, which demonstrate the construction of the PPR-CPA projects in the mission-oriented context and reflect the researchers' visions in this regard. I explore these dimensions through four questions, each representing a sub-chapter: How does the construction of the PPR-CPA projects reflect the researchers' visions of 1) their contribution to eradicating pesticides? 2) their contributions to a '0-pesticides society'? 3) a change compared to their previous projects, considering the 0-pesticides mission? 4) the associations between their projects and a 0-pesticides society?

4.1 Researchers' Visions of the Eradication of Pesticides

The main objective of the PPR-CPA projects is to contribute to a 0-pesticides agricultural future in France. It required the projects to define and orient their research in such a way to be able to contribute to this large societal mission. Hence, in this first sub-chapter I will explore the first dimensions: how the researchers' visions of the eradication of pesticides defined the construction of their projects. It demonstrates how the researchers expected to contribute to the eradicating of pesticides at T_0 .

In the interviews, the PIs indicated that they had been involved before in projects that aimed to reduce the use of pesticides, but none of them had worked for a 'zero' pesticides mission thus far. Because of their experiences in this field of pesticides reduction, many of the ideas of the ten consortia

emerged already before the launch of the programme. At the time of the launch in 2019, the PPR-CPA was seen as an opportunity or facilitator to apply the ideas that were already there in a ‘0-pesticides’ situation.

In this first dimension, I illustrate how the construction of the projects is influenced by researchers’ visions of the expected contributions of the alternative solutions to the eradication of pesticides. Their visions reflect three interlinked elements of expected contributions to the eradication of pesticides:

1. The 0-pesticides research paradigm;
2. The contribution to a change in the pest management function;
3. The research on alternative solutions to pesticides.

Table 7. The researchers’ visions on the eradication of pesticides: three elements

3 Elements of research contributions to the eradication of pesticides	Research field 1	Research field 2	Research field 3
1. The 0-pesticides research paradigm	Agri-food systems, markets and policies	Genetics, diversity and biocontrol	Epidemiosurveillance and prophylaxis
2. Contribution to change of the function of pest-management	Agri-food system change	Plant resilience, defence, and immunity	Prophylaxis
3. Research on alternative solutions to pesticides	Systemic approaches – organisational and social innovations	Cropping technologies (e.g., seeds, biocontrol)	Technologies for epidemiosurveillance (incl. data models)
The involved projects	Be Creative; Fast; SPECIFICS; MoBiDiv	CapZeroPhyto; Deep Impact; MoBiDiv; SUCSEED; VITAE	Beyond; PheroSensor; VITAE

Exploring these three elements provides a framework for understanding the construction of the ten PPR-CPA projects (summarised in Table 7). To start, the ten projects support three main research paradigms in eradicating pesticides.⁷⁹ The first research field is on ‘**Agri-food systems, markets and policies**’. Research projects in this thematic field embed visions that moving away from chemical pesticides in pest management requires a transition in the agri-food system. The researchers aim to contribute with their projects by adopting systemic approaches, including organisational, institutional and social innovations.

⁷⁹ Some projects focus on more than one of these research fields through their various work packages.

The second thematic research field is about '**Genetics, diversity and biocontrol**'. Research projects within this field focus on plant resilience, (natural) defence and immunity, through (new) crop technologies such as improved seed varieties, better understanding defence processes or biocontrol options. This research explores rather technological and agronomic innovations. A third thematic research field, which is like the second field also technology focussed, is about '**Epidemiosurveillance and prophylaxis**'. These projects aim for improved prophylaxis⁸⁰ through technologies for epidemiosurveillance. This includes not just the technologies itself, but also data, indicators and models to better predict the spread of disease.

I demonstrate for each of the three thematic research fields, how these three research elements influenced the construction and orientation of the research projects in their contribution to the mission. I illustrate this by discussing three research dimensions of each research field:

1. Level of analysis and intervention (in relation to pest management)
2. Associations of research to society
3. Activities to favour acceptance by society

4.1.1 Research field: Agri-food system, markets and policies

The projects within the thematic research field on 'agri-food system, market and policies', are building upon rather systemic and integrated approaches. Table 8 highlights the characteristics of this research field for the 0-pesticides mission, based on the three research dimensions. This contributes in understanding how the researchers expect to contribute to the eradication of pesticides and how this is reflected in the construction of the research projects.

Table 8. The characteristics of research field 1 based on the three research dimensions (Agri-food systems, markets and policies)

Research Dimensions	Characteristic of the research field
1. Level of analysis and intervention	System level – reduce dependence on pesticides
2. Association to society	Response to socio-economic challenges and system lock-ins
3. Activities to favour acceptance by actors	Stakeholder involvement

Level of analysis and intervention

To start, emphasising analyses beyond field level is essential for the research projects within this research field who embed a more systemic approach. Integrating various scales or levels of analyses allows combining knowledge from various research domains and stakeholders of various

⁸⁰ Phrophylaxis refers to the measures to prevent the spread of diseases (source: Merriam Webster Dictionary)

sectors that are interlinked to one another. These projects strongly embed the vision that an agricultural future without pesticides does not just affect farm or field level, but embeds various levels of the agri-food system.

For instance, the proposal of FAST emphasises the importance of understanding interactions between actors at different scales and domains, such as markets actors and policy makers, as well as at different levels (e.g., local, regional, national or European) in the transition to 0-pesticides. The proposal highlights the projects' orientation to produce knowledge about the level at which '*changes must occur to be socially acceptable and legally feasible*' as well as knowledge on how actors at different scales and domains are impacted by a 0-pesticides future. In addition, FAST argues that a food system approach is key in supporting public policies, which support transitions '*based on collective action*'.

Similarly, the PI of Be Creative argued [*translated from French^{xxiii}*]: "*For us, agriculture without pesticides is the bet we made in the project that it obliged us to think on a territorial scale or territorial agri-food system. I think that there is still a bit of vagueness, but in any case, we cannot be satisfied with producing very detailed knowledge on plots or farms.*" Hence, Be Creative embeds a specific focus on the territorial level, as this scale is envisioned an essential level of analysis for a transition to food systems without pesticides.

Association to Society

Second, the rather systemic approaches embedded in this research field are a response to socio-economic challenges and (market) system lock-ins that need to be overcome for a 0-pesticides future. The PI of Be Creative argued [*translated from French^{xxiv}*]:

There may be negative effects on these sectors, which are very well organised today. And that's why I have doubts at the same time as I'm talking to you, because they are already so locked in, so well organised that to deconstruct them, niche markets will have to hold on to shake up these dominant models. The ambition of our project is to shake up this dominant model in certain territories in order to demonstrate it or not.

Hence, building upon the first point, a systemic approach is needed to overcome lock-in effects, which might result from the impact of a 0-pesticides future on various sectors of the system. Important aspects in this regard are the economic impacts of the eradication of pesticides on various sectors, and how these sectors within the system can be changed. To give another example, the PI of MoBiDiv explained that markets for 'pest management products' are centred on a few important crop species. Hence, such lock-in effects are expected to be studied in the project. This is also about the

socio-economic system that should be in place to support the transition to a 0-pesticides agricultural future.

In this regard, the researchers expect to contribute in overcoming such challenges and lock-ins, which they consider key for the mission. The researchers of SPECIFICS, for instance, argue in the proposal:

At the farming and agri-food system level, the objectives are on one hand to quantify the benefits and risks of grain legume-rich pesticide-free farming systems through agronomical and micro-economical multi-criteria approaches and identify the conditions of success, and on the other hand, to imagine new ways out of socio-economic locking such as more adapted counselling, or contractualisation.

They will conduct specific organisational analysis such as the influence of eco-labels or production contracts on on-farm crop diversification. To provide another example, FAST aims to conduct such assessment on a rather policy level. They will assess the effect of policy approach, which supports the 0-pesticides transition on socio-economic lock-ins. Hereby they aim for *'the harmonisation of local, national and European regulations'*.

These projects embed therefore a systemic approach to transform the agri-food system on two main levels of analyses. First, they aim to analyse the effects of the eradication of pesticides on farm level from environmental, agronomic and socio-economic points of view. Second, they aim to understand the socio-economic lock-in effects for the 0-pesticides transition, by analysing how other sectors influence and are impacted by the eradication of pesticides.

Activities to favour acceptance by society

Third, and a very strong aspect in this research field, is about the involvement and interaction with stakeholders, in order to favour acceptance of alternative solutions to pesticides by actors in society. As the PI of Be Creative argued in this regard [*translated from French^{xxv}*]: *"It is inevitably, something that is thought out and constructed with the actors in the field at the interface between research and action"*. Therefore, the research projects embed various multi-actor, action-research and participatory approaches. Such approaches do not just focus on innovation for change on field- or farm-level, but on the broader socio-economic changes needed for the transition to a pesticide-free agri-food system. Researchers envision the interactions and production of knowledge among actors about the transition of the system and what is required to achieve this. Hence, such approaches target a wide range of actors from within the system, such as farmers, breeders, extension services, researchers, cooperatives, policy makers and other agri-food companies. This also aims at creating

context-specific solutions and influencing interactions among stakeholders within the agri-food system on different levels (e.g., territory or landscape).

4.1.2 Research field: Genetics, diversity and biocontrol

The research field on ‘genetic, diversity and biocontrol’ is a rather broad research field, with a major focus on crop protection strategies. Table 9 highlights the characteristics of this research field for the 0-pesticides mission, based on the three research dimensions. This contributes to understanding how the researchers expect to contribute to the eradication of pesticides and how this is reflected in the construction of the research projects.

Table 9. The characteristics of research field 2 based on the three research dimensions (Genetics, diversity and biocontrol)

Research Dimensions	Characteristic of the research field
1. Level of analysis and intervention	Crop and field level – replacing pesticides
2. Association to society	Transfer scientific knowledge into practice
3. Activities to favour acceptance by actors	Appropriation and feasibility of innovation

Level of analysis and intervention

The research projects within this research field aim to contribute to (technical) alternative solutions to pesticides, whereby the researchers target field level. These alternative solutions can be divided into two main categories, but they are all focussing on crop immunity and resistance. The first category is about crop protection technologies, such as improved seed technologies or biocontrol options, as alternatives to pesticides. This is for instance the focus of SUCSEED and CapZeroPhyto. The second category was emphasised by the PI of DEEP IMPACT:

My dream is really to say that we are going to - with plant microbiota interaction - give a strong aspect of how to manage crop production and trying to put the nature at the heart of the system. And if you are able to have a good understanding, a good balance with this biodiversity, normally the plant doesn't need pesticides. And so, I think we are on the way to go to zero-pesticides, we just need to put the good knowledge on what happens.

Hence, this is about the re-design of cropping systems, targeting in-field diversity (including breeding activities to facilitate crop diversity), to support crop resistance through in-field interactions (e.g., crops, microbiota). This type of research is for instance found in SPECIFICS, MoBiDiv and DEEP IMPACT.

Association to society

The second characteristic of this thematic research field is the envisioned transfer of scientific knowledge into practice. Hereby demonstrations, field experiments as well as exchange of expertise

between various stakeholders play an important role. The main idea is to exit the primarily research environment, where experiments are conducted under controlled conditions, to practical application under 'real' circumstances of cropping systems. For instance, the PI of CapZeroPhyto explained about the project [*translated from French*^{xvii}]:

It's a project that is linked with the technical institutes to facilitate the transition between the research aspects and the aspects applied in the cropping systems. There is also the involvement, as an academic partner, of subcontracting trials to experimentation stations, for example. That's how we are... to test the effectiveness of these levers under production conditions.

Hence, this envisioned transfer to practice does not have a sole focus on farm or field level. It also largely links to technology level, as technical institutes are envisioned to play an important role in this transfer.

To support the practical applications of these technological innovations, various projects embed participatory approaches. This is envisioned with two main objectives, with a focus on the research outputs. First, activities are envisioned such as workshops, exchanges or demonstrations (field visits) of alternative solutions to pesticides. The focus here is to discuss the transfer from research to the field, or to demonstrate the efficacy of proposed solutions to pesticides. For instance, DEEP IMPACT and CapZeroPhyto plan to implement such activities.

Second, such activities are envisioned for the analysis of alternative solutions to pesticides under farm-conditions. For instance, in their breeding activities, researchers of MoBiDiv aim to support '*optimising the on-farm management and selection of diversity*', including assessing the efficacy of varieties with breeders and farmers. Such participatory approaches are also envisioned for demonstration and knowledge exchange of the performance of cropping systems, whereby a connection to the French Dephy farm network⁸¹ is often envisioned. For instance, the PI of SUCSEED mentioned:

Do you know Dephy? Because there is a number of farms or systems on that. And I looked quickly at the different projects and there are some projects that are specifically looking at growing seeds without any pesticides in seeds. That is definitely need something to bridge – I mean if we can contact these people and see if they are interested in being included for example during the project. That would be really interesting.

Others, such as researchers of SPECIFICS are already connected to farms within the DEPHY network through previous research activities. This allows them to study the 'multicriteria

⁸¹ The DEPHY farm network is an important outcome of the Ecophyto plan: https://ec.europa.eu/food/system/files/2019-03/pesticides_sup_nap_fra-ecophyto-2_en.pdf

performance’ – e.g., economic, environmental or agronomic (pest regulation) performance - of the diverse, legume rich systems they envisioned within a large number of farms in France

Activities to favour acceptance by society

A third important characteristic of this research field are analyses of feasibility and the acceptability of the alternative solutions to pesticides by actors in society. Hereby multiple aspects and envisioned research activities play a role to support this. To start, for instance, researchers envision participatory approaches to ‘develop context-specific solutions’ (MoBiDiv), through the anticipation of ‘needs and obstacles’ (CapZeroPhyto), or through understanding acceptance by analysing ‘willingness to pay’ (VITAE). Hence, such envisioned research activities are to identify facilitating and blocking factors to the acceptance of alternative solutions by actors.

Second, for example, researchers of CapZeroPhyto envision conducting a feasibility study whereby they analyse farmers’ preferences as a key step towards the adoption of their alternative solution. This envisioned analysis concentrates on ‘economic profitability’, as the researchers argue in the project proposal:

We know that producers are more likely to adopt innovations with low initial investment, reduced production cost including working time, higher average yields and lower risk of harvest lost as well as improved nutritional quality, taste and appearance for food products. Yet, alternatives to pesticides tested in the project are unlikely to fulfil all these conditions. Producers will necessarily face trade-offs. Using a methodology named “discrete choice experiment”, we will estimate the relative importance of each characteristic and the trade-offs.

During the interview, the former PI of CapZeroPhyto complemented [translated from French^{xxvii}]:

This phase is an integral part of the project, therefore, either by carrying out surveys on the current practices on apple and tomato and then... to carry out feasibility surveys in fact of the use of these levers in the cropping systems to make them evolve. The idea is also, through this feasibility survey, to study the choice of professionals.

Hence, research activities to favour acceptance of alternative solutions are also about the socio-economic feasibility and marketability, to overcome or anticipate socio-economic lock-ins. Similarly, researchers of projects such as SPECIFICS and MoBiDiv also envision analysing their alternative solutions in their socio-economic context. Their focus is on identifying what changes or conditions on organisation or institutional level should be in place for their solutions to be adopted in the field. For instance, researchers of SPECIFICS will analyse the influence of ‘adapted counselling and contractualisation’ on the acceptance of alternative solutions by farmers.

Building further upon this, also policy and regulations are considered key in relation to the acceptance and marketability of alternative solutions to pesticides. This specifically counts for MoBiDiv and SUCSEED, both projects with a focus on seed solutions. MoBiDiv aims to market seed mixtures, and the PI of MoBiDiv mentioned about this subject [*translated from French*^{xxviii}]:

There are criteria called DHS - distinctness, homogeneity and stability -that go against the use of...diversified seeds, so one of the changes we expect from the project is to have an evolution of the regulations on the registration of seeds that allow the marketing of mixtures, the registration or at least an evolution of the regulations to allow a diversity of the seed offer.

In addition, SUCSEED aims to develop improved seed technologies, and researchers argue in their proposal:

Improving scientific knowledge is essential to put in place an appropriate legal framework to support innovation and encourage companies to invest in alternatives to pesticides [...] These different questions will be tested experimentally in the SUCSEED project and the results will guide the design of effective seed microbiota-based solutions to replace pesticides.

Hence, both projects mention their dependence on regulation and standards for the marketability of their seed-innovations, and their envisioned contributions in this regard. Researchers of MoBiDiv will analyse current seed standards in France along the value chain (e.g., certification and registration) to see how their proposed solutions fit within the current regulations. As SUCSEED's researchers propose another type of technology, they fall under another type of regulation than MoBiDiv, which includes beyond national, also European and International regulations (on phytosanitary products). The 'adaptation to scientific progress' is essential, as it could block the marketability of their solutions.

4.1.3 Research field: Epidemiosurveillance and prophylaxis

The third thematic research field on 'Epidemiosurveillance and prophylaxis', a technology driven field, is diverse and includes different scales of analysis to contribute to the eradication of pesticides. Table 10 highlights the characteristics of this research field for the 0-pesticides mission, based on the three research dimensions. This contributes in understanding how the researchers expect to contribute to the eradication of pesticides and how this is reflected in the construction of the research projects.

Table 10. The characteristics based on the three research dimensions of research field 3 (Epidemiosurveillance and prophylaxis)

Research Dimensions	Characteristic of the research field
1. Level of analysis and intervention	Field and landscape level – direct relation to pests
2. Association to society	Transfer to the field and the user interface
3. Activities to favour acceptance by actors	Contributing to decision making

Level of analysis and intervention

This research field has a rather technological focus. However, compared to the second research field, visions in this research field reflect another way of reducing pesticides use. It is not about directly replacing pesticides as envisioned in the other research fields that largely focussed on diseases and fungi. Instead, researchers' visions reflect changes in decision-making for pest management, through early prediction, detection and (eventually) interruption of pest pathogens on field and landscape level. Hence, it is not about alternative solutions to replace pesticides directly, but about alternative solutions to pesticides by facilitating prophylaxis, i.e. the measures to prevent the spread of pests. Examples of such projects are BEYOND and PheroSensor, and partly VITAE.

BEYOND and PheroSensor are rather complementary projects. They both focus on epidemiosurveillance (ES) in relation to the collection and analysis of data on pest occurrence in order to adapt prophylaxis. For example, PheroSensor specifically focusses on insect pests, and in this regard, the researchers emphasise in their proposal: *“The control of insect pests requires alternative solutions as well as early species detection before infestation settles in order to adapt the timing of treatments and to monitor population trends and dispersion”*. Therefore, they aim to develop ‘pheromone sensors’ to early detect pest insects by capturing pheromones released by insects. They define this as a key measure in controlling pest outbreaks:

The challenge for ES is to create a reasonable timeframe to carry out the various, more time-consuming, prophylaxis. For example, biocontrol agents, deployed through inundative or conservation methods, require time to be installed and often need to be coordinated with seasonal or cyclic phenomena.

Hence, where PheroSensor has a focus on ‘early detection’, BEYOND targets ‘early prediction’ of pests in order to control outbreaks and adapt pest management strategies in this regard. A major difference between the two projects is the scale: PheroSensor’s scale of intervention is on field level, while BEYOND embeds a larger (international) geographical scale. With their focus on field-level, the researchers of PheroSensor – and likewise VITAE - also want to approach. Hereby the aim is to disrupt

the biological cycle of insect pests, for instance by the spread of artificial pheromone odours. The PI of PheroSensor commented about this envisioned research effort:

So, this is great, but not always working and so when people...the farmers...when they know that it's not always working, they will say: well it's not always working and it's expensive, so I don't want to use it. So, we have a way with our sensors, to improve this technique and to make it more reliable. So, I think this can be a very positive effect for farmers in the end. So that's another way to help to reduce the use of pesticides.

However, this quote illustrates that this type of research needs to be further developed as, so far, it is not always very effective in practice.

Association to Society

Second, rather than focussing on the user interface, PheroSensor targets to study the feasibility and sensitivity of the pheromone sensors under field conditions. In the interview, the PI of PheroSensor stressed [translated from French^{xxix}]:

It's the sensor lifetime in the field. It's a problem that will be complicated to manage perhaps. So, this is very technical [...] I think that the project will allow us to optimise...as much as I have restrictions on the project on the short-term application as much as I am totally convinced on the importance of the project to optimise this type of sensor to make it more operational and reduce the cost. So, reducing to an acceptable or economically viable level...I don't know, but reducing yes. And I am totally convinced that sooner or later it is a very good strategy. I don't have a crystal ball, I could be wrong, but I think it's a very good strategy [...].

Hence, the limited focus of PheroSensor on users in society might be due to the complexity of the sensors, which shows to be a challenge in terms of sensitivity and selectivity of capturing pheromones in the field. What might work well under controlled conditions might cause problems in outdoor, field situations. Compared to BEYOND, PheroSensor has a longer-term focus, as the sensors will not be ready to be implemented within the 6 years' timeframe of the project. Nevertheless, PheroSensor's researchers show to be aware of the transfer of their innovation to the field, whereby they focalise in these six years to proof 1) the sensitivity of the sensor, 2) the lifetime of the sensors and 3) the economic viability of the sensors (minimising production costs).

Activities to favour acceptance by society

As this research field is about the detection and prediction of pest pathogens, it does not directly replace pesticides, but rather requires changes in prophylaxis. Consequently, the alternative solutions envisioned in this research field do not provide clear-cut alternatives to pesticides, but instead they require changes in decision-making and pest management strategies by actors. Particularly BEYOND has a strong focus on this decision-making aspect of their alternative solutions to

pesticides. The researchers argue how individual decision making in prophylaxis depends on the 'surrounding environment' – for the spread of pests - and thus also on the decision making of others (farmers). Transitioning towards 0-pesticides farming is thus part of collective decision making in pest-management.

In this regard, BEYOND's researchers aims to look at spatial coordination between actors in the transition to 0-pesticides systems, and aim to guide them in this regard. The PI of BEYOND emphasised in this regard:

The farmers will have to be... there's no farmer today thinking about long distance aerial dissemination of pathogens from Iceland or whatever. OK, so they will have to be trained. And that's part of something we'll do in the programme where we have participatory workshops. We want to use the ESV platform to disseminate a lot of the simplified information about this.

Hence as a response, based on the data they will collect on ES that embed such spatial scales, they aim to develop tools for decision making. The researchers envision to do this using participatory approaches to 1) co-design the tool, 2) reveal the 'attitude of farmers and ES planners towards risk aversion and scientific uncertainty in pest plant management' and 3) co-design strategies for prophylaxis.

To conclude, these three research fields highlight the complementarity between the ten PPR-CPA projects. It shows the clear visions of how the researchers address the ambitious 0-pesticides mission, which gives an idea of the construction of the projects, their aims and objectives, and the specific dimensions of the pesticides system they address. I demonstrated this by exploring the three interlinked elements of expected contributions to the eradication of pesticides: 1) Their 0-pesticides research paradigm; 2) the expected contributions to changes in the pest management functioning; and 3) their specific research on alternative solutions to pesticides.

In the expected contributions to the eradication of pesticides, each of the three research fields highlight a different approach and focus. The alternative solutions explored in the research field on 'agri-food system, markets and policies', largely emphasise the support of system change/transitions, in particular with a focus on markets, value chains and policies. The alternative solution studied in the projects of the second research field are expected to actually replace pesticides products, by for example, new or alternative seed varieties, biocontrol products, or alternative cropping strategies. The alternative solutions in the third research field are expected to contribute to change in pest management strategies and decision-making, for instance, by responding to the early prediction or detection of pests.

4.2 Contributing to a '0-pesticides society' in the mission-oriented context

As discussed in the introduction of this chapter, the alternative solutions studied in the PPR-CPA have to 'meet society's demand for a pesticide-free agriculture' (Jacquet et al., 2019). Visions of the projects' contributions to the mission should thus not just be about studying alternative solutions to pesticides, but also about how these solutions could contribute to addressing challenges in society. Eventually, the actual eradicating of pesticides in society is not the mere result of research, but the implementation of the alternative solutions in society. This means that the researchers should not just aim for scientific excellence in the mission, but they should also rethink their contributions to society: how the researchers envision a '0-pesticides society' and how they expect to impact society in this regard. In this second sub-chapter, I respond to the question *How does the construction of the PPR-CPA projects reflect the researchers' visions of their contributions to a '0-pesticides society'?*

In the T₀-interview, we asked the PIs how they expect to impact society. It showed that it is not easy to envision contributions to societal impacts. The PI of PheroSensor, for instance, responded as follows [*translated from French^{xxx}*]:

I'm going to say without shame: I'm sliding on...I'm getting out of my comfort zone. I find that it can be interesting to get feedback from you and to be linked with other projects and other partners. So...my vision of the impact, what...I am trying to switch to English...the objective is early detection of insect.

The PI expressed that this got out of his comfort zone, and eventually responded by providing the projects' objective. Also, from the project proposals it became clear that impacts are easily confused with research outputs or objectives. Even though these reflections as such might not be easy, this sub-chapter shows that the researchers' visions of their contributions to the 0-pesticides societal mission do embed visions of impacting society. However, rather than a process from research to society based on visions of a '0-pesticides society', I illustrate how societal impacts are perceived as a scientific outcome of the research projects.

At the T₀-phase, most PPR-CPA researchers showed to be rather unfamiliar with the ASIRPA RT terminology and reflections such as on societal impacts and societal transformations. This did not only become clear from the proposals, but also during the interviews with the project PIs. In the introduction of this chapter, I provided the example where the PI of DEEP IMPACT emphasised that for him thinking about impact is a new way of doing science. In addition, the PI of SUCSEED expressed during the interview:

If you have any tips or something like that, I mean if you can help to construct... well if I understood correctly right that's also the purpose of the webinar in February? I mean

anyway, try to improve and if we didn't think about a solution. We are really happy to have such input. In that respect I feel like that so far, the PPR call is great, because there are these types of workshops or webinars at the beginning, because it was far from my area of expertise. And to have these types of events I feel it's really key, even though it's a bit time consuming, it's really interesting as it helps a lot to prioritise also of my to-do list. Also, if you have contacts, remarks or tips we would be happy to receive this.

The interviews made visible that the ASIRPA jargon might be new as well as such types of reflections. It emphasised the necessity to adapt the ASIRPA RT tools to the needs and understanding of the projects. At the end of most interviews, we had to clarify ASIRPA's expectations from the projects – that it will not be the ASIRPA team creating IPs for the projects. Instead, ASIRPA provides the tools to guide the projects in navigating their societal visions.

By conducting the T₀-interviews with ASIRPA RT – before the official start of the PPR-CPA - we wanted to get an idea of how the researchers reflect on the expected contributions to the 0-pesticides missions. Considering this ambitious societal mission, we were especially interested in their envisioned contributions to a '0-pesticides society'. The following quotes from various interviews illustrate that thinking about this is not a 'business as usual' activity in (fundamental) research:

Je n'ai pas bien compris... ah...well...it will be probably changing practical use. So, as I said...right now... I mean post-harvest there is seed treatment, you treat with fungicides. The idea is to stop that treatment right now. So that's a first change, right. So instead of doing that we are hoping to...so either you change the...you change the uhm... sorry the practice when you grow your plants, right. So, during the seed development. So really during the growth period, pre-harvest. Or if you still want to go on with post-harvest system, it's more to rely on a number of different types of let's say micro-organisms.

- PI SUCSEED, T₀ interview

So, about the short term. I would say that we started this project because we have already worked in the past on legumes and particularly on the genetics of legumes. And so, in Dijon there is a...and also in Rennes...there are some labs working on improving cultivars. Produce some cultivars that are tolerant to pests. and so, I would say that by the end of the project probably we will have some cultivar candidates for this multi tolerance objective. [...] I know that by the end of the project we will not have a cultivar on the market that is able to achieve this goal. But for sure, we have some good candidates. new cultivar. This is at least one of the objectives of this this project.

- PI SPECIFICS, T₀ interview

What we hope to do is to provide solid empirical and theoretical evidence because our project is geared towards the quantification of effects. We hope to be able to provide a set of presumptions on the effectiveness of a group of public policy instruments. In this group of instruments there are different things: economic incentives and regulatory instruments,

which is very standard in environmental economics. Our idea is not to reinvent public policy instruments that have always existed, but to test their effectiveness using the most recent methodological tools.

- PI FAST, T₀ interview [translated from French^{xxxii}]

So, the project aims to stimulate the natural immunity of plants through different levers. In particular, practices. To achieve perhaps zero pesticides, in any case, go towards that. So, the project is based on two major species. A model that smells of apple and tomato. And then, the project also plans to look at the effect of these levers...on other cultivated species, either from the Solanaceae family or the Rosaceae family. To try to see if what we find on apples and tomatoes can be transferred to species of the same botanical family. I don't know, I need to develop this further?

- PI CapZeroPhyto, T₀ interview [translated from French^{xxxiii}]

Instead of envisioning how research is expected to contribute to society, the responses focussed on scientific outcomes. The researchers referred to their scientific activities, research outputs, and research objectives. These examples illustrate that ASIRPA's way of envisioning societal impacts as a process (i.e. impact pathway) is a 'new way' of reflecting on research for the PPR-CPA researchers. The projects show to be well aware of the societal challenges the 0-pesticides mission represents. However, the majority of the researchers rather translate this into scientific questions or 'objectives' to which they aim to respond and obtain scientific outputs.

Rather than visions of how a society without pesticides is envisioned to be constructed based on the alternative solutions they study, societal contributions are envisioned as 'desired' scientific outputs of the research projects. This shows that such visions consider the sole role of research in the mission to produce scientific knowledge. To demonstrate this, in this chapter, I discuss two elements in the construction of the project that reflect visions of: 1) scientific performance of a 0-pesticides society; and 2) scientific viability and acceptability of alternative solutions to pesticides in a 0-pesticides society.

4.2.1 The Scientific Performance of a 0-pesticides society

In contributing to the societal mission, how do the researchers expect to impact society? In the T₀-phase, researchers' visions of the contribution to changes or impacts in society as part of the mission, are reflected in the PPR-CPA projects as the study of 'scientific performance'. The researchers mainly envisioned to scientifically study the economic, agronomic and environmental (and partly policy) performance of the alternative solutions to pesticides in society they aim to contribute to.

Performance of alternative solutions to pesticides in society

To provide a few examples, Be Creative, VITAE and SPECIFICS use the term ‘performance’ in their proposals. Researchers of Be Creative will assess innovations, such as biocontrol options or landscape diversification, based on their ‘agronomic, economic and environmental performance’. They state: *“To our knowledge, there is no study that assesses effects of combining biocontrol methods with biodiversity-based practices on ecosystem services and economic performance”*. VITAE’s researchers focus on the performance of vine production without pesticides. Their performance study is based on economic indicators such as yield, as well as other indicators such as ‘risk aversion, price, subsidies, regulations and insurance’. A third example, in the proposal of SPECIFICS it states:

An original feature of the proposed scheme is to analyse the impacts of changes at different times in the transition to pesticide-free conditions, and to compare, for different situations of systems in transition, the trade-offs between agronomic (productive performance), agro-ecological, environmental and socio-economic performance criteria.

This illustrates the researchers’ aim to assess the impact of changes in a 0-pesticides society, by analysing the agroecological, environmental and socio-economic performance of pesticide-free farming systems.

Studying societal impact

Such research activities are also largely about studying potential impacts of proposed alternatives to pesticides in society. Yet again, this translated into scientific questions of the projects, and not necessarily how it could be achieved. To provide a few examples, the proposal of MoBiDiv mentions to analyse the effect of ‘diversified, pesticide-free systems’ on ecological variables such as soil fertility or greenhouse gas emissions. Researchers of FAST, on a more political level, will be analysing the effect of policies on pesticides reduction. They study the impact and effectiveness of taxes on pesticides use. Additionally, they will assess the economic impact of this pesticide reduction. They stated in their proposal: *“it is necessary to provide a precise and reliable quantitative answer to the question of the impact of pesticide reduction on the different sectors of the economy and at different scales”*.

These visions could be explained as, in their contribution to the eradication of pesticides in society, they are limited to the six-year duration of the research projects. For example, the PI of SPECIFICS emphasised:

And one objective of the WP3 is to find within the three thousand farms in France [red. Dephy farms] to find some farms that are economically performant but that also produce a high amount of protein. And so, for sure, by the end of the project will be able to identify how...which are these farms and what are the determinants of their performance. So, I think that through the short term we will be able to assess also this part. Then, try to use this

knowledge in the long-term perspective to redesign the system and see how the farmer that are not as performant as the targeted system can move towards this. To the redesign at the country scale, for instance, the redesign part is with the long-term perspective, but with the short-term perspective is more the assessment of the performance of the system.

Hence, this focus on short-term scientific perspectives might be a result of time constraints of the projects' funding. BEYOND and FAST mentioned the discrepancy of what they can do in the short term versus the long term. BEYOND stresses the time constraints of the project in their proposal, as they state:

The economic and sanitary effectiveness of prophylaxis is the ideal indicator of performance, but it is not feasible to directly assess this in the few field seasons remaining in the project after the conception of ES plans. As indirect measures of performance we will assess the opportunities to pyramid different prophylaxis at multiple time/space horizons and/or to break dissemination networks.

In addition, the PI of FAST emphasised in the interview [translated from French^{xxxiii}]:

There may be contributions from Fast, things that have been initiated in this project that may have very strong repercussions in 2050; and it may also be zero. This project can have either very strong impacts or none at all. Can it have intermediate impacts? Yes, I would like to. That's what we were saying when we were talking about the national Ecophyto programme and the Green Deal of the CAP. If we can influence, through our results, the way in which money is allocated in Brussels between the first and second pillars, we would be happy. But this is not immediate, it's really long-term.

For most projects, the six-year timeframe is too short to result in the finalised alternative solutions to pesticides. Hence, after the six years the projects aim to have a (quantitatively) measurable scientific proof of their alternative solutions. Apparently, reflections on longer term societal impacts, which might only become visible 10-20 years after the end of the project (See ASIRPA Ex-Post Matt et al. 2017), is challenging (this is further discussed in sub-chapter 4.4). Instead, the researchers highlight the input and output phases of their projects – hence that are under the control and management of the researchers - and not per se the further development and implementation of the alternative solutions in society, nor how society is envisioned to be constituted in this regard.

4.2.2 Visions of Viability and Acceptability in Society

Building upon the previous section, researchers' visions of a '0-pesticides society' are also related to scientific questions about 'viability' and 'acceptability' of alternative solutions to pesticides in society. Rather than reflecting on and anticipating societal needs or demands, these aspects are approached as criteria for scientific excellence. For instance, FAST highlights in their proposal: *"The ultimate objective of our project is to effectively contribute to trigger and support a large-scale*

transition to pesticide-free agriculture that is both economically viable and socially acceptable." However, as I demonstrate in this section, such objectives translate into scientific questions and studies, instead of societal demands. This reflects visions that the researchers contribute to favouring acceptance when they can scientifically prove the efficiency of alternative solutions.

The researchers illustrated the study of acceptability and viability of the alternative solutions to pesticides in society through three main aspects: 1) the envisioned benefits for society; 2) the envisioned costs for society; 3) the envisioned needs from society.

Societal benefits

First, expected contributions of research to a 0-pesticides society are envisioned as a response to expectations of society in terms of gains and benefits. In the proposal, SPECIFICS phrased benefits from research to society as: *"[the] results expected by society in terms of reducing environmental costs and social gain"*. In other words, the researchers want to demonstrate the societal benefits of the alternative solutions to pesticides they study/aim to contribute to. Among the PPR-CPA projects, this is largely envisioned in terms of economic profitability, rural development, or labour input. But, as the following examples demonstrate, these are approached as scientific questions and thus to provide scientific proof of the viability of alternative solutions. The PI of SPECIFICS specified in the T₀ interview:

There are some farmers that produce more protein and have the same, for instance, economic profitability as they have. So just to show them that there is no antagonism between producing high amount of protein and other viable, economically speaking, systems. And also find the factors that determine this this big challenge between production of high protein and economic profitability.

SPECIFICS has as objective to implement diverse, pesticide-free farming systems based on legume crops. In this regard, they study the profitability of such systems as they understand the potential trade-offs for farmers. Similarly, in other projects, visions of societal benefits refer largely to the direct benefits, or trade-offs, for the expected end-users of the alternative solutions to pesticides (e.g., farmers). The alternative solutions should remain or increase yield, increase profitability and not cause higher workload or harvest products that are difficult to market.

To give another example, also CapZeroPhyto includes such types of analyses in their proposal, as the researchers argue: *"We know that producers are more likely to adopt innovations with low initial investment, reduced production costs including working time, higher average yields and lower risk of harvest lost as well as improved nutritional quality, taste and appearance for food products"*. This shows again the analysis of the benefits for end-users, even though a clear dissemination strategy is lacking (I further discuss this in chapter 4.4). As a final example, in the proposal of FAST the objective

of one of the WPs is explained as follows: *"They will demonstrate that adoption of suitable production practices by farmers can significantly alleviate the impacts of drastic reductions in chemical pesticide uses on production levels and farmers' income"*. This illustrates the awareness of the researchers of the economic impacts in a 0-pesticides society, but it translated into a scientific question and not into a vision of how such a society (with increased farmers' income) is constituted.

Societal costs

The second aspect of visions of the viability and acceptability of alternative solutions to pesticides refers to the costs for society. The projects' main scientific analyses in this regard focus on the expected costs of implementing alternative solutions to pesticides. This is not just referring to economic costs, also environmental costs are considered. For instance, the PI of PheroSensor stressed in the T₀-interview [*translated from French*^{xxxiv}]:

There is resistance...so I am not a man of the field as you have understood. I'm initially more fundamental. But I like it, I'm at the end of my career in about ten years, I like to be sure to apply it. What I understand...what I see is that yes, farmers need to be convinced, but I also see thatwhat can I say...it's general...more and more people are convinced that it's good to go towards more environmentally friendly methods. So, we are in a context that is favourable. The use of all pesticides I think everyone agrees.....now we have to propose solutions. As soon as we have solutions, everyone understands that this is potentially good, but we must have solutions that are economically viable. That's why I was happy to be able to explain that we were planning to go towards reducing production costs. And this reduction in production cost would be all the more important as the production scale of this sensor would be large. Then, in relation to the farmers' resistance, we do not release anything into the environment. We do not release any molecules. We only detect the presence of a molecule. So that's pretty easy to explain and understand I think.

Hence, this researcher explained the resistance expected for the technology. The quote highlights the importance of considering the economic and environmental viability necessary for convincing the actors that the sensors they are developing in the project are a good solution. Visions of societal costs are reflected in the projects through socio-economic analyses (e.g., CapZeroPhyto, Be Creative, MoBiDiv, SPECIFICS) or through research on the 'Willingness to Pay' (e.g., VITAE or FAST). All PPR-CPA projects include some type of analysis on this, to convince users and favour acceptability of the alternative solutions. It illustrates that visions largely consider the user context of a 0-pesticides society.

Needs from Society

The third and final aspect of visions of the viability and acceptability of alternative solutions to pesticides in society refers to the researchers' expected needs from actors in society. This is mainly reflected in the projects, which require policies and regulations for the alternative solutions to be

marketable in France. Such visions are reflected in the MoBiDiv and SUCSEED projects, on seed development (see also chapter 4.1.2):

Market incentives are detrimental to diversification because innovating firms strongly invest on larger markets (Charlot et al, 2015). Alternative organisation and funding of research and extension services need to be studied to promote accurate incentives for diversification. If market standards are also defined on the basis of homogeneous seed, they are currently evolving, with the new EU regulation allowing the marketing of heterogeneous organic material. One key objective of MoBiDiv is to analyse the efficiency of such standards for seed and crop commodities embedding genetic diversification.

- PPR-CPA proposal MoBiDiv

The regulations applicable to the proposed SUCSEED innovations fall under national, European and international laws. The legal qualification of these innovations (phytosanitary products, fertilising materials) is important because their supervision is different and more or less constraining. It is, therefore, necessary to assess the current legal framework and adapt it to scientific progress.

- PPR-CPA proposal SUCSEED

Hence, both projects study alternative solutions to pesticides related to seeds. These quotes highlight the need for such policy reforms, and show how this is reflected as scientific questions in the research projects. They require a national regulatory framework that would allow the marketing of their proposed 'seed solutions' – thus essential for the viability of their alternative solutions. To anticipate this, both projects aim to scientifically analyse the effects of such policies.

To conclude this sub-chapter, I showed how the construction of the research projects reflect the researchers' visions of contributing to a society without pesticides. Rather than visions of how the researchers expect to contribute to the constitution of a society without pesticides with the alternative solutions, contributions to society are envisioned as 'desired' scientific outputs of the research projects. This is emphasised in the PPR-CPA projects through 'scientific performance', which reflects the scientific study of the economic, agronomic and environmental (and partly policy) performance of the alternative solutions to pesticides in society. The same counts for visions of 'viability' and 'acceptability' of alternative solutions by actors in society, to enable the eradication of pesticides. Rather than reflecting on and anticipating societal needs or demands, these aspects are approached as criteria for scientific excellence.

This reflects that the researchers expect to contribute to the eradication of pesticides in society by scientifically proving the efficacy and performance of the alternative solutions. It thus highlights a rather scientific way of knowing a 0-pesticides society. One of the reasons for this might

be the short-term timeframe of the research projects versus the long-term timeframe of the eradication of pesticides in society. The research projects are only funded for six years, and thus the researchers are exploring what that can contribute – or proof - in this timeframe.

4.3 Visions of the multiple characteristics of mission-oriented research projects

The previous two sub-chapters demonstrated how visions of the eradication of pesticides in the ambitious societal mission of the PPR-CPA influenced the construction of the PPR-CPA projects. It showed how the mission influenced the type of analyses and research orientation of the projects. Building further upon this, I explore to the question *How does the construction of the PPR-CPA projects reflect the researchers' visions of a change compared to previous projects, considering the 0-pesticides mission?* Hence, in this sub-chapter I show how the PPR-CPA projects are constructed differently to be able to contribute to the 0-pesticides mission.

Hence, the researchers confirmed that they constructed their projects differently compared to previous projects they have been involved in, mainly by adding complexity to the research. This complexity can be understood through five categories explaining the 'multiple characteristics' of the mission-oriented PPR-CPA projects, which I explore in-depth in the following five sections:

1. multidisciplinary of the consortium
2. multiple dimensions of research
3. multiple levels of analyses
4. multi-actor research
5. multiple (knowledge) resources

4.3.1 Multidisciplinary Consortia

As Jacquet et al. (2019) argued in the PPR-CPA programme report, they demanded for multidisciplinary projects: *"At the same time as the mobilisation of scientific fronts within each discipline, multidisciplinary approaches are essential, crossing biological, agronomic, physical and human and social science disciplines"*. Consequently, it is not surprising that all PPR-CPA projects emphasise a **multidisciplinary research consortium** at the basis of their response to the mission. This concept by itself is not new, but in this specific situation, it is interlinked to the other four multiple characteristics of PPR-CPA projects that I explore in this sub-chapter. The researchers see the eradication of pesticides as an ambitious goal, which goes by default beyond an individual research field. Multidisciplinary in the consortia is considered a catalyser to contribute to the mission: to consider the multiple dimensions the mission embeds, and to ensure that the research goes beyond fundamental science towards applied outcomes.

To provide some examples, BEYOND highlights in the proposal:

The goal of BEYOND is to go beyond the current paradigm of epidemiosurveillance (ES) to create a new paradigm of ES. We will achieve BEYOND's goal by uniting researchers across multiple disciplines in life sciences, mathematics, computer science, social science and economics in the development and comparative analysis of enhanced ES.

A similar argument is highlighted in the proposal of MoBiDiv:

The overall objective of the project is to address the key scientific issues to achieve this paradigm shift, by allowing to breed, mix, register and evaluate varieties for a pesticide-free agriculture. [...] To address these questions, MoBiDiv is a collaborative and multi-actor project and adopts a systemic, interdisciplinary approach, involving genetics, economics, management sciences, agronomy, ecophysiology, ecology, phytopathology, as well as mathematical and statistical modeling.

This illustrates that contributing to something, which has never been realised ('a 0-pesticides future'), requires a shift in 'how research is done'. Hence, as the researchers argue, a paradigm shift in agriculture requires also a paradigm shift in research, which starts with a multidisciplinary research consortium.

The importance of multidisciplinary consortia

One of the criteria of the PPR-CPA call for projects, was to have multidisciplinary consortia (see Chapter 3). How did the researchers consider this in their projects? According to PheroSensor's researchers, it is key to take their research 'out of the lab and into the field'. As they argue in their proposal, the project requires a multidisciplinary consortium to combine sufficient scientific expertise "to design, optimise, manufacture and use in field conditions such innovative pheromone sensors". In addition, the proposal of SUCSEED emphasises the need for multidisciplinary projects if their innovation has to be accepted and disseminated into society. It reflects visions that the inclusion of social sciences will allow a better adaptation of the technical innovations to the expectations and needs from other actors in society, such as the seed industry. During the interview, the PI of SUCSEED complemented this idea by explaining their need for social sciences:

The way how we constructed the project is really to start with that. ... during the kick-of meeting, we have a 1-day discussion on that particular aspect. And the people from let's say the social or economic sciences, they really want to know what type of change you want to do on your product. I mean, just to understand...seeds: where are they coming from, for instance? The micro-organisms you want to apply externally or during the growth of your crops, and so on. In order really to understand at what point you want to make the changes. And from that they want to do the prospective study and I guess probably a couple of interviews with let's say seed growers, seed companies and consumers. And that will help, because...I don't know, maybe I am too optimistic, what I feel is that we have probably

plenty of solutions from science, purely academic, and to me the most challenging part of the project will really be to have a decision tree or to have some priority. Because that will be almost impossible to release all these solutions in a field basis, that will be too many. So, we really have to be really careful on that aspect. And we really have to as many contributions as possible to have the priority on the solution that we can...

This example from the PI of SUCSEED illustrates the vision of the need for collaboration between scientists from different fields as contributing to the eradication of pesticides goes beyond an individual research field in isolation. However, it also shows the focus on technological innovation, and the role of social sciences in selecting the technological solution, which they expect users in society are willing to adopt. In this regard, one of the PIs of VITAE reinforced during the T₀-interview [translated from French^{xxxv}]:

First of all, it is the constitution of a scientific community that is centred on this question of the exit from pesticides. Of course, there are people working on pathology in phytopathology, but there are also people working on genetics, working on economics, in any case interdisciplinary networks. That's the first impact. It's the creation of a kind of consolidation, the networking of a scientific community focused on the exit from pesticides, with a secondary impact that can be not only networking, i.e. being able to have a common [objective], but above all to start speaking the same language. That is to say, to work, to move towards a task that will not be completed in one go, but a task that is more interdisciplinary.

This example illustrates how the researcher considers their contribution to the mission as the result of a longer process between various research fields. Having such a large mission allows and requires all researchers to speak the same language and to contribute to the same ambitious objective. In the following sections, the need for multidisciplinary consortia will be further discussed in relation to the other characteristics of the mission-oriented projects.

4.3.2 Multiple Dimensions of Research

One of the reasons for the construction of multidisciplinary consortia is that the researchers aim to contribute to the mission by including **multiple dimensions** in their research projects. Approaching multiple dimensions showed to be project specific, depending on the alternative solutions to pesticides that are being studied. The researchers' visions illustrate that the eradication of pesticides requires concentrating on multiple dimensions of pest management, and focus on multiple pathogens. For example, CapZeroPhyto focusses on multiple levers to increase plant immunity, and analyses how to combine these levers. The proposal mentions:

New ecological levers are actively investigated to control pests and diseases, but most often individually and for a particular bioaggressor. However: i) individual alternative levers never reach the effectiveness of pesticides, thereby leading to the urgent need of combining them

to get a satisfactory pest control and ii) crops are affected by a diversity of bioaggressors, requiring to consider their control as a whole using if possible broad-range alternative levers with expected synergistic effects and avoiding antagonistic ones.

Hence, the researchers argue the importance to target these multiple dimensions in contributing to the 0-pesticides mission. In the T₀ interview the initial PI⁸² of CapZeroPhyto reinforced [translated from French^{xxxvi}]: “We started from a concept of ecology, immunity in fact, to move towards a concept of agro-ecology...the idea was to combine these different levers that we were studying in the different laboratories to move towards zero pesticides”. The PI confirmed that this is the first time they are studying the combination of multiple levers as to not just contribute to limiting the use of pesticides, but to the eradication. This resulted in the construction of a diverse consortium, combining the knowledge and expertise of various levers of plant immunity. BEYOND reflected in a similar way, as the PI explained in the T₀ interview:

And so, when we saw the PPR come, one of my colleagues [name] here said: we should do something. And I said, OK, we'll do something on long distance aerial dissemination. And [name] said, no, not only on long distance aerial dissemination. And so, he started talking about all these other indicators and stuff. And so that's pretty much the two of us came together. And then we said then there's a socioeconomic context and the land use management that [name] manages, let's get together. So that's pretty much what could we do that's big.

Hence, to go beyond the current paradigm of Epidemiosurveillance (ES) the project includes multiple variables as epidemiological indicators and focusses on multiple pathogen systems - representing various crops and various types of pathogens (e.g., fungi, virus). The researchers expect to achieve this goal through their multidisciplinary team of researchers ‘in life sciences, mathematics, computer science, social science and economics’.

A third example, which highlights the multiple research dimensions, is from the projects, which conduct research on seed genetics. SPECIFICS and MoBiDiv both work on ‘multi pest cultivars’. In the case of SPECIFICS, they aim for breeding legume varieties, which are resistant against multiple pathogens. The PI argued that the focus on multiple pathogens is essential for the eradication of pesticides. The project includes a work package on genetics with the aim to breed ‘multi-resistant cultivars of legumes’ that should be able to “tolerate the different pests, pathogens, weeds. etc. in a zero-pesticides context”.

In addition, MoBiDiv studies how seed mixtures with multiple varieties or species, could increase plant-plant interactions. This is expected to increase plant resistance against pathogens and

⁸² Previous PI, CapZeroPhyto changed their PI in the first year

thereby reduce pesticides use. MoBiDiv provides the follow up of another research project, in which the potential of mixtures has been discovered. However, this previous project had as objective to reduce pesticides use, in contrast to the 0-pesticides mission. According to the PIs, the PPR-CPA provided the opportunity to build further upon these fundamental research results, and translate it into the field under 0-pesticides conditions.

4.3.3 Multiple Levels of Analyses

Building further upon the previous section, a second reason for the need of multidisciplinary consortia lies in the **multiple levels of analyses** the projects include, which is a strong aspect in the projects' visions of the eradication of pesticides. For example, this is, about going beyond the level of the laboratory by testing research outputs in the field. Alternatively, it is about going beyond the fundamental level of exact sciences and include social sciences to study the practical implication of the envisioned alternative solutions in society.

In the end of the previous section, I highlighted the example of MoBiDiv that the researchers are building further upon a previous project. This previous project was about the potential of seed mixtures to reduce pesticides use, but was never implemented on field level nor under 0-pesticides circumstances. During the T₀-interview, the PIs explained how MoBiDiv is building upon this preliminary study on mixtures and the effects on pesticides use. However, they also stressed that towards the eradication of pesticides, they have to test these mixtures under 0-pesticides conditions in the field.

Also, the PI of PheroSensor stressed the need of going from lab to field level, as he explained: But my wife⁸³ told me very early: you have to go up to the field, you cannot have...it was too fundamental for her. So, she is very...I mean she has this expertise of European projects. So, she said you have to convince that you can go up to the field, and really test your sensor. So ok, she helped me and she gave me some confidence to interact more efficiently with the other partners.

In the development of pheromone sensors, this project is rather based on fundamental research, of which the PI expressed to be aware. He explained how the PPR-CPA gives him the opportunity to do research in a 'broader' sense, which means for him going to the field level, something, which he is not used to nor does he have the expertise. This influenced the construction of his consortium, to include partners with stronger expertise in the field, about field-testing as well as about insect damages to plants.

⁸³ The interviewee had explained that his wife works in the European Department of INRAE Transfert.

The PPR-CPA projects show that contributing to the mission means that alternative solutions to pesticides have to be tested in the field, under natural (non-controlled) 0-pesticides circumstances. The researchers of the more (fundamental) exact science projects explained this as one of the reasons to include social sciences. The majority of the PPR-CPA projects embed social science research, mostly in relation to the link between the ‘research’ and ‘society’. For example, such research activities study the obstacles and facilitation in the appropriation of innovation (e.g., SUCSEED); to implement participatory research or co-design approaches (e.g., MoBiDiv, Be Creative, CapZeroPhyto); to support or analyse socio-economic system lock-ins and changes (e.g., MoBiDiv, Be Creative, FAST, SPECIFICS); to understand acceptance, preferences and willingness to pay (e.g., VITAE, FAST, CapZeroPhyto); to conduct foresight activities (VITAE); to develop tools for collective decision making (e.g., BEYOND); to analyse the marketability of solutions, such as regulations and market standards (e.g., SUCSEED, MoBiDiv).

To provide some examples, the initial PI of CapZeroPhyto explained [*translated from French^{xxxvii}*]:

Knowing that an innovation or several innovations combined can have benefits on the one hand, but at the same time, they require, for example, an implementation, a certain cost, etc. The idea is to make an analysis, I'm not a specialist, but try to make an analysis of the choices, of the professionals in mind, to understand those who are ready to lose and to win by going towards zero pesticides.

It highlights how they aim to facilitate the transfer from research to practice, by including socio-economic elements. They plan to conduct a feasibility study through surveys among professionals, to study how they could implement the levers they study into cropping systems. In addition, the PI of MoBiDiv emphasised [*translated from French^{xxxviii}*]:

And currently, an important lock is for breeders, the transformation of their evaluation system with an evaluation system that is quite heavy and behind which markets are currently quite weak. There is a central obstacle, which is the incentive and funding for research into new plant varieties. The system is centred around the dominant species in the market on which there is a return on investment. The most important thing is that this is a central lock that will be studied in the project, but more on the SHS side, research funding. How can we change this? And there is the sector of “conventional breeding”, so the private breeders. But there is the whole participatory selection aspect and so we are going to work on this coexistence of the two sectors.

It explains how ‘multiple levels of analyses’ for the project also refers to different levels of breeding. In their case, they compare ‘private breeding’ to ‘participatory selection’. For them this

analysis is key to overcome market lock-ins of new seed varieties for the eradication of pesticides in society.

4.3.4 Multi-Actor Research

A particular aspect of the PPR-CPA is that the programme only funds academic partners. However, as the projects illustrate, **multi-actor processes** in research are considered key in contributing to a 0-pesticides future. In general, this is implemented in two main ways, to enable the inclusion of actors outside academics. First, various projects include participatory research activities, action-research, or co-creation approaches with stakeholders. Second, several projects embed strong links with industries, who provide expertise on the production and marketability of proposed technologies.

To start with the first, Be Creative is a project with a strong participatory process, by adopting a participatory design approach for pesticides free territories. In the T₀-interview, the Be Creative PI explained [*translated from French^{xxxix}*]:

When you work like that in the field, it still requires quite a bit of agility because the questions that are going to be relevant for the field and that are going to allow for the production of scientific knowledge are not necessarily the ones that you had envisaged from the start. There is a very inductive part to this work. And that doesn't fit in well with the way in which project-based research is structured today. Typically, we have set up a consortium with disciplines involved. And it's only in the field that we realise that the right skills are involved in the project. The Be Creative project should allow us to add a scientific partner who needs an anthropologist because there are really key questions around social dynamics or that we don't know how to deal with our means and that we should be able to add.

Hence, these design processes are organised not just with researchers from different disciplines, but also with the actors within the case study territories of the project. The quote highlights why the PI considered such a participatory design approach key in contributing to pesticide-free territories in reality.

MoBiDiv and CapZeroPhyto both organise co-design experiments and workshops to experiment with cropping systems. MoBiDiv uses this approach for participatory breeding exercises and experiments of intercropping systems. CapZeroPhyto will co-design experimental orchards to test their levers of crop resistance. Both projects aim to combine scientific and practical knowledge, in order to identify the possibilities, efficiency or lock-ins of solutions. For instance, MoBiDiv wants to bridge the work of breeding companies and participatory breeding. The PI reinforced in this regard [*translated from French^{xl}*]:

In fact, you can assemble almost any number of mixtures. Studying mixtures is very complicated. So, one way of approaching this combination is to try to decentralise the evaluation and to have more confidence... not more confidence, but to rely on networks, either of cooperatives, or of farmers, or both, who experiment with mixtures and acquire information and make progress on the knowledge of mixtures. In this way, there are participatory approaches to evaluation and also to selection. So, it's the same thing. There are statistical methods and design techniques that are proposed in the project and on which we expect a strong impact. And we also hope to have an impact on the way it will be done.

Where the previous three examples use participatory approaches in the design of (field) experiments, BEYOND will involve actors to co-design and test tools based on their research outputs on ES indicators. This includes gaining understanding of farmers' attitudes towards pest management strategies and the co-design of prophylaxis strategies based on their studied indicators.

Second, in addition to these participatory approaches, several (technological) projects embed strong connections to industrial partners. Examples are for instance SUCSEED and PheroSensor. SUCSEED's researchers established links to the French seed community, and envision the project as '*a catalyst to reinforce*' these links. Even though these actors are not funded, they will be kept updated about the projects' results to keep them interested. Such connections to external partners already existed before the project. Similarly, the researchers at PheroSensor show being aware of the need to interest industries. However, these actors are less identified yet. PheroSensor collaborates with The French Alternative Energies and Atomic Energy Commission (CEA) as partner who has strong connections to industries and expertise, for instance, in the application of patents. During the interview, the PI stressed the need to interest industries who are willing to invest in their innovation, by developing a demonstrator of their sensor. Therefore, as the PI indicated, they need to demonstrate the **multiple applications** of their sensors, towards **multiple pests**.

PheroSensor indicated that the involvement of industries is key to gain funding to further develop and implement their sensors in the field. This requires efforts (e.g., demonstration) to interest industries, especially since non-academic partners are not financed. In contrast, the PI of DEEP IMPACT argued that this lack of financing is not necessarily a problem:

They [red. industries/companies] said: ok, we don't go with you, because we are not funded. But the expectation is not only to be funded. The question is for me: do you trust the idea, do you trust the science we propose going into this transformation, or going into this final result. And some of them said no: no money, no job in the project. And I am very surprised to say that at the moment 3 or 4 say: ok we are going to give you some additional money, we are going to give you a PhD student, and we are going to work with you after this first project meeting. So, in terms of impact of the project I think that this...I was not very confident at the beginning, when we had the first meeting and the presentation of the PPR

PCA in Paris, when they said: stakeholders will not be funded on the project. Because a lot of them came to see what was going to happen, they said: wonderful we are going to have some money. Because they have some economic problems also. And so, I was not very confident of this way, and at the end I thought perhaps it's a good orientation, and a good view of how we have to work to make the transformations. Because we need to put together all the partners, and not only to have money. To really use this money to move in the same way.

Hence, the PI argued that this lack of funding for non-academic partners is not necessarily a negative situation. What they need is for industries to share similar visions of their contribution to the eradication of pesticides.

4.3.5 Multiple (Knowledge) Resources

Finally, implementing the previous multiple characteristics of the PPR-CPA projects requires **multiple (knowledge) resources**. One of the characteristics of the PPR-CPA is the amount of financial resources (total of €30 million) and time (6 years) available. In addition, there are various animation activities implemented by the programme, such as ASIRPA RT, interprofessional meetings between research and professionals, and foresight activities. Considering the ambitious mission, the availability of various inputs and resources are valued by the project' researchers for various reasons.

First of all, the ambitious 0-pesticides mission in combination with the 1) six-year duration and 2) the large financial funding provides an opportunity for the projects to implement the multiple dimensions and levels of analyses as discussed in previous sections. The PI of DEEP IMPACT reasoned about the funding:

The PPR for me it's a real opportunity with a vision that we already had before. And it's just a good opportunity, because for me it's the first time to have this amount of money or funding on a specific project – when you can put in the project all the things you want to do, but you are not able to do because you have to make an application to develop this aspect of the project, and so to get funding you have to write 10 or 14 applications and expect to have one funding. And you have to do that on the different aspects of the global project: so, it's time consuming, you don't develop your research with the real dynamics you expect, to produce some data and some knowledge and to move towards some transformation. And so, for me the important issue of the PPR is to be able to put this large amount of money on the project on the table and to say: ok, with good perspectives and good visions; if your project is good you are going to be funded. And so, we could develop the research with the different aspects with only one objective. And so, this is very important.

This quote highlights that the size of the PPR-CPA funding gives the project the opportunity to combine various dimensions, which is considered essential in contributing to the eradication of pesticides. In addition, the six-year timeframe of the PPR-CPA was appreciated, although the PI of BEYOND argued about it:

He [red. The PPR scientific animator] said, OK, there has to be a part about prophylaxis and you need to evaluate the effectiveness of the prophylaxis, and I said how in a five-year project can we conceive and evaluate the effectiveness of prophylaxis? So, I think I came to believe that what was asked for in l'appel d'offre was not well thought out part of it. So, what we decided to do was we address that question, but we can address it via modelling. On the other hand, in the project we were very clear we made a table for every model. We said what was the potential prophylaxis that could be used in it as a follow up from the indicators that we will develop. So, it forced me to say I can't just say we're going to do prophylaxis, I have to give specific examples of the prophylaxis, which would be zero pesticides that we're going to do for each model. OK, so that we ourselves know what we're targeting. And we're not just, you know, not just giving it lip service. There's no way we're going to assess that because in five years you can't.

So, even though the PPR-CPA might be longer than most research programmes, in contributing to a 0-pesticides future it might still be a challenge. The PI illustrates how they had to rethink what could be their potential contribution to the mission in the given timeframe.

Second, the programme level scientific animation is valued by the project' researchers. For instance, MoBiDiv's PIs expressed their interest to connect to other PPR-CPA projects, in which the programme activities could play a role. SUCSEED's PI emphasised how the webinars and workshops organised on the programme level facilitate reflecting beyond his own area of expertise. Moreover, the long-term perspective of the PPR-CPA was emphasised by the PI of PheroSensor. Even though it was less present in the audition, according to him the PPR-CPA call focussed on longer term impacts and less on the 'applications at the end of the project'.

Although most of the projects were not (so) familiar yet with ASIRPA at this T₀ stage of the PPR-CPA, numerous PIs already expressed their interest in such exchanges and thinking about the societal impact of their research. To provide some examples, the PI of BEYOND argued:

You can't believe how I have spent 30 years at INRAE feeling like I'm in a closet, no one gives anything about what I'm doing. It gives you an incredible amount of freedom. But I'm working on taxpayers money. OK, and so this [red. ASIRPA] for me, why I'm all excited because it's like, yes, this is how I want to end my career. Somebody cares about what I'm doing or I'm doing something that somebody cares about, whatever, OK? It's not about me. It's about the subject, OK? Every scientist at INRAE this is what they should do. There all should be something to say: Yes, how can we turn this into something useful?

Similarly, the PI of DEEP IMPACT reflected:

I think it will be very interesting to perhaps during the life of the project to have this kind of discussion in three years or at the end of the project to see...because I would be really interested to see how I am going to evolve in my ambitions of my science and how I could keep the discussion today in terms of transformations, in terms of my research [...] it's a new

thing for me, to try to integrate the impact of the research project which are not so plentiful, also because we are on the more basic science and not so much on applied science.

These quotes highlight interests of the researchers to reflect on the ambition of their science, particularly in benefitting society. Remarks about the involvement of ASIRPA RT showed that this type of research impact assessment in Real-Time, and reflections on societal transformations are not 'business as usual' for most researchers. During the interviews, we did not specifically inquire their thoughts about ASIRPA RT, but it was reflected upon in a more spontaneous way at the end of several interviews.

To conclude, as they were applying to a mission-oriented call for proposals, the PIs confirmed that the construction of the PPR-CPA projects changed compared to previous projects the researchers have been involved in. The mission provides a clear objective or goal to the researchers. In addition, the call communicated the need for multidisciplinary research, so in this sense, having this mission in mind also facilitated the construction of the projects. Their multidisciplinary research team enables the projects to study multiple dimensions, multiple levels of analysis, conduct multi-actor research, and obtain multiple (knowledge resources).

This sub-chapter highlighted what having a "societal mission" does to the way researchers need to think about the multiple matters of concern at the same time. Compared to their previous research projects, the mission introduced complexity into the construction of their projects. This illustrated the researchers' baseline-visions that contributing to the eradication of pesticides requires a change in how science is done on multiple levels; e.g., moving from lab to field level, solutions against multiple pests, which requires including multiple research disciplines and actors, etc. This demonstrates that they did not construct their research project as 'business as usual', but they showed ambitious research strategies and organisations.

4.4 From Research to Society: visions of the associations between researchers and 0-pesticides society

The PPR-CPA researchers aim to contribute solving societal challenges by conducting research on alternative solutions to pesticides. Associations between the research and society are thus essential. Therefore, in this sub-chapter I show how the researchers envision the associations between their research projects and a 0-pesticides society. In previous sub-chapters, I have already illustrated the expected contributions to a 0-pesticides society, as well as questions around multi-actor approaches and acceptability and feasibility of the alternative solutions by actors in society. Such visions largely translated into scientific questions. In this final sub-chapter, I explore the researchers' visions of how they expect to contribute to a 0-pesticides society, and thus how they envision the

associations between the projects and this particular type of society. I will answer the following question: *How does the construction of the PPR-CPA projects reflect the researchers' visions of the associations between their projects and a 0-pesticides society?*

As a first observation, which I detail in this sub-chapter, the majority of the PPR-CPA researchers are fundamental researchers who demonstrate knowledge of the 'world outside their lab'. However, they show to be less familiar how and when to connect with other actors and who is needed for their research outputs to be implemented for a 0-pesticides society. Instead, the projects hold rather techno-optimist visions (e.g., Danaher, 2022) of the transfer of the research outputs into the alternative solutions to pesticides in society. This reflects a straightforward interest, use and adoption of the research outputs by actors in society.

This sub-chapter is structured around two subthemes about the envisioned associations between the projects and a 0-pesticides society: 1) the envisioned roles of non-academic actors in the mission; 2) the envisioned communication activities to raise the interest of other actors.

4.4.1 From Research to Society: Envisioned Roles for actors in a 0-pesticides society

As I demonstrated so far in this chapter, the scientific objectives of the mission-oriented PPR-CPA projects are well identified by the researchers. This reflects visions of expected contributions to a 0-pesticides society and how this translated into scientific question, but much less into the role non-academic actors play in the eradication of pesticides with the alternative solutions.

In their project proposals, researchers of MoBiDiv, FAST and PheroSensor talked about identifying the 'beneficiaries' of their research. Human actors are seen as 'users' of research outputs on alternative solutions to pesticides, i.e. in the way how other actors could benefit from the research projects by changing their practices. This reflects visions that research and human actors in a 0-pesticides society are associated through the alternative solutions to pesticides (non-human actors). For instance, when we asked the PI of DEEP IMPACT in the T₀-interview what changes in society he expects to contribute to for the eradication of pesticides, he responded as follows:

After the project, perhaps to put the good scientific knowledge to be able to move to the zero-pesticides system. Because we are going to replace or put the biodiversity and plant microbiota interaction as a key driver of plant resistance and sustainability of the system. So, for me the expectation is clear to say to the technical institutes or the cooperatives, to the private companies, to the breeders to say: you have to take into account biodiversity parameters and how this biodiversity interact with the crop. But we have to give them some tools, we need to give them some demonstrations of the results.

Hence, this quote illustrates a vision, which reflects the expectation of straightforward interest, use and adoption of the studied alternative solutions to pesticides in society. A 0-pesticides society in this regard is seen as this direct result, based on the visions of how ambitious science contributes to the eradication of pesticides. The expected contributions of other actors for the mission is the use of research outputs - researchers talk about the 'deployment' or the 'uptake' of their research outputs.

Such visions of the researchers illustrate a rather linear relationship between their research and society. It largely reflects the role of science for the mission, and how actors in society could benefit from its use. It is less about visions of the changes necessary to establish a 0-pesticides society; to actually eradicate pesticides with the alternative solutions. To provide an example, as discussed earlier, various projects study the socio-economic lock-ins of pesticides use. Such lock-ins might be well identified in scientific terms, but not necessarily what changes in society this requires in order to eradicate pesticides.

In addition, various researchers reflect on the need for changes in market channels and policies, such as in MoBiDiv, SUCSEED, SPECIFICS and Be Creative. However, instead of envisioning how to achieve these necessary changes in society, they rather approach it as scientific questions resulting in a scientific way of knowing a 0-pesticides society. This highlights a main focus on the role of research in the mission, and less the transformative change in society this requires. The following examples illustrate this further.

In section 4.2.1, I discussed how the alternative seed solutions studied in MoBiDiv and SUCSEED require a change in the regulations for seed registration in France to market. MoBiDiv aims to analyse 'the efficiency of such standards for seed and crop commodities embedding genetic diversification'. SUCSEED also aims to analyse current regulations related to their seed technology as they want to 'adapt it to scientific progress'. Both cases illustrate how the envisioned changes in society (i.e. the seed registration system) translate into a scientific analysis.

In SPECIFICS, researchers study organisational structures as a solution to socio-economic lock-ins to the eradication of pesticides. They analyse, for instance, the role of production contracts between agri-food companies and farmers, to support on-farm diversity in pesticides free farming systems. In this regard, as the PI explained, they will study the role of companies in the transition to 0-pesticides farming systems. Hence, the roles of other actors are defined scientifically, but less how to achieve these changes. To further illustrate this, the following quote is extracted from the Be Creative proposal:

At the socio-economic level, the territorial scale is needed to take into account the fact that farmers are not the only ones concerned by pesticide application. Agricultural practices are partially dependent on advisory practices, commercial practices of upstream and downstream actors, regulations issued by public authorities, as well as neighbourhood relationships. The territory is a place of interaction not only between actors with sometimes divergent and conflict-ridden interests, but also between actors who cooperate and consult one another. The objective of pesticide-free agriculture therefore goes beyond the proposal of innovative technical solutions at plot or farm scales. It requires an understanding of how the actors in the territories organise and manage agricultural production today, in order to imagine how they could do so tomorrow by coupling technical, organisational, social and institutional innovations.

The quote shows that the researchers are well aware of the role of actors in the mission and envision analysing this further. However, as before it is transformed into scientific questions, instead of societal questions. The previous examples highlight reflections on the need for organisational, institutional and social change to eradicate pesticides with the alternative solutions. However, the researchers envision this as a scientific way of knowing a 0-pesticides society.

It should be noted that the call for projects specifically required the projects to add a focus on ‘training by research’,⁸⁴ in order to [translated from French^{xli}]: “enable the emergence or reinforcement of the skills needed for the transformation of agricultural systems and the new jobs associated with them” (see Chapter 3.2.1). This might explain why the researchers showed a focus on influencing actors within the scientific atmosphere, such as other researchers or the education system (e.g., students). In the proposal section on ‘expected outcomes of the project’ the researchers largely reflect on their contribution to scientific impacts: advancing scientific expertise, as well as training future professionals (e.g., technicians, engineers). For instance, in the T₀-interview, the PI of Be Creative expressed that she expects to contribute to a different way of doing and reflection on science in 2050. The PIs of VITAE and DEEP IMPACT even argue that in the eradication of pesticides, the first impact should be to have good science in place and create a scientific community around this question.

Associating research and society through the alternative solutions to pesticides

In the T₀-interviews, when we asked the PIs about the expected contributions to short-term societal impacts, we received mainly responses about the use of their research outputs in society. The large majority of expected outputs are scientific articles and scientific reports – hence outputs that communicate scientific knowledge within the scientific community. In addition, the majority of the projects will develop tools, guidelines and policy recommendations as to increase skills and competences of those other actors who are expected to use the alternative solutions to pesticides. It

⁸⁴ <https://anr.fr/fr/detail/call/cultiver-et-protéger-autrement-appel-a-projets/>

emphasises the transfer of scientific knowledge into society to eradicate pesticides, which considers the straightforward interest, adoption and use. However, many researchers emphasised that they will not be able to develop ready-to-use alternatives to pesticides in six years, but rather ‘proofs of concept’ or starting breeding lines.

This illustrates that the PPR-CPA researchers envision their role in the production of knowledge for the mission. An envisioned role, which ends at the output phase, when scientific knowledge is expected to be transferred into practical knowledge to be used in society. It indicates that the ‘outside world’ – a 0-pesticides society - is identified in terms of the expected users of knowledge. However, how society should be constituted to eradicate pesticides with the alternative solutions based on the research outputs is less known. The potential effects of envisioned change (e.g., new policy, pesticides free farming), or the effects of the implementation of an envisioned tool or technology are perceived as a scientific way of knowing. This is reflected in the way 1) how the researchers understand ‘impact’, 2) how they consider short versus long-term contributions, and 3) how they perceive the role of research in this regard. For instance, the PI of VITAE argued in the T₀ interview [*translated from French*^{xliii}]:

I think that the impacts of the project cannot be short term as it is an upstream project on fundamental research. I think we have to be clear on that. On the other hand, the idea is to open up new avenues of research that would be subject to future innovations in order to achieve this objective of reducing or eliminating pesticides and that of the call for proposals [...] an impact that we would like to see is really to have tools to steer or advise, in any case public policies and accompany the wine growers in this transition.

This quote illustrates that societal impacts represented by the 0-pesticides mission will only be visible in the longer term. In contrast, the scope of the projects is short-term, and the contributions of research are thus about the short-term. Hence, impacts are rather seen as the benefits of the ‘research outputs’ to society. In the T₀-interviews it became clear that long-term impacts are not easy to reflect upon for the projects, as it requires to think beyond the project and its direct outputs. When we asked in the T₀-interview about the envisioned long-term (2050) societal transformations to which the projects expect to contribute, we received general answers about the impact of a 0-pesticides future, without a strong reflection on the specific contribution of the project. This was reflected in responses such as [*translated from French*^{xliii; xliiv}]: ‘beyond six year, it’s a good question...’ (PI of FAST); ‘I’m going to say without shame: I’m slipping on...I’m getting out of my comfort zone’ (PI of PheroSensor). It highlighted that it is not a question on top of their minds, and was in various cases rather perceived as a general question about ‘long-term impacts of a reduction in pesticides use’, beyond the scope of their projects.

4.4.2 From Research to Society: raising interest of actors in a 0-pesticides society

In previous sub-chapters, I pointed out the involvement of external actors through approaches such as participatory research, co-design and co-creation/co-conception (e.g., in MoBiDiv, Be Creative, BEYOND, CapZeroPhyto) or through research activities to study actors' preferences (e.g., VITAE, FAST). This largely reflects the input phase of the research projects - in order to adapt the alternative solutions to pesticides to needs and challenges of other actors who are expected to use them. In this section, I highlight how the research outputs are envisioned to be transferred to actors in society. This is about raising interest and awareness of the research about the alternative solutions to pesticides, by communicating to actors.

This is reflected through both the input and the output phases of the projects. First of all, communication with actors is taking place during the input phase. The importance is illustrated by the PI of VITAE [*translated from French^{xlv}*]:

We didn't organise the project as we could have done, or perhaps it was done before, i.e. a scientific project. In the laboratory, we close the door and six years later, we open the door and we say to ourselves: "Oh là là, how can we change the practices?" Maybe that's what we used to do. I don't think it was already done like that, in any case not very often, but there was a little bit of this model. There was a little bit of this model, but today it's no longer at all the way we do science. And in particular, this is not at all how we conceived this project, because from the start, as I was saying, we want the scientists to talk to each other very quickly and to be able to engage in a dialogue very early on with the stakeholders, the players in the sector, the consumers, the producers, the professional organisation.

Hence, such dialogues and discussions are essential to favour acceptability of alternative solutions to pesticides to which the projects aim to contribute. Second, raising interest in the alternative solutions to pesticides is envisioned through the communication of research outputs to other, non-academic actors. The PI of Be Creative commented in this regard:

I am tired because I have the impression that we write reports all the time and that nobody reads them! Afterwards, we have to make sure that the story is covered by the media, that it is visible, that the citizens of the territory, but also of the surrounding areas, become aware that there is progress in all the work that we are doing.

This illustrates that such communication activities concentrate on the visibility of research results. In section 4.4.1, I argued that this is largely envisioned as the transfer of knowledge: scientific knowledge for the scientific community and transfer into applicable knowledge for actors (such as tools and guides). For the scientific community, dissemination activities seem well envisioned, through conferences or seminars, as well as through teaching and training activities at universities and professional institutes (for future professionals). Beyond scientific communities, four types of

activities are envisioned to increase visibility of the research on alternative solutions to pesticides to other actors in society:

- 1) Demonstrations, such as field visits or example cases;
- 2) Multi-actor conferences, workshops and seminars to discuss the research results;
- 3) Platforms and websites, to share tools, models and indicators, as well as information of the project;
- 4) Actor integration in the management of projects, such as a stakeholder committee.

However, such activities are not well defined and detailed yet, nor are the actors who are envisioned to participate -- rather larger actor communities are envisioned, such as breeders, farmers, policy makers, etc. In addition, the activities focus on the final phase of the research projects, and consequently focus on the transfer of research outputs to society. It does not embed detailed visions on the roles of these actors or envisioned changes for a 0-pesticides society in this regard. For example, the PI of DEEP IMPACT illustrated in the T₀-interview:

***Interviewer:** In the context of the 0-pesticides future, what changes do you expect to contribute to, after the project?*

***Interviewee:** [...] So, for me the expectation is clear to say to the technical institutes or the cooperatives, to the private companies, to the breeders to say: you have to take into account biodiversity parameters and how this biodiversity interact with the crop. But we have to give them some tools, we need to give them some demonstrations of the results. Actually, I think it's a major problem with the microbiota in agriculture: Ok we publish some very good research papers in a very good known academic science or basic science journal, but we need to move to more applied science for them. So, we need to give them some tools or bioindicators or some strategy to integrate this factor in their system.*

***Interviewer:** So, it's a project which will produce the knowledge that has to be translated in the field by actors such as cooperative, farmers, breeder etc.?*

***Interviewee:** [...] I don't know if it's a real impact at the moment, but it's for me an indicator perhaps that the transformation is going to arrive at the end of the project. Because when you have these people, the stakeholders of the project, they are going to see how the science is going to be able...what is the result, they could make some adaptation of the result and try to integrate the result in their philosophy or in their different expertise. And so, it's the best way for me and the best demonstration that we are going to make.*

The quote illustrates the interaction with a researcher who is well aware of the links between his research and the implementation of alternative solutions in the field. However, at the same time, it also reflects a rather linear way of transferring scientific knowledge. Communication strategies include visions of knowledge transfer, but is limited in terms of the envisioned roles of actors in

contributing to the eradication of pesticides based on this. Such activities are expected to raise interest or convince actors in the alternative solutions to pesticides, by demonstrating proof of its performance. Actors preferences, desires and needs are considered in the input phase through their involvement in participatory activities, such as analysis as 'willingness to pay', or co-conception: but, 1) it is based on scientific questions and results in scientific outputs, instead of societal questions; and, 2) such type of inclusion is not found in relation to the output phase of the research to support the translation of research outputs into alternative solutions to pesticides in society.

To conclude this subchapter, I showed how the construction of the PPR-CPA projects reflect the researchers' visions of their associations to a society without pesticides. The researchers demonstrated that they know the 'world outside their lab' as they reflect on the need for other actors to contribute to the eradication of pesticides with their alternative solutions. In some cases, various actors are already identified as they have been interacting in previous research projects. However, the researchers' visions reflected the 'transfer of' their research outcomes to society, which demonstrates a rather linear process from science to society. For instance, they show to be less familiar or reflexive on how and when to connect with other actors in society. The researchers tend to concentrate on their role as excellent scientists, which places research outside of society: i.e., it reflects visions of research 'for society', rather than research 'within' society. The researchers emphasise creating visibility of their research on alternative solutions vis à vis other actors, but do not define what the role of these actors are in the eradication of pesticides. Also, raising the interest of other actors in the research outcomes focusses on 'convincing' actors, rather than anticipating that actors could already be interested and enrolled in the mission.

Conclusion

To conclude, in this chapter I demonstrated how the PPR-CPA researchers envisioned contributing to the eradication of pesticides by studying alternative solutions to pesticides, before they got involved in ASIRPA RT. In particular I showed how this societal mission influenced the construction of their research projects. In terms of alternative solutions, these ten funded projects embed different approaches. First, there are projects that focus on system change to support the eradication of pesticides. Second, there are projects that focus on the replacement of pesticides through alternative inputs. Third, there are projects that focus on change in pest-management strategies.

Compared to previous projects without such an ambitious mission, the projects showed renewed and ambitious research questions. The researchers also added complexity to their projects on various levels, such as multi-disciplinary and multi-actor processes, from the laboratory to the field,

and by addressing multiple pests or cropping systems. However, the research proposals still highlighted the perspective of research, and thereby emphasise their breakthrough science contribution to the mission: research for society. Nevertheless, the researchers showed to be highly aware of the limited contribution of research to such an ambitious societal mission, and thereby the need for other actors to get involved to eradicate pesticides with the alternative solutions.

But, the research proposals emphasise their focus on blue-sky excellent science, which reflects visions of their contributions to the mission through a scientific way of approaching how a society without pesticides should be constituted and act. In particular, they highlighted the change of practices they expect for actors in society in the eradication of pesticides with the alternative solutions they study in their projects. Hence, this highlights a rather linear approach to the associations between their research on alternative solutions and a society, without pesticides. It is based on visions that the role of research is to proof scientifically the capacity of the alternative solutions to eradicate pesticides in society. This does not only highlight the study of (technological) efficiency, but also of their multilevel performance and favouring acceptability by actors.

This shows that the researchers do consider the practical situations and needs of actors such as farmers, breeders, industries, or cooperatives. However, such considerations translate into scientific questions, with the idea that if these scientific findings are successful that there will be actors in society will be interested. It shows visions of a straightforward interest, use and adoption of alternative solutions by users in society, for which it is the task of research to provide scientific proof. And so, change in society is envisioned as the result of the 'transfer' of research outputs into society.

Therefore, even though the evident ambition of the research projects to contribute to a societal mission, the researchers' capacity to envision transformative change in society to enable the eradication of pesticides with the alternative solutions is weak. This highlights the need for an approach to support researchers in this regard, which I demonstrate in the following chapters by exploring the T₁-phase: the researchers' visions of the expected contributions of the alternative solutions they study to the mission when they got involved in ASIPRA RT' formative evaluation approach.

Chapter 5

Establishing Associations Between
Science and Society: Researchers' Visions
of the Constitution of a 0-Pesticides
Society

Chapter 5. Establishing Associations Between Science and Society: Researchers' Visions of the Constitution of a 0-Pesticides Society

The PPR-CPA is embedded in France's future investment programme, particularly in the objective to amplify research (PIA3 – see Chapter 1). The ambitious objective is to discover alternative solutions to chemical pesticides for the French agricultural system, by investing in R&I activities. Reducing damage from pests as well as the negative impacts – such as health or environmental impacts - of pesticides for society is central in the program. In this regard, the programme report claimed that (Jacquet et al., 2019) [*translated from French*^{xlvi}]:

The interest of the PPR is to support a long-term research effort, through long and ambitious research projects, with the aim of producing solutions that will enable the deployment of pesticide-free agriculture by 2030-2040.

However, it is obvious that its impact will be important in the shorter term, both by encouraging the structuring of a large scientific community around this ambition, and thanks to intermediate deliverables with an application in transitional agriculture (p.82).

Hence, the PPR-CPA aims to align their research with societal challenges. The ASIRPA RT approach was implemented as a means to accompany researchers in envisioning the expected contributions of the alternative solutions they study to the eradication of pesticides in society, and to the societal impacts that such eradication might bring. Particularly, I want to explore how the researchers take on responsibility for contributing to the societal mission when they got involved in ASIRPA RT as a formative evaluation approach, which requires them to make explicit their visions of a 0-pesticides future with the alternative solutions they study.

In chapter 4, I explored the researchers' visions of their contributions to the 0-pesticides mission before they got involved in ASIRPA RT. I discussed how the construction of the projects reflect the researchers' expectations of contributing to the eradication of pesticides in society by doing research on alternative solutions, as a T₀-measurement. It demonstrated a focus on excellent science, which reflects researchers' visions of their contribution to the mission with the research projects – and the constitution of a society without pesticides - through a scientific way of knowing. This highlights a rather linear approach to the associations between their research projects on alternative solutions and a society without pesticides. It shows visions of a straightforward interest, use and adoption of the alternative solutions by actors in society. Change in society is envisioned as the result of the transfer of research outputs to interested actors.

Consequently, I showed that the researchers' capacity to envision societal change enabling the eradication of pesticides with the alternative solutions is rather weak if they are not pointed in that direction. Following up on these results at T_0 , the collection of data about the researchers' visions when they first got involved in ASIRPA RT enabled me to analyse their visions of the expected contributions of the alternative solutions to the societal mission, as a T_1 -measurement. As I elaborated in Chapter 3 (Methodology), I analysed the responsibility the PPR-CPA researchers take on at T_1 through the three phases of the 'responsible translation' process. Responsible translation describes the process of translating visions of alternative solutions into those of a society that eradicates pesticides with these solutions. This process is largely inspired by the work of Callon (1986), and adapted to two unique situations of the PPR-CPA: 1) visions of a future society without pesticides; and 2) the performance of expected contributions to these visions in real-time, through chains of translation in heterogeneous networks.

The first phase of the responsible translation process

As a first step in this T_1 -analysis, the research question I answer in this chapter is: *How did the PPR-CPA researchers expect that the alternative solutions they study in their research projects can contribute to the 0-pesticides mission, when ASIRPA RT helped them navigating their visions of societal transformations and impacts?* In this chapter, I illustrate the data collected during the T_1 -phase of the PPR-CPA projects; in particular when the researchers were accompanied to make explicit the expected contributions of the alternative solutions to societal impacts and transformations the mission represents. I am showing this, by exploring the first phase of 'responsible translation': **Establishing science-society associations through Problematisation**. This phase highlights the researchers' visions of the constitution of a '0-pesticides-society' to which they expect to contribute with the alternative solutions to pesticides they study in their research projects. This represents visions of how a 0-pesticides society is expected to benefit from the studied alternative solutions as well as what transformations are required, which needs actors in society to change to enable the eradication of pesticides through alternative solutions to the problem.

This phase is inspired by the 'problematisation' moment of the Sociology of Translation by Callon. In the case study about the Scallop of St Brieuc, Callon explained this moment as follows:

*[...] the aquaculture of scallops at St. Brieuc raises a problem. No answer can be given to the following crucial question: does *Pecten maximus* anchor itself during the first moments of its existence? Other questions which are just as important accompany the first. When does the metamorphosis of the larvae occur? At what rate do the young grow? Can enough larvae be anchored to the collectors in order to justify the project of restocking the Bay? But in their different written documents the three researchers did not limit themselves to the*

simple formulation of the above questions. They determined a set of actors and defined their identities in such a way as to establish themselves an obligatory passage point in the network of relationships they were building. This double movement, which renders them indispensable in the network, is what we call problematization (p.204).

Hence, to adapt this to the societal mission of the PPR-CPA, problematisation is about defining how the researchers expect to become inextricably associated with society towards the eradication of pesticides. So, envisioning this phase of responsible translation, means envisioning the establishment of associations between their research projects on alternative solutions and their visions of a society without pesticides. This started to become visible when the researchers were asked to make explicit the societal impacts and transformations they expect to contribute to as part of the mission.

The objective of the PPR-CPA projects is to contribute to the eradication of pesticides in France by 2040 by conducting research into alternative solutions to pesticides. This ambitious societal mission requires the researchers to envision the constitution of a society that eradicates pesticides with the alternative solutions they study in their projects. Consequently, the phase of 'problematization' describes how the researchers expect that these studied alternative solutions can contribute to the 0-pesticides mission, when ASIRPA RT helped them navigating their visions of societal transformations and impacts. Therefore, this first phase of the responsible translation process includes defining the constitution of a '0-pesticides society' based on the researchers' visions of 1) how society is expected to be impacted by the alternative solutions to pesticides; 2) the transformations required so that society can change to eradicate pesticides with the alternative solutions; 3) the potential blocking factors to these transformations.

In this chapter, I demonstrate that in the responsible translation process, societal impacts are envisioned as the societal consequences of the development and implementation of the alternative solutions to pesticides in society. Hence, this thus does not just depend on the researchers conducting their research on alternative solutions. It also requires transformative change in society to enable this development and implementation for the eradication of pesticides. Consequently, as this chapter will highlight, responsible translation represents the process of visions of alternative solutions translating into a society that eradicates pesticides with these solutions. Thereby it highlights the shared responsibilities between researchers and other actors in enabling the eradication of pesticides with these alternatives. These shared responsibilities in this regard are described as two – what Callon describes as - Obligatory Passage Points (OPPs).

The analysis that I present in this chapter is based on the data collected in 2021 during the first phase (T₁) of the ASIRPA RT activities in the PPR-CPA, on project level. In this first year, with the

ASIRPA RT-team, we guided the researchers in constructing their first project Impact Pathway (IP) (see Chapter 3 - Methodology). Hence, this chapter discusses the T₁-phase of the PPR-CPA researchers, when they constructed and collectively discussed their first IP.⁸⁵ By exploring the phase of problematisation, I focus on the researchers' visions of societal impacts and the societal transformations they expect to contribute to in this mission-oriented context. The main data that fed into this chapter are twofold: 1) The first constructed Impact Pathway (IP) of the PPR-CPA projects, including a narrative to explain their IP; 2) The project-level workshops that we organised in autumn 2021 with eight out of the ten projects⁸⁶, to collectively discuss and improve the project IPs.

In this chapter, I explore how ASIRPA RT helped navigating the researchers' visions of the expected contributions to the mission of the alternative solutions they study in their research projects, through the first phase of the translation process. This first phase reflects visions of establishing associations between the PPR-CPA research projects and a 0-pesticides society, which I structured around three questions in this chapter. Each question represents a sub-chapter: 1) How do the researchers think they would impact society with the alternative solutions to pesticides they study?; 2) what transformations are envisioned, which requires society to change to enable the eradication of pesticides with the alternative solutions?; 3) what are the envisioned OPPs to pass and what could potentially block the translation process?

5.1 Researchers' visions of societal impacts

In his work on the Sociology of Translation, Callon describes how the three researchers who study the Scallops of St Brieuc become indispensable to other actors in a network. An essential first step, in constituting the network, is the 'interdefinition of actors'. Callon (1986) argues: "*A single question – does *Pecten maximus* anchor? - is enough to involve a whole series of actors by establishing their identities and the links between them*" (p.205). Even though, the real-time and mission-oriented context of the PPR-CPA is different from the study on the Scallops, a similar situation is emerging: how to constitute a society that is able to eradicate pesticides with the alternative solutions studied in the PPR-CPA projects? Consequently, this embeds the interdefinition of actors who are expected to be involved or contributing to these visions.

⁸⁵ The 'first round' refers to the construction of their first Impact Pathway. During the six-year timeframe of the PPR-CPA, the projects will be asked to reflect, revise and re-anticipate changes in the IPs.

⁸⁶ 8 out of 10 PPR-CPA projects participated in these workshops: Be Creative, BEYOND, CapZeroPhyto, FAST, MoBiDiv, PheroSensor, SPECIFICS, SUCSEED. Hence, the analysis of this chapter is based on these eight projects.

Hence, the 'interdefinition of actors' by the researchers in this mission-oriented context, reflects their visions of this future society. The T_0 -analysis (Chapter 4) demonstrated that visions of a 0-pesticides society were defined in a rather scientific way of knowing the relationship between science and society. Therefore, being able to identify and define this particular type of 0-pesticides society becomes essential for establishing associations in their PPR-CPA projects. Through our formative evaluation approach, with ASIRPA RT we accompanied the researchers to make such visions explicit. This sub-chapter highlights an important first step in this regard by demonstrating how the researchers envisioned impacting society with the alternative solutions to pesticides they study in their research projects.

By constructing an IP, the researchers were asked to make explicit their expected pathways from research to societal impacts – and in this way reflect the envisioned associations between their research and a 0-pesticides society. As the researchers are part of a societal mission, it requires them to not only conduct excellent science on alternative solutions to eradicate pesticides, but also to envision the societal impacts that such eradication might bring. To guide them in this regard, the ASIRPA RT approach holds a 'backward' type of reasoning. This means that the construction of an IP in the 0-pesticides mission starts with envisioning the societal impacts that the mission represents (see Chapter 3 – Methodology). Hence, such visions are a key first step in the definition of a 0-pesticides society, as it reflects how such a society is expected to be impacted by the alternative solutions to pesticides, and thus why they would be interested in them. This forms the basis of then understanding the constitution of a society that could achieve these benefits, which I illustrate in the next sub-chapter 5.2.

As research outputs will not lead straightforwardly to the eradication of pesticides in society, responsible translation illustrates the process from research on alternative solutions into a society that eradicates pesticides. Consequently, in this sub-chapter, I illustrate how the researchers envision impacting society as a result of this translation process. They demonstrate this to be the consequences of societal transformations enabling the development and implementation of alternative solutions to pesticides in society.

5.1.1 Researchers' Visions: Impacting Society with alternative solutions to pesticides

It is widely acknowledged that pesticides have a negative impact on society (Jacquet et al., 2022). Therefore, the PPR-CPA projects are funded to research alternative solutions that should be able to control pests without the use of pesticides. However, providing the scientific proof that alternative solutions have the capacity to contribute to the eradication of pesticides is insufficient for the societal mission. The researchers should go beyond scientific excellence, by envisioning the

translation of their research into the eradication of pesticides in society, and thereby generating societal impacts. In this way, these impacts are envisioned as the societal consequence of a successful translation process, and thereby play a key role in directing research efforts towards the mission. This is because these visions of impacts illustrate which actors in society are expected to benefit from the studied alternative solutions in the projects – and are thus expected to be interested. It also includes visions of how this can be enabled. Therefore, this contributes to visions of the constitution of a 0-pesticides society.

I extracted the following quote from the workshop with PheroSensor, which is a fundamental technoscientific project with the objective of developing pheromone sensors. The project PI expressed [translated from French^{xlvii}]: *“I'll say something and I think the members of ASIRPA will agree, anticipating it is also to avoid having the nose in the handlebars and having only the academic objectives in mind and forgetting everything else”*. The quote illustrates an example of how the researcher reflects about aligning his scientific objectives to a challenge in society. Through the construction of their project IPs, the researchers started to reflect on impacts not just as a scientific outcome, but as a societal consequence of the envisioned translation of their research on alternative solutions. In other words, how they expect that society could benefit from the alternative solutions they conduct research on.

The PPR-CPA researchers were asked to reflect on societal impacts in the five dimensions of the ASIRPA approach: 1) Economic; 2) Environmental; 3) Health; 4) Social; and 5) Policy (Matt et al., 2017). This showed that the researchers envision impacts as the societal consequence of the development and implementation of the alternative solutions for the eradication of pesticides by actors, which requires transformative change in society to enable this. And thus, in their visions of a 0-pesticides society, the researchers attribute an active role to other actors in enabling the contribution of the alternative solutions to the mission. They reflected upon these societal impacts in two ways. First - although this was reflected in a rather limited way - impacts were envisioned as the societal consequence of the eradication of pesticides with the alternative solutions by actors in society. Second - which represents the majority of the reflections - impacts are envisioned as the societal consequence of the actual development and implementation of the alternative solutions to pesticides by actors in society.

Societal impacts in the first minor category - as a societal consequence of reduced pesticides use - are envisioned when pesticides are eradicated with the alternative solutions studied in the research projects. This does not reflect project specific contributions to impacts, but refer to this

future society more generally. Consequently, such impacts are envisioned in a similar way among researchers of all PPR-CPA projects. A few examples for each of the five impact dimensions are:

- **Environmental:** the reduction of negative effects on the environment;
- **Health:** a reduction of residues on food products for consumers;
- **Economic:** the reduction in yield losses due to pests;
- **Social:** an independence of farmers to pesticides;
- **Policy:** the recognition of agriculture without pesticides.

As these impacts are not necessarily project specific, these are not highly explanatory about the researchers' visions of the constitution of a 0-pesticides society and the interdefinition of actors in this regard. The second category is envisioned in much more detail, and tells us more about how the researchers envision this future society with the alternative solutions.

Societal impacts as a consequence of the development and implementation of alternative solutions

So, societal impacts in the second category - as a societal consequence of the development and implementation of the alternative solutions to pesticides – reflect project specific visions of the translation of their research into a society that eradicates pesticides. I provide some examples for each of the five impact dimensions to illustrate this, which emphasise that envisioned impacts depend on the specific solutions to pesticides each project is proposing. For example, projects that focus on in-field diversification to eradicate pesticides (e.g., Be Creative, MoBiDiv, SPECIFICS), envision **environmental** impacts through an increase in biodiversity or an increase in soil fertility levels.

On the level of **Economic** impacts, depending on the type of project, impacts are mainly envisioned in relation to 1) the marketability of the proposed solutions, and 2) the yielded pesticide-free products. For example, in the first category, for several projects impacts are largely envisioned as the creation of new markets (channels) and investments in line with technological innovations - e.g., new seed markets or the development of new technologies. In the second category, impacts are about new market outlets or labels and certification of food products, and thereby the valorisation of products in this regard – e.g., pesticides free products, diversified products, products such as wheat or bread based on new or mixed varieties. Also, in most projects, researchers envision an increase in economic profitability for farmers as a result of the implementation of alternative solutions to pesticides - e.g., because of new varieties, or higher yields due to diversification, etc. Finally, impacts are also envisioned as the improved autonomy (SPECIFICS: plant-based proteins) or competitiveness (SUCSEED: seed treatments) of France in relation to the alternative solutions.

Third, **Social** impacts are envisioned as a result of job creation for companies who take up the research outputs to further develop alternative solutions – this is largely considered by the more

technology-centred projects, such as SUCSEED, PheroSensor and CapZeroPhyto. Societal impacts are also envisioned through the creation of collective farm networks - this is highlighted by the projects with a large socio-economic dimension, such as Be Creative or MoBiDiv. A particular social impact was illustrated in the IP of PheroSensor [*translated from French*^{xlviii}]: “*Preservation of heritage (emblematic palm trees), maintenance of tourism potential (e.g., Côte d’Azur)*”. With the sensors for early pest detection they aim to protect tourist areas with particular palm trees, from evasive species that could damage such trees.

Policy impacts are very project specific, as it is in line with the particular needs of various PPR-CPA projects. For instance, SUCSEED, SPECIFICS, CapZeroPhyto and MoBiDiv envision new procedures, regulations and standards, which they require for the inscription of their specific alternative solutions. This is for instance about the registration of seed and biocontrol technologies/products. Hence, with their research projects they envision contributing to changing such policies. I found similar outcomes in other projects, such as in: 1) PheroSensor, which envisions an evolution in the quarantine regulation for organisms of invasive species; 2) BEYOND, which aims for new epidemiosurveillance strategies on local, regional or international level; and 3) Be Creative, which envisions to impact policies that are better adapted to the 0-pesticides transition on territorial level.

Evidently, the FAST project embeds a specific research focus on policies, and therefore the researchers envision updating national and international policies to support the reduction of pesticides use. Hence, the researchers envision having an impact on policy makers who are involved in such policy making processes. In addition, they imagine that this would also benefit companies as it might allow them to develop and market pesticide-free technologies.

Finally, **health impacts** are in a very limited way mentioned in direct relation to the alternative solutions. It is only mentioned by SPECIFICS as they aim for an increase in plant-based proteins in human food products in France, produced in 0-pesticides farming systems. Hence, the SPECIFICS’ researchers envision to impact consumers.

Positive visions of societal impacts by reducing impact from pesticides use

The researchers demonstrated that the expected contributions to societal impacts go beyond the scientific outputs of the research projects. Instead, it highlights visions of the societal consequence of the development and implementation of the alternative solutions by a 0-pesticides society. This thus demonstrates an active role envisioned for society in the eradication of pesticides. To provide a specific example, SUCSEED focusses on seed technologies (biostimulants), as presented in their ‘IP narrative’ [*translated from French*^{xlix}]:

The development of the biocontrol/biostimulant market and the adoption of new seed production methods should generate job creation and enable farmers to become independent of chemical pesticides thanks to the involvement of experimentation networks (ITA, DEPHY, agricultural service providers, cooperatives, etc.) as well as industrialists, specialised companies and seed companies. These societal impacts are closely linked to economic and environmental impacts. Indeed, the development of these innovations could generate significant economic gains and the development of companies (e.g., start-ups, mergers and acquisitions, extension of internal activities), which will surely lead to greater competition between companies positioned on the seed and seed treatment market. From an environmental point of view, this deployment will result in a reduction or even cessation of the use of conventional pesticides (fungicides) by farmers and therefore a reduction in the environmental damage linked to the use of these products.

As this example illustrates, the researchers expect societal impacts to be a response to challenges in society that are caused by pesticides use. For example, it responds to environmental challenges (pollution), as well as job creation, independence and increased incomes for farmers and increased competition of companies/industries beyond pesticide products. Other projects responded in similar ways. For instance, Be Creative researchers wrote in their IP narrative about the envisioned societal impacts [*translated from French*]: “A more diversified agriculture, less dependent on phytosanitary products and better valued (labels, short circuits, higher remuneration, social pressure from citizens), particularly on a territorial and then national scale, which allows it to be less dependent on volumes while being much more profitable”.

What both quotes illustrates, and what is noticeably reflected more largely among the projects, is that such reflections on societal impacts are only positive, and highlight a response to negative impacts caused by pesticides. In addition, SUCSEED mentioned in this regard [*translated from French*]^{li}: “The first effects on functional soil biodiversity could be felt, although to date we have no hindsight on the negative impacts of these innovations deployed on a large scale”. Negative impacts or trade-offs between impacts as a consequence of the research projects are not envisioned. This illustrates that 0-pesticides societies are envisioned to benefit from the alternative solutions studied by the projects, as they provide solutions to challenges caused by the use of pesticides. At this early stage of the research, human actors are not identified yet in detail, but rather in relation to their actors' communities such as farmers, consumers or agri-food companies.

To conclude, in this sub-chapter I illustrate how the researchers expect that the alternative solutions they conduct research on can impact society. Impacts are envisioned as positive benefits to actors in society, and a response to challenges caused by pesticides use. This showed to be the societal consequence of the development and implementation of the alternative solutions by actors. Even though actors were not yet precisely defined, the researchers attribute an active role to other actors

in the contribution of the alternative solutions to the eradication of pesticides, and thus for society to be impacted. In the next sub-subchapter 5.2, I build further upon this by demonstrating the transformative change required in society to enable the development and implementation of alternative solutions and thus to impact society.

5.2 Researchers' visions of Transformations for a 0-pesticides society

In the previous sub-chapter 5.1, I illustrated how societal impacts are envisioned as the societal consequence of the development and implementation of the alternative solutions to pesticides in society. Building further upon this, in this sub-chapter I show that this requires societal transformations, which reflect the necessary change of actors how they act in the future to enable the development and implementation. Consequently, without such transformations there will not be impact, and impacts are thus the consequence of transformative change in society. This embeds thus an active role for other non-research actors in the eradication of pesticides, by enabling the development and implementation. To further define visions of such a future society, in this sub-chapter I illustrate how the researchers envision the societal transformations required to eradicate pesticides with the alternative solutions.

With ASIRPA RT we guided the researchers through this process. In the construction of their project IP, they were asked to reflect on the societal transformations necessary in their contribution to societal impacts (see Chapter 3 - Methodology). We explained the notion of societal transformations to the projects as “*a change in society and among non-academic actors induced by the adaptation, development, adoption and use of research results*”. The following quote from a researcher from BEYOND during the workshop, illustrates a reflection on transformations as the conditions for achieving impacts [*translated from French*^{lii}]:

I have a question about impacts. Are these the conditions for achieving impacts? It's because the economy... because it's more profitable to sell to farmers, and that is one way. The objective here is to have an impact on the fact that more people will use the proposed solutions in terms of prophylaxis. That is one way. There are two ways to change behaviour, either by regulating incentive policies or by convincing people that it is good.

Societal transformations are considered as the conditions for achieving impacts in society; i.e. impacts are the societal consequence of transformations. Consequently, transformations in society are about the change necessary for, and generated by, the non-research actors to enable the development and implementation of the alternative solutions to eradicate pesticides. I demonstrate that one type of transformation can contribute to multiple impacts (dimensions), and one impact might require multiple transformations.

Hence, visions of societal transformations are key in the translation process. Such visions represent how a 0-pesticides society is expected to be constituted and act in the future to enable the eradication of pesticides with the alternative solutions. Transformations are needed for the development and implementation of alternative solutions, and are thus about the necessary change to constitute a society that is able to eradicate pesticides with these solutions. Hence, building further upon sub-chapter 5.1, this provides a second step in the problematisation phase – and thereby the interdefinition – of a 0-pesticides society.

5.2.1 Five interdependent poles of societal transformations

First, transformations are envisioned in relation to (pesticide-free) farm practices on crop, field and farm level. This refers to the implementation of the alternative solutions to pesticides by farmers on these various levels of action - such as crop diversification; the use of adapted seed varieties; adapted prophylaxis to pest presence/prediction. Nevertheless, such change does not happen in isolation. Instead, the researchers show that transformative changes are envisioned in various interdependent poles. For instance, the implementation of 'pesticide-free' farming practices by farmers, could depend on the development of technologies, changes in marketing channels, as well as on the adaptation or evolution of policies: i.e., multiple aspects to enable the eradication of pesticides with alternative solutions. This shows that transformations are not envisioned in isolation, and, as I emphasised, one type of societal transformation could contribute to multiple impacts and one impact might require multiple transformations.

Where the researchers were asked to reflect on societal impacts in the 5 dimensions of ASIRPA (Economy, Environment, Health, Social and Policy), no pre-defined dimensions of societal transformations were given. Based on the researchers' visions, I identified five interdependent poles of societal transformations. The researchers envision change in each of these five poles to constitute a society, which eradicate pesticides, to which they also expect to contribute with their research projects. Therefore, from now on, I will speak about the **five poles of societal transformations**. I will present each pole individually, using examples provided by the PPR-CPA researchers, which highlights the interdependence of these poles of transformations. The poles thus illustrate the transformations necessary to constitute a society that is able to eradicate pesticides, and embeds actors that should change the way they act in the future to enact these transformations (the results are summarised at the end of this section in Table 11). These five poles are:

1. User Context;
2. Technology;
3. Markets;

4. Policy and Regulation;
5. Science and education.

The User context-pole

First, societal transformations are envisioned in the user context in the constitution of a 0-pesticides society. I start with this pole, as this is where the actual eradication of pesticides in farming systems is expected to take place. Transformations in this pole refer to changes in the entire societal context of users of the alternative solutions to pesticides as well as to the related pesticide-free products. This is about transformations in farming, agricultural extension services or changes in consumption. Although, the latter transformations are limitedly envisioned by the researchers, the majority of such visions refer to the implementation of alternative solutions to pesticides in farming systems.

The PPR-CPA researchers were quite good at defining transformative visions in the user context. Especially transformations on the crop, farm, and field level are largely elaborated, as this is where the actual eradication of pesticides is taking place. To provide some examples, SPECIFICS foresees a change in farming systems, as they aim for diverse, pesticide-free legume crop production. One of the researchers argued during the workshop about the transformations they envision [*translated from French*ⁱⁱⁱ]:

So, the initial context was an identified need for a radical change in cropping systems to a less resource-intensive, more environmentally friendly agricultural system capable of meeting growing food needs. As an intermediate context... crop systems that are richer in leguminous grains, more resilient and based on biological regulations that meet France's environmental and food needs. In the final context, a pesticide-free agriculture and a transformation of food habits for 2050.

Hence, this illustrates envisioned transformations in relation to existing farming practices: a change to legume-rich pesticide free farming -, as well as in relation to consumer practices: a change to a diet based on plant proteins. In SPECIFICS, the envisioned transformations necessary for the constitution of a 0-pesticides society are based on their research activities on legume rich cropping systems. In projects such as BEYOND and PheroSensor, the researchers do not study alternative farming system or practices as such, but for these projects envisioned transformations in the user context are a consequence of the innovations they are developing. For example, BEYOND studies epidemiological⁸⁷ indicators, which according to the researchers provide opportunities for new

⁸⁷ A branch of science that deals with the incidence, distribution, and control of disease in a population
- Source: Merriam Webster 2023

strategies in disease control. As the researchers argue in the IP narrative, they envision this as follows [translated from French^{liv}]:

The new indicators and the expanded window of opportunity for disease control will allow better implementation of well-known control methods - such as biological control - and innovations in disease control. For example, some indicators will draw attention to pathogen pathways via wind and water or to land use history that may predispose to certain diseases.

In addition, the PI of PheroSensor explained how the pheromone sensors they conduct research on could contribute to the performance of precision agriculture practices [translated from French^{lv}]: "So, the fact of detecting the odours emitted by the insects, will allow us to locate the site in Calisson more precisely and to apply means of control in a more targeted way, both in time and in space. And so, this is what we call precision agriculture". Hence, both projects conduct research on epidemiosurveillance, with which they expect to contribute to changes in prophylaxis⁸⁸. These examples also illustrate the researchers' visions of transformations in other poles (e.g., technology development) that are required for the transformations in the user context. I will further discuss this interdependence in the coming paragraphs.

To provide a final example from Be Creative, one of the researchers proposed during the workshop that [translated from French^{lvj}]:

Another transformation of another degree, which concerns a change in consumption, is to go towards a mode of consumption rather local without pesticides. And thus there, one acts rather on the consumers. And there, it will perhaps be necessary to re-examine a little how the outputs of the project can be re-used by the consumers to eventually arrive at this transformation in mode of consumption by the consumers.

This quote illustrates that the 0-pesticides society the researchers envisions, also requires change in consumer practices in the user context. The examples of the 'user context-pole' I gave, demonstrate the envisioned changes in practices related to the use of the alternative solutions to pesticides, and also in a limited way to the consumption of pesticide-free products.

The Technology-pole

The second pole of societal transformations is about Technology development for a 0-pesticides society. Transformations in this pole are envisioned as a key phase of the development of the alternative solutions, before its implementation in the farming system (eradication of pesticides). Consequently, this pole is strongly connected to the User-context pole. Mainly the fundamental and

⁸⁸ Measures designed to preserve health (as of an individual or of society) and prevent the spread of disease – Source: Merriam Webster 2022

more technology-centred projects emphasise the necessity for transformations in the technology-pole, which are expected on two main levels.

First, it is about the development of technological alternative solutions based on the research outputs (e.g., breeding technologies based on research on genotypes). For instance, the PI of MoBiDiv presented the societal transformations as envisioned in their constructed IP in relation to the genome research they conduct, and illustrate the need for a change in breeding activities [*translated from French*^{lvii}]:

In order to achieve transformations towards a diversification of agriculture and practices, with a modification of crop rotation and cropping systems, [requires] new technical itineraries. And, to achieve this upstream transformation, a transformation of reference production activities on the qualities of the mixtures is needed. [...] But the second part of the work that we have identified is rather everything that involves the identification of very genomic regions, plant ideotypes, tools that can be used in breeding, a certain number of which can be used by breeders, whether they are breeders in the traditional sense of the term or networks of farmers in participative breeding. And also, the organisations that supervise breeding activities, such as the CTP and GEVES, and these outputs used by these actors should allow transformations within the breeding activity, both through selection schemes adapted to the mixture, and therefore a modification or diversification of the selection objectives, a selection of varieties and species specially adapted to the mixture or selected in a mixture and a selection strategy for more local environmental conditions.

This example from MoBiDiv emphasises a need for change related to breeding activities based on their research outputs. They conduct research on seed mixtures as an alternative solution to pesticides, which requires different breeders (e.g., companies of participative breeders by farmers' networks) to further develop their research outputs - e.g., genomic regions, plant ideotypes, tools – and thereby thus changing their breeding activities. SUCSEED and CapZeroPhyto shared similar visions in relation to biocontrol technologies. For instance, SUCSEED conducts research on biostimulants for seeds as an alternative solution to pesticides. The researchers envision changes in the development of 'high sanitary quality seeds', to which they expect to contribute with their research on 'new processes for applying innovative solutions to seeds'.

The second level of visions of transformations in the technology pole is about the increase of the Technology Readiness Level (TRL). For example, a researcher of PheroSensor argued in this regard during the workshop [*translated from French*^{lviii}]:

...an industrial partner should help us with the manufacture of the devices once we have made prototypes, since in the course of the project we will have different levels of prototypes. We want to arrive at the end of the project at prototypes, so we will need these partners, an industrial partner to optimise the costs [...] And then, at the end of the, we

marked technical institutes to...make the best use of sensor for the use of prophylactic methods. Because the sensor is a chance, but it is not the end. The purpose is early detection to set up or optimise the most effective, most biological means of control.

During the given six-year timeframe of their project, the researchers aim to develop prototypes of their pheromone sensors. To enable society to eradicate pesticides requires a change to industrial processes, in order to increase the TRL of this technology, and to allow the actual use in the field and control pests in this regard.

The example of the technology pole highlights the development of alternative solutions to pesticides to which the researchers expect to contribute with their research outputs. This showed to be highly interlinked to the implementation of the alternative solutions in the field and thus to transformative change in the user-context.

The Market-pole

The third pole of expected societal transformations is related to Markets for a 0-pesticides society. Where the user- and technology-poles reflected transformative visions for the actual development and implementation of alternative solutions to pesticides, transformations in the market pole provide the essential conditions in this regard. Visions are, for instance, about the creation of new market channels or marketing standards necessary for the development and implementation of alternative solutions. Transformative change in the market pole refers to actors related to agri-food companies, cooperatives, industries and marketing channels of agri-food products.

I provide a few examples to illustrate this point, which is twofold. First, it is about the marketability of the alternative solutions to pesticides in a 0-pesticides society. For instance, SUCSEED and MoBiDiv envision the need to transform marketing channels for biocontrol products and seeds (e.g., for new varieties or seed mixtures). The PI of MoBiDiv explained [*translated from French*^{lix}]:

We have also identified a large part of the impact on the economic dimension with the evolution of the professions, so the evolution of the breeding professions, the evolution of the advisory professions, the seed production site. So here is the emergence of new offers, new products, including diversified products, mixed seed offers, advice on mixtures must study new economic models for financing research and also, at the downstream level, a transformation of the sectors with new products, new outlets for production, the use of diversified production.

This quote highlights this interconnectedness between the Technology, Market and User poles. The transformations of marketing channels are envisioned as an essential connection between the development of technological alternative solutions (technology-pole) and the marketing of these

technologies so they are available for the implementation as alternative solutions to eradicate pesticides at farm, field or crop level (User-pole).

Second, envisioned market transformations are about the change of market channels of pesticide-free food products as well as food processing. This is argued by the PI of Be Creative [translated from French^{ix}]:

A transformation which is a little different and which aims rather at the downstream of the sector, it was the fact that there is a relocation of supplies, in particular to develop the more diversified local productions of the farmers, and thus that, that passes by which are the comparative actors, in particular the processors, the food-processing actors, it passes by the remobilization, the readjustment, the innovation proposals which occur within the framework of the project.

Such transformations are essential preconditions for the implementation of alternative solutions, and thus connect to transformations in the user-pole. As these examples highlight, for farmers to implement alternative solutions to pesticides requires market outlets which accept and are able to sell these food products. This might result in a diversification of quality and quantity of products. Hence, it requires awareness throughout the entire value chain. To provide some examples, SPECIFICS aims for a 0-pesticides society based on an increase of pesticide-free legume products. The implementation of such legume-rich, pesticide-free farming systems require transformations in the market pole, in terms of adaptation to the global legume market and change to more 'plant-based protein' food products.

To provide a different example, transformations of markets are also largely envisioned in relation to the heterogeneity of pesticide-free food products. As Be Creative's researchers argue, they envision a transformation of agri-food industries to focus on local products and tolerating heterogeneity in 'quality/volume'. In addition, MoBiDiv stresses in this regard [translated from French^{xi}]:

A study will be carried out on downstream quality standards, which should lead to the development of scenarios for the relaxation of downstream quality standards and which could be used by cooperatives and players in the agri-food sector to adapt downstream sectors so that they accept mixtures in the collection and processing sectors in order to diversify outlets and develop specific sectors such as the pulse sector, for example.

Hence, the implementation of alternative solutions to pesticides might result in heterogeneity in the quality or volume of crops, and this should be accepted by market actors. These are key transformations in the constitution of a 0-pesticides society envisioned by projects such as Be Creative, MoBiDiv and SPECIFICS.

The Policy and Regulations-pole

The fourth pole is about transformations related to policy and regulations for the constitution of a 0-pesticides society. Like the market pole, transformations in this pole are envisioned to be necessary in supporting both the implementation and development of alternative solutions in society. PPR-CPA researchers highlight the necessity of policy transformations for two main reasons in this regard. First, the marketability of some alternative solutions to pesticides require transformations in terms of standards and regulations. Hence, such regulations are essential in interconnecting the Technology and the Market poles.

For example, SUCSEED, MoBiDiv and CapZeroPhyto envision transformations of regulations to allow the marketing of the alternative solutions. For instance, the IP narrative SUCSEED emphasises [translated from French^{xii}]:

The expected outputs of the SUCSEED project will be industrial with the development of alternative solutions to pesticides and the elaboration of atlases of compounds and agents that can be used for R&D for this future generation of biocontrol/biostimulants, but also with the projection of strategies/trajectories to reach the market taking into account the regulatory context, whose research can be used to inform future public and political decisions.

This highlights SUCSEED's need for a change in regulations for the marketing of the seed technologies they research. Also, MoBiDiv emphasises the strong link between transformations in the policy and market poles regarding the registration of seed varieties, as they state in their IP narrative [translated from French^{xiii}]: "We have also identified political impacts, since the economic aspect should enable us to move towards a relaxation of the regulations for the registration of varieties and to move towards a public policy design favourable to diversification". Hence, transformations are mainly about (updating) regulations and standards necessary for the marketing of seed varieties and biocontrol products in a 0-pesticides society.

The second type of policy transformations are envisioned for valorising food production and farming without pesticides in a 0-pesticides society. For instance, Be Creative highlighted in their IP narrative the need for transforming public policies which support [translated from French^{xiv}]: "1) the diversification of activities, 2) the valorisation of local and phyto-free agricultural products because actors are convinced of the long-term economic interest of moving towards zero-phyto by becoming aware of and communicating on the costs of the externalities of all phyto". Such policy transformations interconnect the Market- and User-poles, and are thus important to enable the implementation of alternative solutions to pesticides. They are in this way essential in the constitution of a society that eradicates pesticides with the alternative solutions.

The FAST project is a particular case in this regard, as it has a specific research objective to study the effect of – and to contribute to – a change in policies to support 0-pesticides farming systems, such as incentive systems (taxes, subsidies). This includes the transformation of existing policy programmes as Ecophyto, the CAP and the Green Deal. In this way, for FAST, the transformations of policies are about the implementation of the alternative solutions they study.

The Scientific and education-pole

The fifth and final pole is about transformations of Science in the constitution of a 0-pesticides society. As I am studying researchers in this dissertation, they know their scientific field and domain well. Therefore, with ASIRPA RT we did not put a particular emphasis on the envisioned scientific transformations. However, what we did learn from our interactions with the researchers, is to acknowledge the level of scientific transformations and impacts. For instance, it is about the contribution to the development of their particular research fields - e.g., through peer researchers or by educating students and early career researchers. It also largely focussed on education for future professionals in the field. This could be about new knowledge creation and processes in their scientific fields in relation to the eradication of pesticides, as well as new methodologies and techniques to conduct this type of research. Finally, institutional changes of science were mentioned, for example changes in the way how we evaluate science, the governance and direction of research institutes, or funding rules.

Table 11. The five poles of societal transformations, and their interdependences in the configuration of the network (NB. The researchers were not specifically asked to reflect on changes to science. Since they mentioned this, I it filled in based my observations)

Poles	Expected Transformations	Interdependence and associations of poles
User context	1) Implementation of alternative solutions - Eradication of pesticides in farming systems 2) Dietary/consumptions patterns	All/Central Market to Users
Technology	1) Development of technologies 2) Improvement of TRL	Technology to Users Technology to Users
Market	1) Marketability of the alternative solutions to pesticides 2) Market channels of (alternative) food products	Technology to Users Users to Market
Policy and Regulation	1) Regulations to market alternative solutions to pesticides 2) Support 0-pesticides food product(ion)	Technology to Market User to Market
Science and education	1) Further development of scientific fields, incl. education 2) Institutional change of science	Not included

Table 12. An overview of the eight PPR-CPA projects are their positioning towards change along the five poles of societal transformations for the 0-pesticides mission

Project	Envisioned change in the five poles of societal transformations				
	User context	Technology	Market	Policy and Regulation	Science
Be Creative	More diversified farming systems; Coordination between actors on territorial level	New professions for biocontrol products	New distribution and commercialisation channels of pesticides free products	Evolution of territorial policy	Adapting training courses and new ways of financing science and advisory
Beyond	New epidemiological surveillance based on indicators for early predictions of pests	Changed diffusion methods of FAIR data		Modified epidemiological surveillance approaches by (inter) governmental surveillance agencies	Develop an interdisciplinary science approach; Production of FAIR data
CapZeroPhyto	Implementation of levers of plant resistance in farming systems	New technology developed in line with the levers of resistance (varieties, biostimulants, equipment)	New market outlets for alternative solutions and pesticides free products	Evolution of policies to market the different levers of resistance	Change education programmes
FAST	Creation of zero-pesticide territorial "niches"			Implementation of policies at national and EU level to support 0-pesticides transition	Improvement of the resources available to researchers (data access, experiments)
MoBiDiv	Change in cropping systems based on seed mixtures	Breeding of seed varieties suitable for mixtures	Diversifying of market outlets and acceptance of crop (grain) mixtures	Evolution of regulation to favour the use of seed mixtures	New ways of financing science and advisory
PheroSensor	Use of Pheromone sensors to early detect pests and change pest management strategies (precision agriculture)	Manufacturing process compatible with mass production of sensors	Availability of market channels of the sensors	Assessment of the rules or obligations for the use of the sensors	
SPECIFICS	Diversification of legume-rich cropping systems; Increase of plant-based protein consumption	Breeding of multi-level resistant legume varieties	Development of (local) pesticides free legume market outlets	Promotion of production and consumption of legumes; New registration criteria of legume seed varieties	Interdisciplinary collaboration
SUCSEED	Use of the treated seeds in farming systems, and adapted farm management	New methods of seed production/treatments	New seed treatments available on the market	Evolution of registration system to foster seed technologies	New advisory system and education

In Table 12 I synthesised the envisioned change along the five poles of societal transformations, for each of the eight PPR-CPA projects. It also indicates how broad actor groups (e.g., breeders, farmers, policy makers) are envisioned to change, which is necessary to enact the envisioned societal transformations. Although, the detailed definition of these actors is rather limited at this early phase of the research projects. Almost all projects envision change in each of the five poles, except for those projects that are less focussed on developing marketable technologies (such as FAST and BEYOND). It highlights that the majority of the projects largely focus on change in the technology pole, whereby manufacturers or breeders have a large envisioned role to play. A lot of the envisioned changes in the market pole are therefore linked to the marketing of technologies, and in the user-context about the use of technologies. Also, the envisioned changes to policy and regulation by most projects show to emphasise the use of technologies or innovation. They are in this way rather specifically identified to allow the use of the alternative solutions.

Surprisingly, also changes to market outlets of pesticide-free products are mentioned, while in the user-context only one projects (SPECIFICS) emphasises a change in consumption practices. This might indicate a limitation in the envisioned changes; i.e., the researchers want to ensure the existence of market outlets for pesticide-free products to support farmers in this regard, without necessarily considering the change on the consumption side this requires.

To conclude, in this sub-chapter I have highlighted the envisioned transformations that are required so that society can change to eradicate pesticides with the alternative solutions studied. As illustrated in Table 11, these transformations are envisioned in five interdependent poles so to enable the development and implementation of the alternative solutions. This indicates what is envisioned to change in these five poles to constitute a 0-pesticides society. In other words, it shows visions of the constitution of society – and the necessary change among actors in these poles - which is able to eradicate pesticides with the alternative solutions that the projects are studying. Particularly, the researchers envision the expected contributions of their research projects on alternative solutions to these envisioned transformations in society, which is synthesised for each project in Table 12. In terms of the interdefinition of actors in this mission, it highlights how the expected research contributions are interlinked to these societal transformations. I further elaborate this in section 5.3.1 by arguing that this represents visions of shared responsibilities between researchers and other actors in society.

5.3 Obligatory Passage Points and blocking factors of science-society relations in the mission

In the previous two subchapters I illustrated the PPR-CPA researchers' visions of enabling society to eradicate pesticides with the alternative solutions studied in their research projects. These

visions were revealed when ASIRPA RT supported the researcher to make explicit how they expect to impact society with the alternative solutions, and the societal transformations that are needed to achieve these impacts. Since it enabled the researchers to interdefine the poles and actors in the constitution of such a future society, it represents an important step in the problematisation phase of the 'responsible translation' process. Consequently, it illustrates visions of establishing associations between the research projects and a 0-pesticides society, through visions of alternative solutions and a 0-pesticides society.

Building further upon this, in this sub-chapter I explore the Obligatory Passage Points (OPPs) and potential obstacles, to the constitution of an envisioned society that eradicates pesticides by the researchers. This leads to an understanding of the OPPs in the translation process in this mission-oriented context. In addition, the researchers shared their visions of potential obstacles, which might be blocking factors to the OPPs and thus to establishing the envisioned science-society associations through responsible translation.

To explore this, I subdivided this sub-chapter into two sections. In the first section, I demonstrate how this responsible translation process from research on alternative solutions into a society that eradicates pesticides has two OPPs to pass; i.e. the OPPs for the constitution of a society that is able to eradicate pesticides. In the second section, I illustrate the envisioned potential obstacles to the passing of these OPPs, and thus to the translation process in this mission.

5.3.1 Two Obligatory Passage Points to constitute a society that eradicates pesticides

In the case study of the Scallops of St Brieuc, Callon (1986) describes how the three researchers 'establish themselves as an obligatory passage point' in the relationships between actors in the network: the anchorage of the scallops. Hence, if the three researchers want the defined actors to benefit, the scallops need to anchor. For this to happen, the researchers need to study how the scallops anchor and if the towline that they observed in Japan will work in France as well. Through the OPP – 'do the scallops anchor themselves' - the three researchers made themselves indispensable in the network with the other actors. The researchers were the ones studying and creating knowledge about the circumstances under which the scallops would anchor or not, which is essential if the defined actors are to benefit. As I explain in this section, in the mission-oriented context of the PPR-CPA, where visions play a key role, the situation is slightly different.

In this missions-oriented situation, I am talking about the constitution of a future 0-pesticides society, through the translation of visions of alternative solutions into those of a society that eradicates pesticides. As the visions of the constitution of a 0-pesticides society showed, as described in sub-chapters 5.1 and 5.2, enabling the eradication of pesticides in society with the alternative

solutions does not solely depend on the conducted research. The eradication of pesticides largely depends on other actors who enable the further development and implementation of the alternative solutions.

This highlights that in this mission-oriented context, the alternative solutions are indispensable to the associations between the PPR-CPA research projects and the envisioned future 0-pesticides societies by the researchers. Consequently, the constitution of a society that eradicates pesticides requires two situations. First, it requires the researchers to conduct research on the alternative solutions, resulting in research outputs. Second, it requires transformations in society to enable the development and implementation of these alternative solutions. Consequently, the PPR-CPA researchers illustrate that the expected contributions to this societal mission, requires to pass two OPPs:

1. The eradication of pesticides requires the PPR-CPA researchers to conduct research on alternative solutions to pesticides.
2. The eradication of pesticides requires societal transformations in five interdependent poles, which are necessary to enable the development and implementation of the alternative solutions in society.

What these two OPPs show is actually a shared responsibility for the eradication of pesticides in society between researchers and other actors, as envisioned by the researchers at this early T₁-phase. The researchers themselves hold on responsibilities to conduct research on alternative solutions to pesticides. And, the envisioned responsibilities of the other actors are to enact the societal transformations, to enable the development and implementation of the alternative solutions. Hence, constituting a society that is able to eradicate pesticides does not only represent a change in the way of doing responsible research, it also represents change by other actors. This means that performing the expected contributions of the studied alternative solutions to a society without pesticides, highlights the interdependence and hence embeddedness of science and society as part of the same system. However, at this early stage of the research projects and the participation in ASIPRA RT (T₁-phase), it reflects only the visions and expectations of the researchers.

This reflects that to perform the expected contributions of the alternative solutions to the eradication of pesticides, these two OPPs should be passed. The OPPs emphasise that research on alternative solutions is part of the envisioned 0-pesticides society, they cannot be considered separately in this mission-oriented context. In other words, the researchers' expected contributions to the mission are embedded in the visions of a society without pesticides - and thus when the contributions to impacts and transformations that the mission represents are envisioned, the 0-

pesticides society is co-produced with these visions. In terms of the expected contributions to the mission, this reveals that all actors – PPR-CPA researchers and other actors - are part of the network to perform the expectations and thus all actors share responsibilities with regards to the OPPs: changes that must be made to enable society to eradicate pesticides with the alternative solutions. Consequently: 1) visions of passing the OPPs should be anticipated in real-time: i.e., anticipating the future society today; 2) the two OPPs – and thus the projects and a 0-pesticides society - are interdependent through the alternative solutions to pesticides. This makes the alternative solutions indispensable to the heterogenous networks.

In reference to my conceptual framework presented in Chapter 2, responsible research is about the responsibility researchers take on for the performance of the expected contributions (i.e., their alternative solutions) to the eradication of pesticides in society. What this chapter illustrates is that this performance thus requires the assumption of responsibility by all actors in the heterogenous network to pass the OPPs: shared responsibilities of the PPR-CPA researchers and other actors to enable the eradication of pesticides in society. In this chapter, I illustrated how the researchers envision a 0-pesticides society to which they expect to contribute. In particular, this highlights how the researchers at this T₁-phase envision responsibilities for themselves in their role as researchers and responsibilities of other actors. In the next Chapter 6, I explore the construction of the heterogenous networks to perform these visions.

5.3.2 Potential Obstacles to establishing science-society relations

I described the OPPs of the translation process in this mission-oriented context, and thus visions of establishing associations between the PPR-CPA projects and a society that eradicates pesticides. Building further upon the previous section, the researchers showed visions of various potential obstacles or blocking factors to the OPPs. Hence, such obstacles could potentially block the translation of the research on alternative solutions into a society that eradicates pesticides. The researchers emphasised potential obstacles in four main categories:

1. Risks and efficiency of alternative solutions to pesticides;
2. Policy and regulation;
3. (Blocking) Actors
4. Access to data

Risk and efficiency of alternative solutions to pesticides

The first category is about risks related to the use and efficiency of alternative solutions to pesticides. For example, in CapZeroPhyto a researcher questioned the following [*translated from French*^{kv}]:

But does this mean that we must systematically have a technical itinerary that is somewhat imposed and that will not necessarily be accepted by the producer if we want to promote greater efficiency? It can also be a brake if there are too many constraints on the use of these levers. These practical genetic combinations.

The researchers in CapZeroPhyto emphasised their concerns that they will have to acknowledge the trade-off between plant resistance and productivity, something, which will not be easily accepted by farmers. In addition, they question the reduction in efficiency against pests of their innovation over time, for instance by the adaptation of pests. Hence, this leads to questions such as: will it be an efficient alternative to pesticides in the practical context of a farm? Will the solutions work as imagined by the researchers?

SUCSEED and MoBiDiv respond to such risks of efficiency in relation to seed technologies, by developing (re-)evaluation tools or reference systems. The IP narrative of SUCSEED emphasised about this need [*translated from French*^{lxvi}]: “[...] *the need for new benchmarks for the evaluation of these innovative solutions (effectiveness or unintended effects) in order to identify and manage their effects as accurately as possible, whether for screening purposes or to guarantee added value for the seed*”. In line with this discussion, a researcher from SUCSEED stressed [*translated from French*^{lxvii}]:

But I had put a, it's maybe a big post-it, but rethought the frame of reference with which, finally, we evaluate. But there are the aspects and the undesired or unintended effects that [name] was talking about, but in the end there are others. I think that we cannot evaluate these solutions with the same frame of reference as conventional products because it is still, it seems to me, but it is something that is still done a lot. And we have to rethink this because otherwise we will have difficulty in highlighting the added value that is associated with these solutions. If we continue to use the same criteria, the same indicators, we can think that this is something important.

These quotes highlight that new reference or evaluation frameworks are key to manage possible negative effects of technologies as well as to (re-)evaluate and (re-)valorise such alternative technologies. Such frameworks should differentiate from those used in conventional farming, and can otherwise block the 0-pesticides transition.

Policy and regulation

The second category of potential obstacles is about policy and regulations. This is an issue mentioned by the majority of the projects. First, there is a risk that more or a larger variety of chemical pesticides will be registered (by the national government), which was for instance mentioned by researchers of MoBiDiv. Currently, in line with their research objective on seed mixtures, there are no pesticides registered for interspecific mixtures that can be used for ‘associations of several species’. Hence, by default such farming systems based on mixtures are pesticides free. If such pesticides

products were to be registered, this risks resulting in an increase of pesticides use in mixed farming. Around a similar issue, researcher from CAPZEROPHYTO argued [*translated from French*^{lxviii}]:

At the moment, bio-stimulants are considered as fertilizers. Yes, so they are easier to market, you could say. It costs less, it's easier to pass. But as [name] said, as soon as a bio-stimulant is published or if a company is unwise enough to say that it protects plants against pathogens or pests, it can automatically be classified as a phytosanitary product, which is more expensive, complicated, etc.

In line with the issue mentioned by MoBiDiv, policy and regulation could work against alternative solutions to pesticides. In this case, if the type of biostimulants [biocontrol technology] they study will be classified as a phytosanitary product instead of a fertilizer, it could block the registration and marketing of their alternative solutions.

Other blocking factors around policy and regulations are mentioned in relation to the marketing of alternative solutions to pesticides by the projects. Specifically, SUCSEED is highly concerned about this issue, as they need to register the biostimulants for seeds they will develop in order to market their innovation. A researcher explained [*translated from French*^{lxix}]:

So we wait. We wait for three years or more just to submit the file somewhere. And then you can imagine how long it takes to evaluate and approve it. There is a real concern, and for us, one of the levers, one of the keys, is to recognise these biocontrol solutions on a European scale and then to add a series of measures that take into account the specificities and important accelerators for it to go much faster.

To further emphasise the potential blocking factor to their project, another researcher of SUCSEED responded [*translated from French*^{lxx}]:

I do agree with [name]. This is surely one of the most blocking factors, the regulatory aspect. So what? Afterwards, if there is a way to discuss with people who can then make things progress, at least discuss it. The concern is to have the right people to talk to and to see what means might be available in the long term. Not necessarily in the short term, because that's not in the long term, to try to make things move forward and, if necessary, to remove a few obstacles without necessarily removing them, because even if I'm very optimistic, I'm not sure that it can be done within six years.

Hence, the main potential obstacle in this regard is that even if product registration will be allowed (e.g., in the case of seed varieties and biocontrol technologies), this process can take up several years, probably beyond the timeframe of the PPR-CPA. As such regulations are essential (see section 5.2.1) for various of the PPR-CPA projects, the marketing of biocontrol or seed innovations are blocked by such timeframes. This is a key challenge in a competitive market.

Blocking actors

The third category of obstacles is related to actors. In general, the PPR-CPA researchers reflect on and interact with actors in a facilitating sense. In relation to potential opponents of the alternative solutions, for instance chemical pesticides companies, the researchers did not show much reflexivity. Instead, the researchers rather reflect on actors who are expected to change how they act in the future, to enable the development and implementation of the alternative solutions, but who potentially are not willing to do so and thus block the eradication of pesticides.

For instance, researchers of PheroSensor and SUCSEED questioned whether farmers are willing to invest and implement their innovation, and whether farmers are ready and willing to change their farming practices. FAST researchers stressed that actors could be blocking their proposals for policy makers, which aim to advise policy makers about supporting 0-pesticides transitions. MoBiDiv and BEYOND reflect on actors that could actually be against or resisting change. In the case of BEYOND, which requires the translation of their epidemiosurveillance indicators into decision-making tools for prophylaxis, a researcher argued that [*translated from French*^{lxix}]:

You have to realise that we are going to have strongly opposed players and a lot of circulation of information that will aim to reduce the decision to a binary. And that's one of the big risks, so effectively a complex decision-making process with uncertainty and using everything around and decisions where there are strong uncertainties.

This quote illustrates their concerns that actors will be blocking the process of converting their indicators into decision-making strategies, which is essential for the eradication of pesticides. Similarly, in the case of MoBiDiv such risks of actors refusing to change are considered for two groups of breeders: private companies and participatory (farm) breeders. A researcher mentioned in this regard [*translated from French*^{lxxii}]:

Among breeders, there is some reticence, yes. When you hear many breeders say that there are a few pioneers in mixtures among breeders, but they are few in number. And the reluctance is to say that mixtures are made and developed a lot in organic farming or by people who use a lot of farm seeds. So we're not here to work for people who don't buy from us on Sunday, and we don't hear that regularly enough. In concrete terms, and therefore among breeders who are very reticent because we are talking about zero, I think we have seen at this level. They are not blocking, they are not blocking because positive mixes are produced. The selections do not necessarily have the ability to associate.

This example shows that as mixtures cannot be registered yet, private companies tend not to take these risks as there are issues with registration of variety mixtures. These actors might not be blocking *per se*, but rather they are resistant, specifically in relation to the '0-pesticides' objective.

Nevertheless, the researchers of MoBiDiv also stress in their IP narrative that [*translated from French*^{lxxiii}]:

The development of a supply of blended or mixture-adapted seeds for farmers depends on the strategies of the upstream players. However, several actors can take charge of the implementation of the mixture (breeder, distributor, farmer). This limits the risk of blockage: if one category of actors refuses to commit to the development of a mixed seed offer, another category of actors can take over this offer. However, the potential for disseminating mixed or blended seeds will depend on the actors involved: this potential will be limited if only farmers or distributors offer mixed seeds, as there will be no selection on the aptitude for association.

This quote emphasises the potential of having multiple actor groups involved in breeding. If one actor does not take it up, another will. At the same time, actors also depend on one another, so they require involvement to reach the best results.

Finally, anticipation strategies against such envisioned blocking actors are rarely mentioned. In CapZeroPhyto, for instance, researchers plan to conduct surveys to understand obstacles and levers of change for farmers in the adaptation of their proposed alternative solutions to pesticides. As they state, this will allow them 'to adapt the proposed solutions to the profiles of the users and to be more efficient in the transfer'.

Access to data

The fourth category of obstacles is related to access to data, both for researchers as well as for other actors. This is largely discussed by researchers from BEYOND and FAST. Such obstacles are related to various issues such as availability, transparency or FAIR principles⁸⁹, and storage of data. For instance, BEYOND requires data for the development of their epidemiosurveillance indicators for the early prediction of pests, and as the researchers indicate, some type of data might be very difficult to access. Specifically, in the case of data from customs (e.g., the import of plant material) it might be blocked by juridical rules. Also, they might have very large dataset available at some point and this requires the researchers to have a massive storage capacity. In addition, in their case it is also about the data coming out of the project (the indicators) being accessible to the users, as the researchers emphasised in their IP narrative [*translated from French*^{lxxiv}]:

As the project will rely on the collection/use/processing of massive data of different types (from textual data to satellite images) we will be very invested in open science issues and in particular the respect of FAIR principles (in particular interoperability). For example, we will ensure that we develop user interfaces to facilitate access to and use of the data we have

⁸⁹ FAIR: Findability, Accessibility, Interoperability, and Reusability

collected or generated, for all potential users (project partners or external to the project, including gardeners, park and garden managers, etc.).

As I discussed earlier, their indicators need to be translated into pest control measures, and therefore BEYOND requires a platform to share their indicators. This development of a user interface is thus a key point in this project, to not block the use of indicators. The researchers of FAST envisioned similar issues related to data, specifically in relation to access of data from the researchers themselves as well as for other actors. In their case, it is mainly about the availability and transparency of environmental and economic data, and are not authorised using or storing it, which blocks the research project. One of FAST's researcher stressed in this regard [*translated from French^[xxv]*]: "*There is a lot of data when we are there and we should be able to store it on free platforms. And we're not allowed to, I don't know what. There's no infrastructure for that*".

To conclude, in this sub-chapter I elaborate on the two OPPs of this mission-oriented responsible translation process of research on alternative solution into a society that eradicates pesticides. The researchers' expected contributions to this envisioned 0-pesticides society highlights shared responsibilities between researchers and actors in enabling the eradication of pesticides in society. This emphasised that this research is embedded in the visions of a 0-pesticides society. Thus, when the contributions to impacts and transformations of the projects are envisioned, the 0-pesticides society is co-produced with it. The researchers reflected also on four categories of blocking factors, which can potentially be blocking the translation, and thus concerns both researchers and other actors.

Conclusion

To conclude, in this chapter I have presented the first phase of responsible translation. When the PPR-CPA researchers were accompanied by ASIRPA RT, they envision societal impacts and societal transformations that the mission represents, in a very project specific way. They largely envision this in terms of the alternative solutions they study in their research projects. This reveals how the researchers envision responsibilities of themselves and other actors in this mission-oriented translation process. To contribute to the mission with their research projects, the researchers demonstrate their capacity to reflect on how society should be enabled to eradicate pesticides with the alternative solutions. This highlights that if the researchers are to envision their contribution to the mission, they need to understand the contribution of others.

Consequently, to contribute to the mission through the alternative solutions, researchers envisioned shared responsibilities for themselves and other actors, which I defined in terms of the OPPs. The researchers have to conduct research on alternative solutions, and other actors have

envisioned responsibilities to enact societal transformations in five interdependent poles necessary to enable the eradication of pesticides in society. These transformations are essential to enable the development and implementation of the alternative solutions, which requires these actors to change how they act in the future. How the eight participating projects reflect on these transformations, and thus the change of actors, is synthesised in Table 12. This table emphasises the interdependence of the different poles, but also the emphasis on technologies. At this early T_1 -phase of the PPR-CPA, the envisioned transformations are quite well defined, but the detailed identification of actors who are responsible to enact this is still rather limited. Instead, actors are defined in their actor' groups such as farmers, breeders and manufacturers.

This chapter highlighted that envisioning societal transformations is key in responsible translation, as it reveals the responsibilities of a heterogenous set of actors. Consequently, it helped the researchers to identify actors that are part of the translation process to construct a future society that is enabled to eradicate pesticides. The researchers' expected contributions to the mission are embedded in the visions of society without pesticides - and thus when the contributions to impacts and transformations that the mission represents are envisioned, the 0-pesticides society is co-produced with it. However, this translation process could be blocked by potential obstacles. Even though the PPR-CPA researchers shared reflections on these obstacles, it was relatively limited. In general, also with regard to societal impacts, the researchers showed rather positive visions of the contribution of the alternative solutions they study in their projects to the 0-pesticides mission.

In the next chapter I am building further upon these outcomes, by discussing how the researchers anticipate the envisioned responsibilities of the other actors in enacting societal transformations in responsible translation. Chains of translations are performed by heterogenous networks, and so, I illustrate how the researchers envision the construction of these future networks to enable the eradication of pesticides in society with the alternative solutions.

Chapter 6

Realising Associations between Science
and Society: Anticipating Heterogenous
Networks to Perform the Researchers
Expected contributions to a 0-Pesticides
Society

Chapter 6. Realising Associations between Science and Society: Anticipating Heterogenous Networks to Perform the Researchers Expected contributions to a 0-Pesticides Society

ASIRPA RT supports the PPR-CPA researchers in envisioning the expected contributions of the alternative solutions to pesticides studied in their research projects to the 0-pesticides mission. In chapter 4, I have illustrated that without this navigation, the researchers' capacity to envision transformative change in society to enable the eradication of pesticides through alternative solutions is weak. Instead, they envisioned the expected contributions of the alternative solutions to the mission in scientific terms, and highlighted a straightforward interest of the research outputs by other actors. Hence, instead of imagining the constitution of a 0-pesticides society to which they expect to contribute with their research projects, they approach visions of such a future society rather scientifically. In contrast, in Chapter 5, I explored the researchers' visions of societal transformations and impacts when they were guided to make this explicit by ASIPRA RT. By defining the problem of this societal mission, this chapter highlighted how the researchers envision active roles for other actors in the constitution of a society without pesticides with the alternative solutions.

The researchers demonstrated to envision responsibilities of other actors in terms of societal transformations; i.e., enabling the development and implementation of the alternative solutions to pesticides that they study in their projects. Hence, this reflects shared responsibilities between the researchers and other actors to enable the eradication of pesticides in society with the alternative solutions. This requires the other actors to change how they act in the future to enact the societal transformations. These shared responsibilities represent the researchers' visions of the expected contributions of the alternative solutions they study to the constitution of a society that eradicates pesticides. I.e., researchers' visions of responsibilities to enable the eradication of pesticides with the alternative solutions.

However, as discussed in my conceptual framework (Chapter 2), the researchers' expectations of the contributions of the alternative solutions they study to this particular mission are not yet performative, but are to be performed by heterogenous networks. In other words, the networks are to perform processes of change of how actors are to act in the future to enable the eradication of pesticides with the alternative solutions. This means that all actors should eventually assume responsibilities for the 0-pesticides mission, which requires actors to be interested and enrolled, and thus to become a performative part of these networks to put into practice the alternative solutions. At this T_1 -phase, the responsibilities of actors in these networks are only envisioned and anticipated

by the researchers. However, the construction of the network reflects an iterative process, this has to become more participatory over time through the interaction of the researchers with other actors. And so, the envisioned construction of these future networks by the researchers, is based on visions of actors' responsibilities to enact societal transformations that are necessary to enable the eradication of pesticides. Therefore, in this chapter, I explore how the researchers envision and anticipate the construction of heterogenous networks in line with their societal goals. This represents the second phase of responsible translation that describes the process of translating visions of alternative solutions into those of a society that eradicates pesticides with these solutions.

The second phase of the responsible translation process

As a second step in this T₁-analysis, the research question I answer in this chapter is: *How did the PPR-CPA researchers envision the construction of heterogenous networks of actors to enable the eradication of pesticides with the alternative solutions they study in their research projects, when ASIRPA RT helped them navigating their visions of the intermediary context?* In this chapter, I mobilise data collected during the T₁-phase of the PPR-CPA projects. In particular, I use the moments when the researchers were accompanied to make explicit the intervention of intermediary actors in the translation of the research outputs into a society that eradicates pesticides. I refer to this as the second phase of the 'responsible translation' process: **Realising Science-Society associations through interessement and enrolment.**

This phase highlights how the researchers envision and anticipate the construction of heterogenous networks to perform the expected contributions of the alternative solutions they study to a future society without pesticides. It considers the contribution of various actors – including the researchers themselves - at different points in time, to anticipate the chains of translations that might be performed by these networks. These chains of translation in the networks will only be performed eventually when actors assume responsibility for the mission, to collectively enable the eradication of pesticides in society with the alternative solutions.

This second phase builds on Callon's moments of 'interessement' and 'enrolment'. In the *Sociology of translation*, Callon (1986) defines 'interessement' as "*the group of actions by which an entity attempts to impose and stabilise the identity of the other actors it defines through its problematisation [...] to be interested is to be in between (inter-esse), to be interposed*" (p.208). In addition, 'enrolment' is described as "*the device by which a set of interrelated roles is defined and attributed to actors who accept them. To describe enrolment is thus to describe the group of multilateral negotiations, trials of strength and tricks that accompany the interessements and enable them to succeed*" (p.211).

Hence, building further upon Chapter 5, the expected contributions of the alternative solutions to the eradication of pesticides in society are solely based on visions of the researchers at this T_1 -phase. It is not by default that the other actors are interested and get enrolled in the roles and responsibilities the researchers attributed to them to enact their visions of societal transformations. The other actors assume the responsibilities that the researchers envisioned for them - requiring them to change to enable the development and implementation of the alternative solutions to eradicate pesticides. This needs convincing and negotiating the relationship between the alternative solutions studied by the researchers and the other actors to enable the constitution of the envisioned future society that eradicate pesticides. Hence, this convincing and negotiating is anticipated by the researchers in the construction of the future heterogenous networks.

In this regard, I explore anticipation of 'interessement' and 'enrolment' as two parts of a dynamic process (Arnold & Loconto, 2020) in the envisioned construction of networks, through the associations with other actors with whom the researchers must interact. Currently many of these actors might be interested by and enrolled in agri-food systems where pesticides are used. Interessement is thus about convincing these actors of the need to eradicate pesticides with the alternative solutions. However, even if the others actors become convinced, it does not necessarily mean they assume their envisioned roles; i.e., they do not necessarily 'enrol' in the 0-pesticides mission. As Callon illustrates in the Scallops case, the three researchers study towlines used in scallop fishing systems in Japan and they want to examine whether this would work in France as well. Callon explores the towline as an 'interessement device' to interest the scallops to anchor. But, it requires also negotiation with the scallops, regarding the placement of the towline in the water; placing them not too close to the shore, considering predators etc. This means also negotiating with the actors that could interfere the anchorage (e.g., currents or starfish) – who problematise the scallops in another way.

Therefore, in this chapter, I highlight how the PPR-CPA researchers anticipate the interessement and enrolment of the other actors for the societal mission. In other words, it reflects anticipation of the chains of translation for a future society that eradicates pesticides, and thus anticipating the heterogenous networks performing the researchers' expected contributions of the alternative solutions. Hence, I explore how the researchers anticipate performance through the chains of translation, by envisioning the construction of future heterogenous networks. Hereby, intermediary actors come in the network with the envisioned responsibility to raise interest and to enrol the actors who are responsible to enact the transformative change. For Callon "*series of intermediaries and equivalences are put into place which lead to the designation of the spokesman*" (p.216); i.e., that the alternative solutions can speak on behalf of the network that will put them into practice in the future.

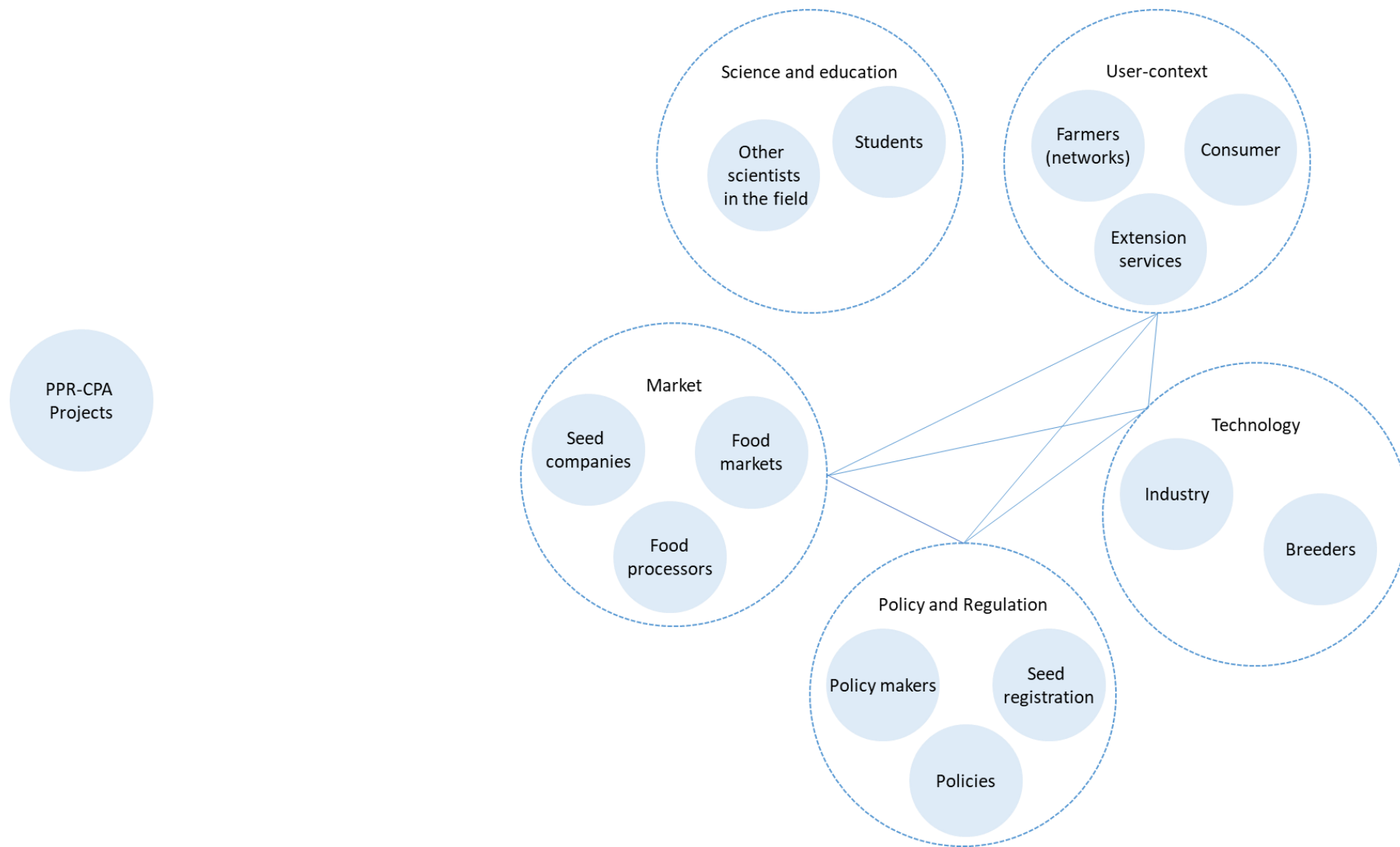


Figure 16. First elements of the heterogenous networks: example of actors in the five poles of societal transformations based on chapter 5

This means that actors' responsibilities in the network, go beyond those of the researchers and the other actors in the researchers' visions for enabling the eradication of pesticides with the alternative solutions as illustrated in Chapter 5 (see examples Figure 16).

Responsible translation also involves other, intermediary actors in the heterogenous networks with responsibilities for interessement and enrolment, and thus with responsibilities to the performance through chains of translation. This requires the researchers to envision the construction of the networks and anticipate the involvement and associations between the different actors with whom they must interact. Throughout this chapter, I illustrate how the network of Figure 16 will be extended. However, as I highlight, I am providing an analysis of the T₁-phase, which means that the researchers are in an early phase of their research projects. Towards the performance of the network in enabling the eradication of pesticides, the researchers do reflect upon the intermediary actors that need to interest and enrol the other actors in society (those who are envisioned responsible to enact the transformative change). However, at this point, they do not necessarily anticipate the future associations are in the construction of the networks.

The PPR-CPA projects' reflections on the intermediary context of their IP fed into this analysis. This phase is to identify the key intermediary steps – between the research projects and the societal transformations - that are necessary to develop and implement the alternative solutions (i.e., performance through chains of translation). Moreover, this chapter is largely based on data collected during the ASIRPA RT workshops we organised with each individual PPR-CPA project in autumn 2021. Eight out of ten projects participated in these workshops⁹⁰. Specifically, during the workshop we asked the researchers to make explicit their visions of the intermediary context of their research projects: what should be in place if their research is to contribute to the constitution of a society that eradicates pesticides? (we named this 'STEAM UP' – see Chapter 3 Methodology). In other words, what should be in place to enact the envisioned societal transformations? Therefore, this brainstorm was divided into the poles of societal transformations, as elaborated in Chapter 5: Technology; Market; User context; Policy and regulation; Science and education. As they already highly reflected on the 'science and education' pole, we inquired them to concentrate on the other four poles. Similarly, we asked the researchers to prioritize these requirements and reflect on the human actors they require to involve. However, at this early stage of the projects, this second part seemed a challenging assignment. After the workshop, the researchers were asked to add this reflection on the intermediary phase to the narratives of their IPs.

⁹⁰ 8 out of 10 PPR-CPA projects participated in these workshops: Be Creative, BEYOND, CapZeroPhyto, FAST, MoBiDiv, PheroSensor, SPECIFICS, SUCSEED.

So, in this chapter I explore how ASIRPA RT helped navigating the researchers' visions of the contribution of other actors to a future without pesticides, through the second phase of translation. I sub-divided this chapter into three sub-chapters, in which I discuss the researchers' visions of construction of the heterogenous networks to perform the expected contributions of the alternative solutions to the eradication of pesticides through chains of translation. It highlights the intermediary actors who are hold responsible for the interessement and enrolment of those actors that should enact the societal transformations (Chapter 5). This also highlights how the researchers anticipate what their associations are in the networks. In this chapter I will demonstrate the expansion of the network. In this regard, I respond to the following three guiding questions, each representing a sub-chapter: 1) What intermediary actors are anticipated in the network, associated to the inputs and outputs of the research projects?; 2) What intermediary actors are anticipated in the network, external to the research projects?; And 3) How are the actor associations in the network envisioned to perform chains of translation?

6.1 Intermediary actors in the network: inputs and outputs of the research projects

As I elaborated in my Conceptual Framework (Chapter 2), heterogenous networks are to perform the expected contributions of the alternative solutions to the eradication of pesticides in society. This is the result of chains of translation, through associations when actors within the network assume their responsibilities, from visions of alternative solutions to a society that is able to eradicate pesticides. To anticipate these translations, I illustrate how the PPR-CPA researchers anticipate raising interest and enrolling those actors that they envisioned responsible to enact the societal transformations in the networks. In this first sub-chapter, I highlight how they anticipate this through the inputs and outputs of their research. In this way the researchers expand the networks with intermediary actors who are responsible for interessement and enrolment in the translation process.

Many of these envisioned intermediary actors are external to the research projects, as I will illustrate in sub-chapter 6.2. In the current sub-chapter, I highlight those intermediary actors that are related to the projects, which represent associations to the input and output phases. The researchers anticipate **three categories of intermediary actors** associated to their research projects who are responsible in the network for the interessement and enrolment of the other actors responsible to enact societal transformations:

1. Convincing actors with demonstration and proof of the alternative solutions;
2. Adapting alternative solutions to actors' financial constraints;
3. Building capacity of actors for the alternative solutions (e.g., skill development).

Chapter 6. Realising Associations between Science and Society: Anticipating Heterogeneous Networks to Perform the Researchers Expected contributions to a 0-Pesticides Society

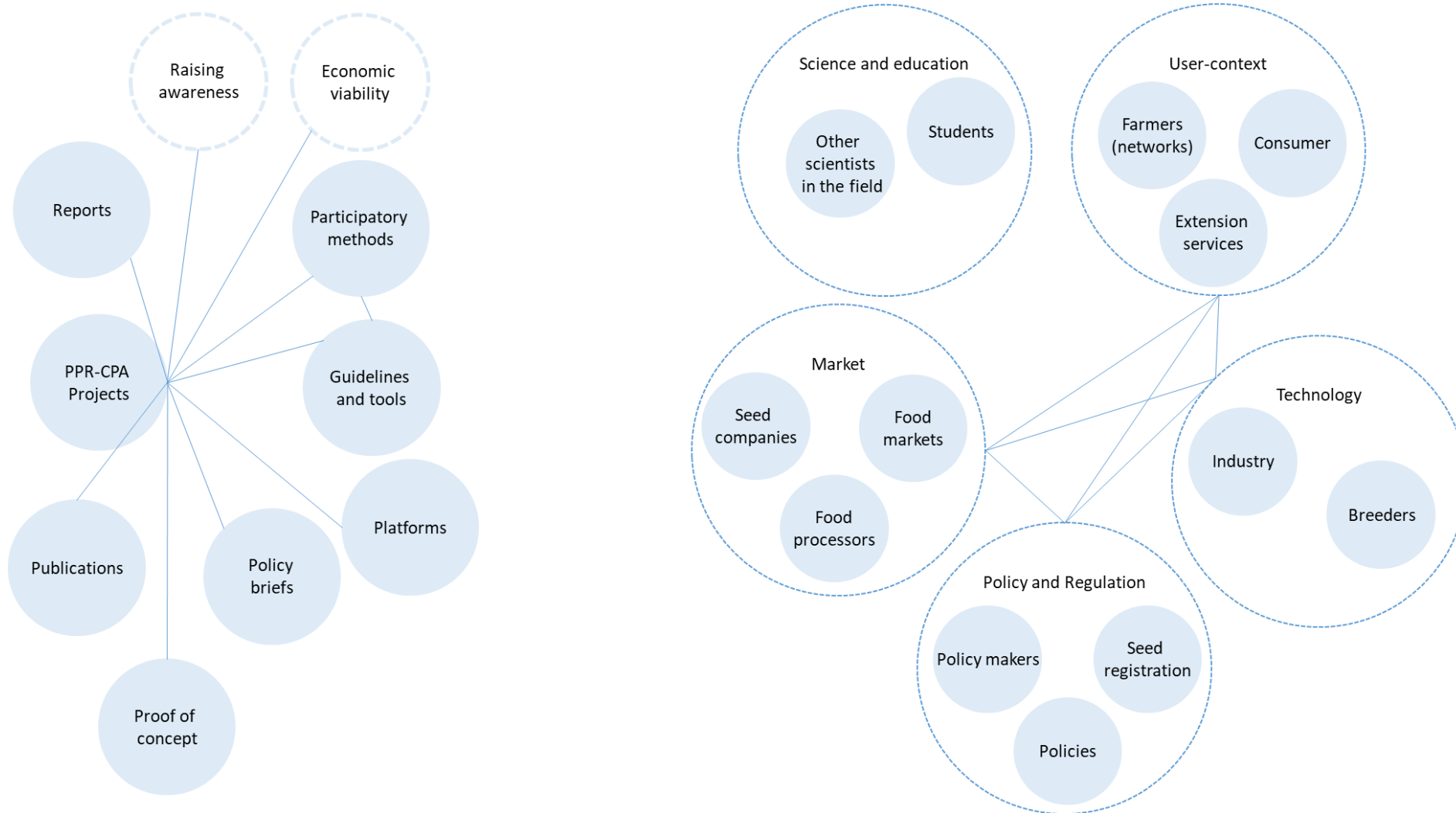


Figure 17. Examples of the expansion of the heterogeneous network with intermediary actors linked to the PPR-CPA projects, who have the responsibility for enrolment and interestment in line with the envisioned societal transformations. The blue circles represent actors, the dotted circles represent envisioned responsibilities but the specific actors are not yet identified.

The expansion of the envisioned network with actors in these categories is highlighted in Figure 17. It provides an example network, that builds further upon Figure 16 based on observations from the eight PPR-CPA projects that participated in ASIPRA RT. It highlights how the researchers reflected on the inputs and outputs of their research projects as intermediary actors in relation to the enactment of the societal transformations. The blue circles represent envisioned intermediary actors as outputs or inputs of the research projects, the dotted circles represent envisioned responsibilities but the specific actors are not yet identified. I demonstrate each of these three categories of responsibility in the following three sections, with qualitative quotes from the researchers.

6.1.1 Convincing actors with demonstration and proof of the alternative solutions

The first category of intermediary actors responsible for the interesement and enrolment, is about convincing actors by providing them with demonstrations and proof of the alternative solutions. This is envisioned to raise interest and enrol four main groups of actors: farmers, consumers or the general public, agri-food companies, and industries. Even though, in general, concrete actions and the identification of specific actors is limited, visions of what should be known or done to convince such actors to enrol in the mission are clearer. Surprisingly, the PPR-CPA researchers reflected in a rather limited way on policy makers or other actors related to governance. Policy and regulation are considered as essential conditions in the responsible translation process, but the researchers believe to have limited influence through their research projects. As this is the objective of FAST, in contrast to the other projects, they do have a clear vision of convincing policy makers to enrol in the mission.

In the next paragraphs, I provide two particular situations that explain how the researchers anticipate convincing other actors in society by providing proof of the alternative solutions. First, the researchers anticipate this by providing proof of the societal benefits and potential of the alternative solutions to pesticides. I show three complementary examples to illustrate this point. To start, the researchers of PheroSensor argue in their IP narrative [*translated from French*^{lxvii}]:

We need to communicate on this new approach to monitoring insect populations, to understand any reticence on the part of both the scientific community and the profession (technical institutes, farmer networks, etc.) in order to better convince them of its potential. One of the challenges will be to explain the possibilities offered by sensors for precision agriculture and the reduction of pesticide use.

This quote illustrates that efforts of PheroSensor are focussed on convincing a variety of actors on the potential of the pheromone sensors they develop. As these sensors are about pest detection that could contribute to a change in pest management strategies by adapting the timing and use of pesticides - and thus not *per se* a direct replacement of pesticides - the researchers aim to prove the

potential of the sensors for such pest management strategies. A PheroSensor researcher argued in this regard [*translated from French*^{lxvii}]:

And it will also require media coverage that will far outstrip that of this new concept. To inform, to convince. We can already see that in the scientific sphere, there is a certain amount of reticence. So, I imagine that it is even worse for farmers or ... That's it, all by itself, of this whole sphere, plus... the whole profession. That's what we've also identified, that's the need for an investigation. However, in the order in which we did things to fill the whole market that exists. The economic aspect, because obviously, it must be economically viable. The sensors must not be too expensive, otherwise it won't work. It's also linked to the media coverage that is above to convince people, farmers, the profession, one of the benefits of these sensors. So that's what we had listed below, i.e., relays to technical institutes. We were wondering which technical institute or which relays could help us in this information sharing. It's maybe something we need from the 'chambre d'agriculteurs', the cooperatives, etc.

This quote illustrates the multiple aspects of 'convincing actors', which is not only about the potential to reduce pesticides use, but for instance, also reflects economic aspects. The researchers of PheroSensor are very aware that they will only be able to develop a prototype or 'proof of concept' of the pheromone sensor by the end of their six-year project, which might encounter resistance by potential users. Hence, convincing actors for the further development and implementation of the sensors is key as it will take time and money to actual bring the sensor to the market, and hence, full demonstrations cannot be given yet during or right after the project terminates. Therefore, they emphasise the need for media coverage about their project to convince actors of their results. To give another example, a researcher of SUCSEED argued [*translated from French*^{lxviii}]:

And in terms of acceptability. Afterwards, when we want to convince users that they should use these products rather than the products they are used to, I think we need to highlight the added value of these advantages compared to the few disadvantages that there may be. And [name] mentioned it on a post-it. And there are things that we still don't know much about, it seems to me, but [name] can contradict me, but it's the life span of these solutions. How long does it last? Because it will change things in the way we practice, something I put on another post-it. It has an impact on the way people will use them, perhaps in their usual practices. So, you have to think about all that when you want to convince or propose your solutions to users or farmers.

This researcher highlights the importance of convincing users of the alternative solutions, particularly in the practical context of its application such as the lifetime of the solutions they develop. While in the case of PheroSensor it is about convincing the use of an additional technology for pest management – i.e., it is not replacing per se an existing technology -, in the case of SUCSEED it is about replacing currently used inputs of the farming system (seeds), by alternative products (i.e., their seed

technologies). Therefore, SUCSEED aims to anticipate such replacements by users, by demonstrating an added-value compared to the currently used inputs. The researchers do not elaborate in a detailed way how to achieve this; i.e., the responsibility for the interestment and enrolment is known (to convince), but the (non-human) actors to assume this responsibility are not known yet in detail.

CapZeroPhyto's researchers share similar reflections as in SUCSEED, as they aim to replace currently used inputs in farming systems by biocontrol products. As for the use of pesticides, one of the biocontrol solutions they are developing still requires spraying products in the field. For this project the challenge is to not just convince farmers on the use of the projects' biocontrol solutions. They also aim to prove to the general public that spraying products is not necessarily chemically based, as in their case it contains biocontrol products. They want to raise awareness that, compared to spraying pesticides, it is 'not, or less, dangerous for them or the environment'. Similarly, as for SUCSEED, how to achieve this is still rather unknown at the T₁-phase.

6.1.2 Adapting alternative solutions to actors' financial constraints

The second category of intermediary actors responsible for the interestment and enrolment is about adapting the costs related to the alternative solutions to the financial situations or constraints of the users. This considers two main situations: 1) the costs of implementing the alternative solutions; and 2) the costs (reduction) of alternative pest management strategies.

First, the researchers consider the costs of implementing the projects' proposed solutions to pesticides, or the economic model around it. This is a very central question in PheroSensor, as they emphasise in their IP narrative [*translated from French*^{lxix}]: "*The need to match the effectiveness and cost of solutions to ensure the deployment of innovations as well as to consider the impact and need to adapt the industrial processes of seed companies.*" Hence, as this example shows, it is not only relevant for the implementation of the sensors in the field by farmers, but also to get industries and companies involved in the development of the sensors.

In the same line of considering trade-offs related to economic viability of the alternative solutions, I share an example from SUCSEED. The researchers stress the need to understand the economic impact of the use of the seed technology they are studying. A researcher from SUCSEED emphasised this as follows during the workshop [*translated from French*^{lxxx}]:

The whole question that you have just mentioned about the acceptability of the technology, but also the economic aspect, to see how these new seeds are or will be more expensive than the usual ones. What economic impact can it have on the farm and the change of practices in terms of cultivation which has just been mentioned in the way of cultivation, the processes, and the users. Here, the farmers will be ready to change these practices and

adopt new ways of doing things? Because well, maybe the seed will not react in the same way as the seeds that we could call classic, traditional.

This quote illustrates that considering economic viability of their alternative solutions is not only about whether the alternative seeds are costlier for farmers. Also, their seed technologies might not lead to the same production level or might require other or additional farm management practices. Hence, the costs of the entire change in the farming system should be considered by the researchers.

Second, for both the projects on epidemiosurveillance and prophylaxis - BEYOND and PheroSensor - the economic viability of adapted prophylaxis measures or strategies are essential. As discussed, their alternative solutions are about the early prediction (BEYOND) and detection (PheroSensor) of pests, and thus not about the direct replacement of pesticides. Instead, their solutions contribute in adapting pest-management strategies. The researchers reflect on questions such as: when would a farmer be ready and willing to pay for the costs of implementation? Would this include higher costs compared to pesticides application they have done so far? And who will bear the costs of the transition towards a 0-pesticides society? BEYOND's researchers argued for example in their IP narrative [*translated from French*^{lxxxii}]:

There will be increasing evidence (through economic research) that it is more cost-effective to sell farmers advice on disease control than on the use of synthetic chemicals. At the same time, private initiatives to provide FAIR and open sentinel data are economically viable. Overall, there will be a coexistence of private agricultural advice and public consultants, and the role of chambers of agriculture or other technical advisors (e.g., CTIFL) will grow.

This quote illustrates that the researchers are convinced that their project will contribute to a reduction of costs of pest management measures. They aim to provide the (economic) data to prove this. In addition, PheroSensor's researchers consider economic viability an important issue they have to work on in their research project, by reflecting on trade-offs between agronomy and economy. In their IP narrative they emphasise [*translated from French*^{lxxxiii}]: "*Surveys are needed to know the market and the level of economic viability of the sensors, which implies estimating the reduction in intervention and treatment costs resulting from early detection of pests (to be discussed with the technical institutes).*" This highlights the researchers' aim to also consider the economic in the translation of sensor data on pest detection into adapted prophylaxis strategies. A researcher from the project argued in this regard during the workshop [*translated from French*^{lxxxiii}]:

If I may intervene, there are indeed things that can be put in place now because they will help us in the design of the sensor, such as [name], for example, allowing surveys to ensure stability. This is something that we need to anticipate and also have an idea of the price

order. That a farmer is ready to put in good provisions because it can really guide the prototype if we see which farmer is not ready to put more than 10 euros per hectare. This is an important constraint for us.

This researcher stresses the need to adapt their research on the sensors to the willingness of farmers to pay for the implementation of it, and the pest management strategies this requires. Hence, it is the role of researchers to consider economic constraints of the users in the development of their sensors.

6.1.3 Building capacity of actors for the alternative solutions

This third category of actors responsible for the interessement and enrolment is about informing, guiding and teaching other actors to build capacity to use the alternative solutions. I illustrate this based on examples from a variety of projects. The researchers demonstrate rather well-developed visions of anticipating the capacity building of actors. This is in particular envisioned in two ways: through the production of research outputs; and through participatory activities in the inputs phase of the research projects.

Research outputs to build capacity

First, building capacity is anticipated by discussing and sharing research outputs with non-academic actors. To illustrate this, FAST's researchers anticipate the development of 'concrete and directly usable' solutions for decision-makers. They argue in their IP narrative about these decision makers [*translated from French*^{lxxxiv}]:

Their mission is precisely to collect research results on agricultural and environmental policy issues (CEP of the Ministry of Agriculture, DITP, France Stratégie, CGAAER). Where appropriate, they are already members of the expert committee that was set up at the time the project was set up to monitor its progress. For this type of interlocutor, the production of scientific publications will be accompanied by popularisation work in the form of policy briefs in French.

This illustrates that the researchers specifically anticipate communication strategies for 'scientific representatives of public decision-makers'. Not only of scientific publications and tools, but also the translation of research outputs into policy briefs. The objective of these public decision makers is to collect such research results to be used for policies in agriculture. Beyond this example from FAST, various other strategies are envisioned by researchers from other projects to communicate and discuss their research results and support actors in the use of alternative solutions to pesticides. This is for instance anticipated through the organisation of scientific or professional seminars, or more directly through meetings with the targeted actors. For instance, SUCSEED wants to discuss their

outputs on alternative seed technologies directly with seed companies, as to 'anticipate the adaptation of their industrial process'.

However, building capacity of other actors in society for the alternative solutions is most largely anticipated through the development of guidelines and tools. For instance, researchers of SUCSEED are working on training strategies for the implementation of their seed solutions. Similar in SPECIFICS, the researchers consider tools to guide actors essential, as legume crops are not a commonly grown in pesticide-free farming system. Therefore, they aim to develop a variety of tools, which a researcher from SPECIFICS emphasised as follows [*translated from French*^{lxxxv}]:

I'm taking them from quite a few people because we're working on the identification of learning tools, and this is also the result of part of WP1, which is more about the plant, and genetics in WP2, and so the objective is to build learning tools that will allow us to reach the zero phyto objective while inserting legumes, a diversity of legumes into the cropping systems. I was thinking, who is it going to be for? For our famous storage agency advisors and the farmers, of course, on the one hand. And then also to have a valorization of these tools via teaching, whether it is technical or engineering, or even at my professional baccalaureate in an objective at the end, in these two elements at the same time, to have perhaps stockings, advisers who are more aware, in fact, of the insertion of leguminous plants in the cropping systems. Because that's what we identified as being a big obstacle, but also to have informed and trained farmers.

Hence, such tools for different actors range from educational tools - for students, decision makers or citizens and consumers, to inform them about pesticides free legumes -, to more specific tools for storage agencies, agricultural advisers or farmers to guide the practical implementation of such farming system.

In the case of BEYOND, it is key that their expected indicators (data) for early prediction of pests will be translated in decision strategies for adapted prophylaxis. Therefore, the researchers reflect on how to use their expected indicators for this early prediction, to improve epidemiosurveillance by other actors, such as farmers. They argue in the IP narrative that [*translated from French*^{lxxxvi}]: "One way to encourage/favour the acceptance of our solutions by a wide audience would be the implementation of a "Quality/Good Practice Charter" for agricultural advice based on traceability using FAIR⁹¹ open data and transparent analytical procedures". A researcher of BEYOND argued about this during the workshop [*translated from French*^{lxxxvii}]:

So, I will say the three research outputs when they are directly related to these transformations of the long-term future, is that we are going to establish examples that illustrate that it's feasible and useful to deploy open data, FAIR for epidemiological

⁹¹ FAIR data principles stand for: findability, accessibility, interoperability, and reusability

surveillance and disease control decision making. You really need to illustrate that it is possible and useful to do that. So, I think it could be a research output. Secondly it will explain and facilitate complex decision processes that are based on many, many different factors and that lead to the implementation of prophylaxis for experts. It serves as an output for experts, scientists, agricultural consultants, teachers, etc.

Hence, the researchers are planning to develop a ‘Good Practice Charter’, which will be based on the early pest prediction-indicators, and should guide actors to use their FAIR, open data in practice. Particularly, this should guide the pest management decision-making processes based on this data.

Finally, in MoBiDiv, researchers work on methodologies and tools to guide users on two main levels. The first is on the level of breeding companies, to build capacity for the breeding of varieties, which are suitable to be used in mixtures. The researchers anticipate developing tools for the selection of mixtures or varieties that would be beneficial for mixtures, such as ‘methodologies of selection’ and ‘tools to evaluate the performance of mixtures’. The second level focusses on farmers, to build capacity for the implementation of seed mixtures on field level. The researchers of MoBiDiv argue in the IP narrative [*translated from French^{lxxxviii}*]: *For farmers, the development of mixtures requires the availability of suitable varieties, access to technical references on the performance of varieties in mixtures, and access to advice and decision-making tools on the choice of mixtures and the cultivation practices to be combined.* Consequently, they anticipate the development of tools to guide farmers in their decision-making on the selection and use of seed varieties in mixtures.

Participatory approaches

Second, building capacity is anticipated through participatory approaches in the inputs phase of the several projects. To continue with the previous example of MoBiDiv, the researchers argue in their IP narrative [*translated from French^{lxxxix}*]:

The knowledge that will be generated will result in mixture design tools that can be used directly by farmers, their advisors, as well as contract sorters and seed cooperatives. MoBiDiv will also identify traits and genomic regions involved in mixing ability, as well as plant ideotypes. These breeding tools will be tested with breeders and in participatory breeding networks, which will also benefit from training modules. The project will study scenarios for changes in the organisation of the seed sector, regulations and research funding, which allow the development of seed mixtures. [...] Finally, MoBiDiv will look at the use of mixed productions by the downstream sector and will propose scenarios for the relaxation of quality standards downstream of the sector, which will be disseminated to agricultural cooperatives and processors.

Hence, in order to develop and adapt these tools to the various actors, and to ensure that they can be used in practice, MoBiDiv integrates participatory research methods. This points to a

broader anticipation of participatory approaches in the capacity building of actors. For instance, researchers of CapZeroPhyto emphasised their participatory research activities in accompanying farmers 'towards a modification of their production system'. Similarly, the researchers of BEYOND illustrated in their IP narrative [*translated from French*^{xc}]:

The transition to new ways of conducting epidemiological surveillance and implementing disease control will require us to help farmers and other stakeholders understand the opportunities. One approach will be to ensure that solutions are co-constructed. Thus, the project will strive to help stakeholders understand options for decisions involving increasingly complex parameters and scales of space and time that go beyond the farm and a single season. Together, we will explore new types of reasoning for decision-making in cases where there are multiple pathogens simultaneously and where control methods can be evaluated by cost-benefit measures rather than cost-effectiveness.

As the quote highlights, by adopting a co-construction approach, the researchers of BEYOND aim to guide actors – largely farmers – in their pest-management decision making based on BEYOND's indicators of early pest prediction.

To conclude this sub-chapter, the researchers anticipate various intermediary actors in the networks through the input- and output-phases of their research projects. These actors are attributed with envisioned responsibilities to raise interest and enrol actors in the researchers' visions of the eradication of pesticides. These responsibilities are mainly about convincing those actors that are responsible to enact the societal transformations, and building their capacity to do so. At the start of this sub-chapter, I introduced Figure 17, which shows how the network got extended with these intermediary actors, to perform chains of translation. These intermediaries are indicated as nodes in the network: in some cases, the specific actors are known (blue circles in network), while in other cases only the responsibilities are defined at this early stage of the projects (dotted circles in the network). While some of these intermediary actors were already envisioned at T_0 , the researchers showed their capacity to embed them in a network with other actors, and align them towards the performance of envisioned societal transformations. Building further upon this, in the next sub-chapter in which I illustrate visions of responsibilities for interestment and enrolment to be anticipated by intermediary actors in the network, who are external to the projects.

6.2 Intermediary actors in the network external to the research projects

Following up on sub-chapter 6.1, some intermediary actors who are envisioned responsible for the interestment and enrolment of actors in the researchers' visions of societal change, are external to the research projects. Hence, these actors are also envisioned by the researchers in the construction of the networks, but they have no direct associations to the input or output phases of

the research projects. Their involvement should be anticipated otherwise. At this T₁-phase, the researchers identified these intermediary actors as nodes in the network, but they show to have limited visions of how to anticipate their associations in the network. Consequently, this could be potentially blocking the construction networks to perform the expected contributions to the mission, and thus the responsible translation process.

However, it should be noted that I only describe an early phase of the research projects. In addition, these intermediary actors and their responsibilities already showed to be envisioned, and so in the following years the researchers could build further upon, in the anticipation of the network. The researchers anticipate **two main categories of intermediary actors that are external to the research projects**. They are responsible in the network for the interessement and enrolment of these actors responsible to enact the societal transformations. Each category is sub-divided into three more specific groups of responsibilities of the intermediary actors.

1. Enabling the adoption of alternative solutions to pesticides
2. Valorising the alternative solutions to pesticides

The expansion of the envisioned network with intermediary actors in these categories is highlighted in Figure 18. It highlights how the researchers reflected on intermediary actors that are external to their projects in relation to the enactment of the societal transformations. At this early stage of the research projects, these external actors are not yet associated to the research projects. That means that it is not yet anticipated how they become a performative part of the network. I demonstrate each of these categories of responsibility in the following two sections, with qualitative quotes from the researchers.

6.2.1 Enabling the adoption of alternative solutions

The first category of intermediary actors responsible for the interessement and enrolment, that are external to the projects, is about enabling the adoption of alternative solutions. In this regard, I identified three subgroups that I highlight in this section: 1) access to alternative solutions; 2) standards and regulations; and 3) provision of additional technologies.

Access to alternative solutions

First, it is essential to reach (potential) users and enable them access to the alternative solutions. Visions of the access to alternative solutions are particularly emphasised in relation to new seed varieties and other technologies. A researcher from SPECIFICS mentioned for instance, that new seed varieties are sometimes 'neither known nor available to farmers'. Additionally, MoBiDiv stresses that diversification – through the use of seed mixtures by farmers – requires the availability of 'suitable

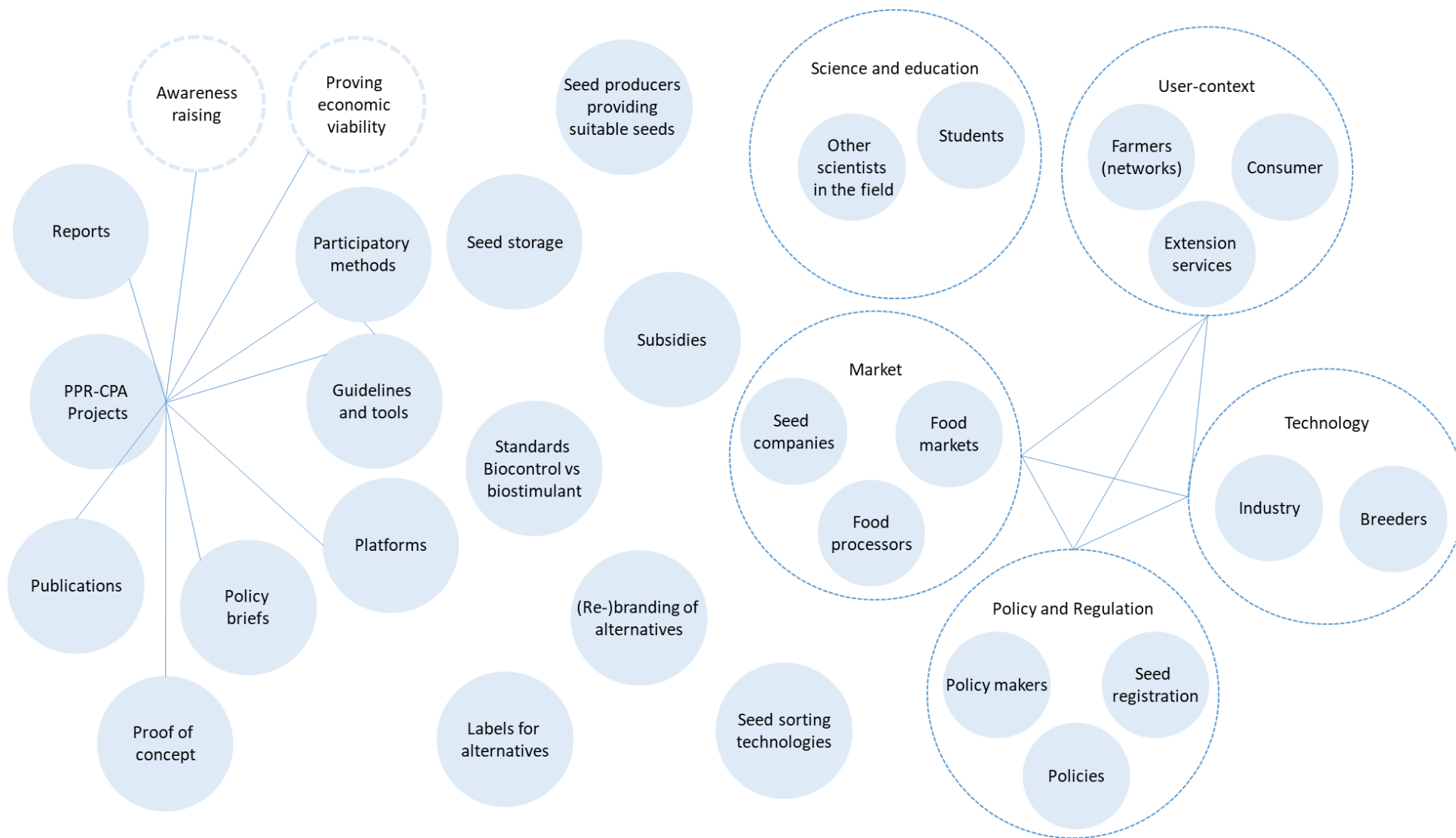


Figure 18. Examples of the expansion of the heterogenous network with intermediary actors that are external – and not yet associated – to the research projects, who have the responsibility for enrolment and intersement in line with the envisioned societal transformations.

varieties' which can be grown together in mixtures. A researcher from CapZeroPhyto mentioned about the access to technologies [*translated from French^{xcj}*]:

And then, if we continue with the other levers, we have a lever which concerns the use of VC flash which can stimulate the defence capacities of plants. So, there are both, in this case, prototypes that have been designed. So, this is going to be directly linked to agro-equipment manufacturers, for example, who will then, if it is an effective lever, distribute this lever to farmers, for example.

This quote highlights that manufacturers are considered to be responsible for the distribution of alternative solutions to farmers. Researchers from other projects shared similar visions. For example in PheroSensor, it is the envisioned responsibility of the manufacturer to distribute the end product to farmers. In addition, in MoBiDiv, the researchers argue that for the farmers to be able to diversify their fields by using seed mixtures to eradicate pesticides, they are interdependent to downstream actors. These actors are for instance seed producers, which offer mixtures to farmers. In this regard, the researchers stress the need for linking upstream versus downstream actors in the value chain.

Standards and Regulations

Second, various researchers reflect on regulations and standards that are envisioned necessary for the adoption of the alternative solutions by non-academic actors. A particular case in this regard was emphasised by researchers from CapZeroPhyto and SUCSEED in relation to the biocontrol solutions they both study. A researcher in CapZeroPhyto shared the following personal experience in this regard [*translated from French^{xcii}*]:

I found myself in the situation where we had identified an interesting product [red. biocontrol product], but it was being sold as a bio-stimulant. I went to tell people about it, at congresses, farmers' meetings etc. and the company came to me and said stop talking about it, you're going to cause us problems. If that's where the situation is, it's still stupid. If we find interesting products in crop protection, but sold as bio-stimulants, that we can't make them or work on them, finally. Because in fact, in the companies, that would force them to register them as plant protection products, which is too expensive and they don't want to do it. So, what does that mean? It means that when you have interesting products, you have to say so, but if you don't say so, it's no good.

In addition, the IP narrative of SUCSEED mentioned about this topic [*translated from French^{xciii}*]:

It is necessary to define a clear positioning of these innovative "biocontrol" or "biostimulant" solutions from the outset in order to limit marketing complications (different regulations). It is also necessary to establish the compatibility with conventional plant protection products and to know the emerging competing technologies.

These researchers highlight the marketing issues this lack of positioning and regulation of biocontrol products could cause. The regulations and marketing channels differ a lot between 'biocontrol' and 'biostimulant' products. Manufacturing companies tend to register products as being 'biostimulants' as it is a cheaper and easier process compared to 'biocontrol' products. However, biostimulants are considered part of conventional plant protection products, and can thus not be used in a chemical pesticide-free farming system. These quotes stress that manufacturing companies should distinguish well the marketing of plant protection products between 'biocontrol' or 'biostimulant'. Particularly since it refers to competing marketing channels and cannot both be used in 0-pesticides farming systems.

Especially for SUCSEED's researchers this recognition of biocontrol products as a replacement of pesticides, refers to a long process for the registration of such products. They emphasised in their IP narrative that they [*translated from French*^{xciiv}]:

[...] Need to have biocontrol recognised at EU level, especially for active substances that do not benefit from accelerated procedures (it can take up to 3 years to get a first appointment for the registration of a new active substance!). More generally, there is a need to update and harmonise the FR and EU regulations.

As highlighted in Chapter 5, for SUCSEED such regulations are particularly important, as at this moment, the seed technologies they study in their project are not registered in France, and can thus not be marketed as such. As they indicate, this process of registration can take a long time. It is a process, which manufacturing companies have to go through and they might not be interested in this as it might take long and costly. Therefore, SUCSEED stresses the need for a better, more harmonised, process to register biocontrol products.

Similarly – as highlighted in the societal transformations in Chapter 5 -, MoBiDiv requires change in regulation that will enable the registration, and thus marketing of, the seed mixtures they conduct research on. To enable this transformation to happen, the researchers stress a role for breeders in this regard. They stress in the IP narrative [*translated from French*^{xciiv}]:

Regulatory changes favourable to diversification (while guaranteeing the quality of heterogeneous material) are also necessary, and the support of breeders is essential to enable these changes. At present, due to the lack of a specific economic context promoting selection on the aptitude for mixing (character not considered for the registration of varieties and impossibility of marketing mixtures of unregistered varieties), breeders have not integrated this objective. It should be noted that even without making specific selections for mixtures, some breeders could take advantage of these regulatory changes favouring greater variety heterogeneity, by registering varieties that can be used in mixtures and that would otherwise have been eliminated.

This quote describes a similar case as SUCSEED, highlighting the limited interest of breeders in the alternative solutions – seed mixtures – as seeds cannot be registered in mixtures and thus not be marketed as such. The researchers of MoBiDiv also envisioned specific responsibilities for breeders to contribute in achieving transformations to the regulatory system: 1) contribute in supporting the regulatory changes that are necessary to market seed mixtures; 2) contribute by registering varieties that will not necessary be marketed as part of mixtures, but which can be used in mixtures anyway.

Finally, I illustrate an example in a very different situation, which is about standards and obligations that are particularly important for BEYOND and PheroSensor. They study solutions for early detection (PheroSensor) and prediction (BEYOND) of pests. This does not directly replace pesticides, but require the adaptation of decision-making strategies as earlier discussed. A researcher of PheroSensor emphasised in this regard [*translated from French*^{xcvi}]:

Is there an obligation to do so? Can a farmer also make a measurement and find that there are insects? But he decides that, for example, he prefers to continue using pesticides. Or does he have to declare them? Is he obliged to do the measurement? Because if there is a farmer, he does a measurement. And again, if the neighbour is not, maybe that can influence in the medium term. The spread of the insect or it may be an important question also to know who is going to induce obligations or direct aid, standards.

The researchers demonstrated to be aware that the implementation of their sensors in the field would not by default mean the eradication of pesticides by farmers. As this quote illustrates, there is the question of ‘obligation’ and ‘standards’ concerning the use of pheromone sensors in the field and to act upon them. Assuming responsibility by farmers goes beyond the implementation of the sensors in the field, but also requires them to act upon the measurements emitted by the sensors in order to eradicate, or limit, the use of pesticides.

Provision of additional technologies

Third, the development and implementation of several alternative solutions require additional technologies, to enable the eradication of pesticides. This means that the ‘functioning’ of alternative solutions to eradicate pesticides also depends on the availability of additional required technologies, such as specific techniques, machinery, or resources. For instance, MoBiDiv’s researchers shared the following in their IP narrative about the use of mixtures [*translated from French*^{xcvii}]:

The use of mixtures of species, particularly cereals and legumes, is still strongly constrained by the need to sort the species (mechanically or optically) before milling. The direct milling of cereal/legume mixtures and their use in food processing is currently being studied and could contribute to the development of these practices.

As this quote illustrates, for eradicating pesticides, the researchers study the use of grain seed mixtures, which consists of different species. After harvest, these species have to be sorted to meet standards for the milling process, which is required for the processing into food products such as bread. The lack of a proper sorting system in place could cause constrains in the implementation of mixtures in practice, as sorting mixtures of different grains requires specific technologies and additional work.

To provide some other examples, in the case of SUCSEED, the researchers study a particular seed technology to treat seeds with a 'bio-innovative' solution. The use of such treated seeds in practice require the availability of special technologies for seed conservation. Similarly, in SPECIFICS, researchers aim to contribute to legume-rich, pesticide-free cropping systems. Legume crops have as advantage the capacity to fix nitrogen from the air into the soil, and are thus beneficial for soil fertility and are widely used for these benefits. However, for legumes to fix nitrogen, the seed varieties require inoculants. Inoculants are bacteria that are responsible for this symbiosis in legume plants. However, in the past some of the SPECIFICS researchers have faced situations in which inoculants were limited available.

In the case of PheroSensor, the actual functioning of the pheromone sensors in the field also needs the development of additional technologies in relation the creation of a biomonitoring network. For instance, a researcher from Pherosensor reflected [*translated from French*^{xcviii}]:

What I was saying is that so far, we are thinking in terms of final application in the field. But there will be a stage... We are also talking about intermediate stages around biomonitoring networks, public authorities, etc. It is clear that the end user will be involved. The first will not be the farmer himself, but more reactive, cooperative or public organisations, and another potential outlet.

As this quote illustrates before even implementing the sensors on field-level, requires the further development of not only the sensors itself, but also the network, which it requires to function. This development also necessitates the inclusion of public authorities, cooperatives and manufacturers.

6.2.2 Valorising the alternative solutions

The second category of intermediary actors responsible for the interesement and enrolment that are external to the projects, refers to the valorisation of the alternative solutions. In this regard, I identified three subgroups that I highlight in this section: 1) convincing through the provision of information; 2) economic incentives; and 3) spreading of visions.

Convincing through the provision of information

First, the researchers envision that the valorisation of alternative solutions to pesticides requires the provision of information. For instance, in Chapter 5 I discussed that transformations in the market pole are necessary, as the alternative solutions to pesticides require suitable and accessible marketing channels. This refers to the marketing and valorisation of two product types: markets for agricultural inputs as alternative solutions, such as seed varieties and biocontrol solutions (e.g., SUCSEED, SPECIFICS, CapZeroPhyto), and markets for 0-pesticides food products (e.g., SPECIFICS, Be Creative, MoBiDiv).

To achieve this, both types of markets necessitate clarity on the quality and content of such products. Some researchers reflect on the need for (additional) labels for food products, for instance a label that indicates that a particular product is produced 'pesticide-free'. Such labels should inform consumers and valorise pesticide-free products. Similarly, in the case of alternative inputs such as biocontrol products, various researchers mention the need for labels to inform farmers about the specific input product, and thereby to valorise it as an alternative input to pesticides. However, the researchers do not show how to anticipate the creation of these labels, or in other words, how to associate such labels as an actor in the network.

Hence, as is illustrated by a researcher from CapZeroPhyto, it refers to marketing strategies to valorise alternative solutions to pesticides [*translated from French*^{xcix}]:

Because I think, for example new variety up there, very good, but first, he proposed a new variety, there are huge constraints to varietal change. Because to sell a variety, you don't sell hazelnut, apple or apricot. You sell a variety and so you change one variety for another. You have to change the mindset of people who are no longer going to buy Golden or Granny Smith, but who are going to buy, I don't know what, a new name and so that means an impact... How can I put it, a commercial investment to launch a variety which is very important and it is a very strong brake on varietal renewal among farmers in the current marketing framework. There is marketing, that's what there is... the variety has to be carried somewhere as a brand. It's as if a new brand was being launched somewhere.

This case of CapZeroPhyto highlights a particular example of changing an agricultural input, – a seed variety – and the need to convince farmers in this regard, by changing the branding of the variety. In a similar way, a researcher of SUCSEED reflected about the implementation of the alternative seed technologies they research [*translated from French*^c]:

Because perhaps the seed will not react in the same way as seeds that could be described as classic, traditional. So, there is this whole question of identifying what we propose. Obviously, the constraints in terms of technological, economic and social representation are also there. There is the role of the collective on this and we are dealing with adoptions that

are marginal or more massive. We know that this can have a knock-on effect. And then, the stakeholders can contribute to promoting these new solutions. Or this also means thinking in a slightly more sophisticated way about the marketing of the product.

Both examples highlight that changing inputs to eradicate pesticides by farmers, such as a variety or a type of seed or biocontrol product, is a key challenge that should not be overlooked: it is replacing a current input by something new that you do not know yet the effects of. This also requires a change in marketing strategies and re-branding such products to inform and convince farmers about its use. This requires the support of other actors, such as breeders or agricultural extension services or companies.

Economic Incentives

Second, the valorisation of the alternative solutions to eradicate pesticides is envisioned through economic incentives, for instance in the form of subsidies or compensation measures. Various researchers reflected on this, such as in FAST, MoBiDiv, SUCSEED and Be Creative. For example, researchers of FAST study economic incentives like subsidies or taxes to inform policy makers about the effect on the 0-pesticides transition. In the case of FAST, this is the broader objective of the project, which could in this way be beneficial to other projects as well. They expect such incentivising policies to be in place to support the eradication of pesticides.

In general, the importance of such economic incentives is mentioned by researchers, but such visions are not highly detailed. For instance, MoBiDiv's researchers argue that the remuneration of ecosystem services to farmers could encourage on-farm diversification. Ecosystem services are the benefits – or services – provided by natural ecosystems to humans. As they emphasise, this would require policy strategies to set up such a remuneration system. In addition, a researcher of Be Creative mentioned [*translated from French*^{ci}]:

[...] if the exercise is to help us to think about the actors who could be influential and who are missing in our project. And who we haven't thought of, it's actually the insurers. Because I, I say to myself that it's once again in the light of the discussions I've had recently on this Phyto-free rapeseed story. I think that the cooperatives or the farmers will be either demanding or reassured to know that there is an insurance system that will allow them to compensate for the losses when one of their own does not compensate for all the losses of a zero phyto, for example. And we don't have a choice.

Hence, this researcher argues that an assurance system for farmers and cooperatives could cover potential yield losses potentially caused by the transition to a 0-pesticides farming systems, and thereby thus incentivize the implementation of alternative solutions to eradicate pesticides.

Spreading of visions

As a final category, various PPR-CPA researchers envision the responsibilities of intermediary actors in demonstrating, raising awareness and spreading information about the alternative solutions to pesticides. To provide some examples, the researchers of FAST mentioned in their IP narrative [*translated from French^{cii}*]:

This awareness and change of view of the participating actors on the ways of change is a key turning point expected from the FAST project, because it would allow to transform these actors participating in the research works, into "great witnesses" likely to share and spread their visions to their peers in their professional organisations, neighbourhoods or networks. This spin-off and propagation of visions of possible change and ways of accompanying towards a pesticide-free agriculture could have the effect of inducing the creation of territorial niches or networks of projects of agriculture using pesticides sparingly.

Hence, as this quote illustrates, FAST's researchers expect that the actors involved in their projects will spread the ideas on the eradication of pesticides they obtain among their networks: as 'witnesses' in the 0-pesticides mission. In a similar way, ten territories participate in Be Creative to support the transition to 0-pesticides territories. Eventually, the researchers aim to highlight some of the involved '0-pesticides territories' as so-called 'showcase territories' (in French: 'territoires vitrines'). This is expected to demonstrate the benefits and possibilities of eradicating pesticides on territorial level, in order to support the transition of other (neighbouring) territories. Hereby Be Creative wants to promote 'coupled innovations', which means linking the actors of the value chain, and involving key players of the territories (such as cooperatives).

Where these examples from FAST and Be Creative highlight actors that are involved in the project, researchers of other projects have fewer clear ideas on how to involve actors in this regard. For instance, as is written in the IP narrative of BEYOND: [*translated from French^{ciii}*]: "*at present, we have not formally identified the partners with whom we could interact to support us in this process of raising awareness among stakeholders, labelling, etc*".

To conclude this sub-chapter, the researchers envision various intermediary actors in the networks that are external to their research projects. They are attributed with envisioned responsibilities to raise interest and enrol actors, in the researchers' visions of the eradication of pesticides with the alternative solutions. Hence, in contrast to the intermediary actors and their responsibilities as discussed in sub-chapter 6.1, they are external to the research projects, and therefore their involvement should be anticipated otherwise. The responsibilities of intermediary actors discussed in this sub-chapter are about enabling and valorising the alternative solutions to pesticides. They are largely – but not solely - envisioned to be assumed by manufacturers in particular,

and in some cases by policy makers. It shows that anticipating raising interest and enrolling actors in the researchers' visions of change goes beyond the research projects. At the start of this sub-chapter, I introduced Figure 18 to show the expansion of the network. This figure highlights that these intermediary actors are quite well defined as nodes in the network, but their associations to the research projects are rather lacking at this early stage of the projects.

6.3 Actor associations in the network to perform chains of translation

Eventually, in the construction of the networks, the intermediary actors who are responsible for enrolment and intersement of actors as discussed in sub-chapters 6.1 and 6.2, should be associated in the network with the other actors. This means associations between three types of actors and their responsibilities: 1) the actors related to the research projects responsible to conduct research on alternative solutions (the researchers and their project inputs and outputs); 2) the actors responsible to enact the envisioned societal transformations; and 3) the intermediary actors responsible for intersement and enrolment of these actors. In other words, these associations are essential to enact the chains of translation in the network, and thus for the constitution of a future society that an eradicate pesticides with the alternative solutions. Therefore, in this third and final sub-chapter, I highlight the way in which the researchers envision such associations, which are not highly anticipated yet at this T_1 -phase. I illustrate this through the envisioned network expansion in Figure 19, by indicating the envisioned associations between the various actors. The dotted lines indicate associations between actors that are not yet defined in detail nor anticipated at this early stage.

First, at this T_1 -phase in general, the researchers did not show detailed visions of the actors that are held responsible to enact on the societal transformations (see Chapter 5). At this stage, these actors are reflected upon in larger actors' groups, such as 'farmers', 'breeders', 'companies', 'policy makers' etc. However, such visions are rather heterogenous between the PPR-CPA researchers and projects: some researchers have further developed visions than others. A researcher of MoBiDiv argued for instance [*translated from French*^{civ}]:

But it's the same thing and it's the intermediaries that have an impact. So, there you have it. So, for me, it's certain that we have this listed in the impact pathway, in the upstream. In any case, they're the same. What does that mean? That it's the breeders, the participatory selection networks, the contract sorters, the seed production team, the agricultural advisers and the technical institutes. And it is the public agencies and policies, so the agencies that implement regulations, some of which are partners of the project. But for me, whatever the final scenario will be, it must move on all these actors anyway.

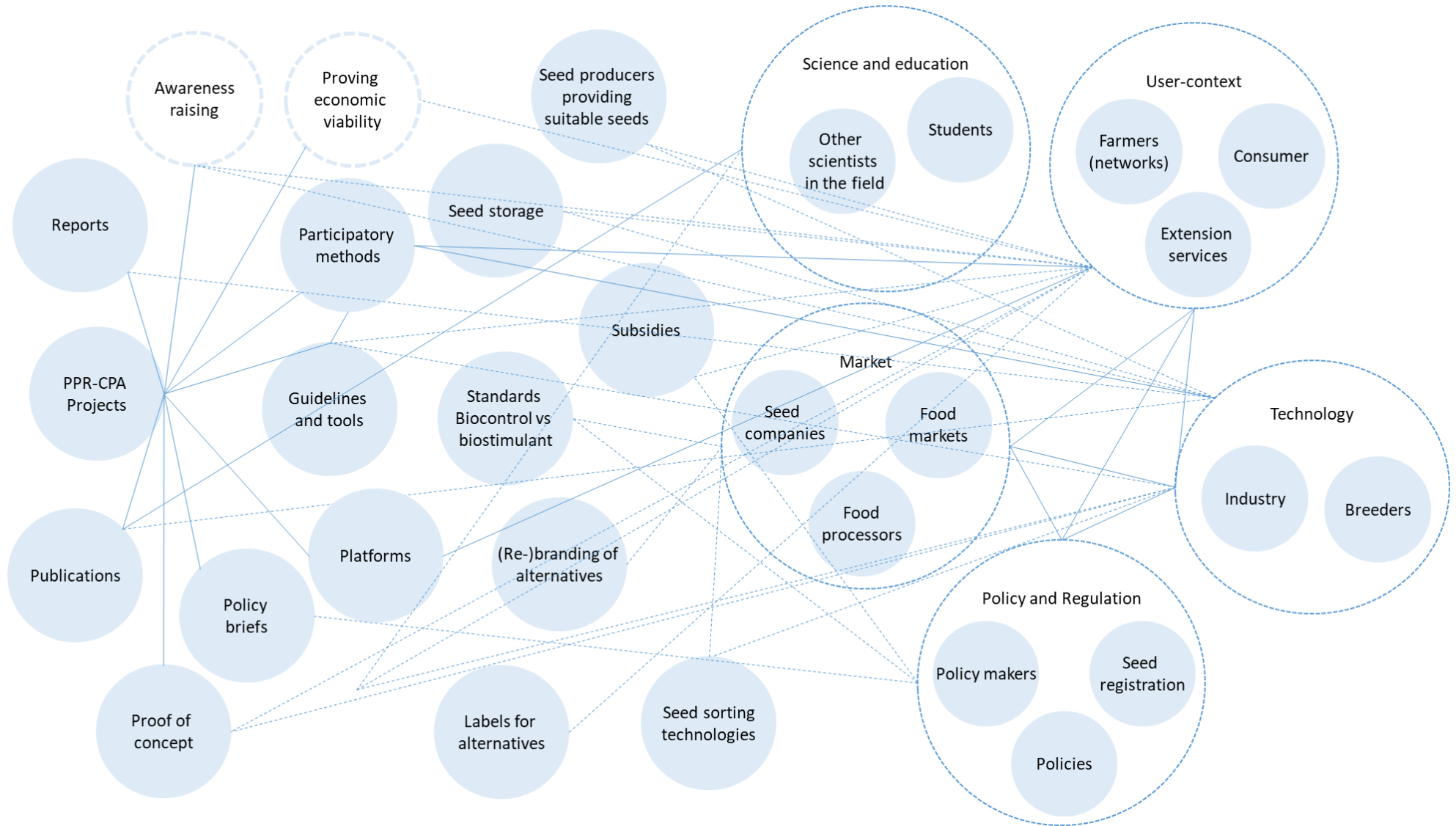


Figure 19. Examples of the expansion of the heterogenous network with the envisioned associations between the various actors – the dotted lines indicate associations between actors that are not yet defined in detail nor anticipated

Chapter 6. Realising Associations between Science and Society: Anticipating Heterogenous Networks to Perform the Researchers Expected contributions to a 0-Pesticides Society

This quote illustrates the awareness for the need of other actors in contributing to the mission. Even though the researchers did not mention the precise names of companies or organisations, it highlights that MoBiDiv's researchers are rather aware of the environment that embeds their research project. For them to contribute to the mission with their alternative solution (seed mixtures) requires to raise interest and enrol all these actors.

The PPR-CPA researchers also indicated that it is not an easy assignment to identify the actors to involve – particular at this early stage of the research projects - and we noticed that this requires more effort from ASIRPA RT in future activities. For instance, researchers from SPECIFICS emphasised the key role ASIRPA RT has to play in navigating the identification of actors. The researchers initially came up with a rather general, non-detailed list of actors in the IP they constructed (e.g., cooperatives, policy makers and farmers). Throughout the ASIRPA RT workshop, they collectively managed to better define and associate these actors.

Second, even though the researchers anticipate capacity building activities and incentives to actors, for some situations a default interest by actors in the alternative solutions is assumed. For example, in PheroSensor, the researchers stressed their need for industrial partners to manufacture their pheromone sensors [*translated from French*^{cv}]: “We aim to set up a manufacturing process compatible with mass production. There will be a technology transfer. The identification of a third-party operator is still premature but it will be necessary to prospect”. At the end of the project they expect to have a ‘proof of concept’ of the sensor ready, and to market and implement the sensors in the field requires industrial actors to further develop, scale up and manufacture the sensors. Hence, such industrial actors are to uptake PheroSensors’ prototypes, and even though manufacturers are not identified yet, they assume that there will be interest. Similarly, a researcher of CapZeroPhyto emphasised [*translated from French*^{cv}]:

And then, the originality of the project is to combine these different levers which only provide partial resistance of the plant to move towards better immunity and which we hope to have some expertise in coupling and combining the levers. There is also something to share that will be of great interest to the technical institutes - leaving room for experimentation -, the agriculture council, the cooperatives and the farmers themselves. And this expertise will also be used for training by training organisations in agricultural colleges to train future farmers, etc.

The project aims to combine different levers of plant resistance, and as the quote illustrates, the researchers require additional expertise from other actors. They have not identified these actors, and assume that there will be interest in these alternative solutions.

Third, if research outputs – such as tools or guidelines – are available to actors, this does not by default lead to associations with, and thereby to the change of, these other actors. For instance, a guide to help farmers using an alternative solution to pesticides might require the intermediation of actors, such as extension services, so that the farmers have access to and will consult the guide. Hence, constructing the heterogenous networks requires the researchers to reflect on the various associations between a large variety of actors along the value chain. The researchers of MoBiDiv showed rather advanced reflections in this regard [*translated from French*^{cvi}]:

And all this should lead to tools to help with the design, choice and assembly rules of mixtures, and so everything is the output of this output component. We have determined that these tools can be used by intermediary actors such as farmers, advisory and development organisations, technical institutes and contract sorters, seed producers, cooperatives, etc. To achieve transformations that lead to a diversification of agriculture and practices, with a modification of crop rotation and cropping systems, new technical itineraries. And to achieve this upstream transformation, a transformation of reference production activities on the qualities of the mixtures is needed. A development of the advisory offer on mixtures and a modification of the seed production and distribution system to have an offer of mixtures proposed to farmers. So, I'll perhaps move on to the impacts later. But the second part of the work that we have identified is rather everything that involves the identification of very genomic regions, plant ideotypes, tools that can be used in breeding, a certain number of which will be usable by breeders, whether they are breeders in the traditional sense of the term or networks of farmers in participatory breeding. And also, the organisations that supervise breeding activities, such as the CTP and the GEVES, and these outputs used by these actors should allow transformations within the breeding activity, both through selection schemes adapted to the mixture, and therefore a modification or diversification of the selection objectives, a selection of varieties and species specially adapted to the mixture or selected in a mixture and a selection strategy for more local environmental conditions.

This quote illustrates the rather detailed visions of the large variety of actors to get involved in the network. MoBiDiv also emphasises the associations between the upstream and downstream actors of the value chain. The researchers highlight that the tools they will develop to guide the breeding, marketing and use of seed mixtures do not by default end up with the other actors they envision (e.g., breeders or farmers). Instead, they illustrate the elaborate network this embeds, such as organisations that supervise breeding activities, or farm advisors. The ASIRPA RT activities guided the researchers in the complexity of such networks. A Pherosensor researcher explained in this regard [*translated from French*^{cvi}]:

We made what we call an intermediation context where we listed a set of - how to say - intermediate actors or actions. So, an industrial partner who should help us with the manufacturing of the devices once we have made prototypes, because in the course of the

project we will have different levels of prototypes. At the end of the project, we want to arrive at prototypes, so we will need these partners, an industrial partner to optimise costs. [...] So that's what we had listed below, i.e. relays to technical institutes. But we were wondering which technical institute or which relays could help us in this information sharing. It's perhaps something that we need from the farmers' chambers, the cooperatives, etc.

As this quote illustrates, the researchers started to reflect in more detail on the network, and the chains of translation this would embeds ('relays to technical institutions'). This reflection moves away from a linear way of thinking from research on a sensor, to a manufacturer to develop the sensor and to a farmer who will use it. However, at this early stage in the case of PheroSensor, the network of actors is not yet identified. Researchers of various projects indicated that they find it too early to reflect on a detailed list of actors to involve. Instead, they indicated that they will need their first research results, before they can define in more detail their interactions with other actors. I further highlight this in Chapter 7.

Other researchers find it less the responsibility of researchers to anticipate the associations to other actors in the network. A researcher from FAST stressed for instance [*translated from French*^{cx}]:

But if we take, for example, the game that we are going to design with a participatory method, with the multiple actors, so the cooperatives, the agri-chemists, the farmers' unions, we will have done our part, i.e. we will put it in an open source. Everyone will be able to use it. The cooperatives, we know that there are already some cooperatives that we have co-constructed, that will use it. Some teacher-researchers have contacted us to use it, but it is certain that for upscaling, it is no longer us. That is to say? We have made the tool available. In fact, the instructions for use. We are ready to go and present the tool to anyone who wants it. Afterwards, it's up to them to mobilise and play with it. But that is not up to us.

The researcher of this quote anticipates the development of a game or a tool for actors, but does not consider it the role of researchers to envision the associations to other actors. Also, for the use of the tool it is expected that actors actively contact the researchers to present it to them. This was not a commonly shared visions among researchers, but I mentioned it here to highlight that it is not evident to reflect on the researchers' embeddedness in networks with actors and the role for formative evaluation to play in this regard. In the FAST for example, which is also highlighted in visions of other projects, such associations are more detailed if it concerns the 'major actors' related to their projects. For instance, in FAST it is about actors involved in public decision making, as their IP narrative states [*translated from French*^{cx}]:

Their mission is precisely to collect research results on agricultural and environmental policy issues (CEP of the Ministry of Agriculture, DITP, France Stratégie, CGAAER). Where appropriate, they are already members of the expert committee that was set up at the time the project was set up to monitor its progress. For this type of interlocutor, the production of scientific publications will be accompanied by popularisation work in the form of policy briefs in French.

Hence, this quote highlights clearer visions of their associations to public decision-maker, which are very central to the topic of their research projects on policies to support the transition to pesticide-free farming.

To conclude this sub-chapter, the actors that are responsible to enact the societal transformations are not yet well identified in this early phase of the research projects (as highlighted in Chapter 5). This also limits the visions of the construction of the heterogenous networks, through the associations between the various actors. In particular, even if the actors will be identified in more detail, their associations to other (intermediary) actors are not by default established, and need to be anticipated. These associations are essential to perform the chains of translation, and that might require additional intermediary actors to get involved. For instance, in establishing associations between guidelines and farmers: does this require other actors such as extension services? This extended network is highlighted in Figure 19, which shows the envisioned associations in dotted lines, since they are not defined in detail yet. This sub-chapter showed that the visions of a 0-pesticides society, as the result of associations between the actors, are becoming part of the network. To put this in other words, the actors are associated in the future network through their envisioned responsibilities for enabling the eradication of pesticides in society. Instead of 'science for society', it is beginning to become a 'science with society': science is conducted with society (i.e., associations).

Conclusion

In this chapter I have presented the second phase of responsible translation. I showed that envisioning the researchers' contribution to the 0-pesticides mission with their research projects on alternative solutions, they have to envision what the contribution of other actors should be in order to achieve the necessary transformations. In this regard, I demonstrated how the PPR-CPA researchers envision shared responsibilities between a heterogenous set of actors to contribute to the eradication of pesticides in society with the alternative solutions. To perform these expected contributions of the alternative solutions to the societal mission, the researchers envisioned the construction of heterogenous networks by anticipating chains of translation among different actors. Hence, the construction of these future networks, is based on the researchers' visions of associations among actors through their responsibilities for the 0-pesticides mission. I.e., actors are associated through

their envisioned responsibilities for enabling the eradication of pesticides for a future society. Building upon my conceptual framework (Chapter 2.2), a 0-pesticides society is the outcome of associations, and it is in this way that societal visions become embedded in the network.

These visions reflect the associations between three types of actors and their responsibilities in the network. First, the researchers themselves are present in the network through their PPR-CPA projects in which they conduct research on alternative solutions. Second, to contribute to the 0-pesticides mission, transformations in society are necessary to enable the eradication of pesticides. This requires other actors to change how they act in the future to enact these societal transformations. Third, intermediary actors are envisioned with the responsibility to interest and enrol the other actors who are responsible to enact the societal transformations. Even though these actors are (broadly) identified as nodes in the network, their associations are still rather limited at this early phase of the research projects (T_1).

Concerning the third group of (non-human) actors – with responsibilities for the interesement and enrolment of other actors – they are either a direct result of the research projects or they are envisioned external to the projects. In the first case, it is the responsibility of researchers through their projects to interest and enrol actors to enact societal transformations. The researchers envisioned this in particular through research outputs that are meant for building capacity and demonstrations of the alternative solutions. However, this puts into question the boundaries of the responsibility of researchers for the 0-pesticides mission, and thus the boundaries of their contribution towards transformative change in society. By only funding academic research in the PPR-CPA, the researchers are attributed a large responsibility to contribute to this mission, and to anticipate the enrolment of actors, and we can question if this is realistic. In the second case, my data showed how the PPR-CPA researchers envisioned that raising interest and enrolling actors towards societal transformations is also highly depended on external actors. In particular, they mention the key role of manufacturers and industries in enabling the eradication of pesticides with the alternative solutions, who are not part of the mission (yet) (See sub-chapter 6.2).

These visions of the key role of other actors shows the large potential for participatory approaches in research with transformative aims. This means that to move from visions to action, other actors must be more systematically included in the research and innovation meant to achieve missions. At the same time, at this T_1 -phase, these envisioned networks are only starting to be constructed and are not yet performative. Over the coming years (at T_2 , T_3 , etc.) it would be interesting to explore how the networks get extended, and how associations get anticipated and established. This

Chapter 6. Realising Associations between Science and Society: Anticipating Heterogenous Networks to Perform the Researchers Expected contributions to a 0-Pesticides Society

would also teach us more about enrolling actors, and the role and responsibilities of researchers and other intermediary actors in this regard.

Chapter 7

Mobilising Associations between Science and Society: A Change in Visions of Alternative Solutions to Pesticides becoming Spokesmen of the Heterogenous Networks

Chapter 7. Mobilising Associations between Science and Society: A Change in Visions of Alternative Solutions to Pesticides becoming Spokesmen of the Heterogenous Networks

The PPR-CPA was launched as a response to challenges that have been caused by an overuse of pesticides. This requires that the ten funded research projects within the PPR-CPA go beyond scientific excellence in the eradication of pesticides, but direct their research towards societal goals: the 0-pesticides mission. However, I have demonstrated in Chapters 4, 5 and 6 that it is not easy for researchers to envision how to contribute to a society without pesticides with the alternative solutions. They face particular difficulties in articulating and anticipating the heterogenous networks to perform the expected contributions to the mission – through the creation of associations between actors with different envisioned responsibilities. I described this by exploring the first two phases of responsible translation from visions of alternative solutions into those of a society that eradicates pesticides (Chapter 5 and Chapter 6): the societal transformations to enable the eradication of pesticides with the alternative solutions, and the chains of translation this requires. In particular, I highlighted the responsibilities of different actors the researchers envisioned in these phases.

As elaborately explained in this thesis, the PPR-CPA programme included the ASIRPA RT approach as a means to accompany researchers in envisioning their contributions to the eradication of pesticides in society. The thesis began by analysing the visions articulated in the PPR-CPA project documents about the contribution that the writers expected their research to make for the eradication of pesticides. Qualitative analysis of these visions was conducted both before and after the researchers were asked to make explicit their expected pathways from research to societal impacts. This analysis enabled me to measure a qualitative change in the researchers' expected contributions of the alternative solutions to the 0-pesticides mission between the T_0 -phase (before the intervention of ASIRPA RT) and the T_1 -phase (after the intervention of ASIRPA RT).⁹²

I described the T_0 -phase in Chapter 4 by demonstrating how the researchers' visions of their contributions of their research on alternative solutions to the 0-pesticides mission influenced the construction of the projects. This T_0 -phase reflects the phase before the intervention of ASIRPA RT in navigating such visions. To describe the T_1 -phase, I demonstrated in Chapter 5 and Chapter 6 how the researchers envisioned contributing to the eradication of pesticides in society when they are

⁹² Please note that only eight out of the ten projects participated in T_1

accompanied through formative evaluation activities that enabled them to make explicit their envisioned societal impacts, transformations and the heterogenous networks of actors.

The data presented in these chapters highlighted how ASIRPA RT – as a formative evaluation approach – encouraged the PPR-CPA researchers to take responsibility for the 0-pesticides mission, by guiding them through the responsible translation process from visions of alternative solutions into those of a society that is able to eradicate pesticides with the solutions. By exploring the data through the first two phases of responsible translation – which is inspired by Callon (1986) - I have thus far been able to describe how the researchers expect to contribute to the eradication of pesticides in society with the alternative solutions they study:

1. How the researchers envision the constitution of a society that is able to eradicate pesticides with the alternative solutions - in particular the responsibilities they assume for other actors to enable the eradication of pesticides with the alternative solutions, and that require transformations (Chapter 5);
2. How the researchers anticipate the construction of heterogenous networks to perform the expected contributions to a 0-Pesticides society with the alternative solutions – in particular the responsibilities they hold for intermediary actors for the intersement and enrolment of actors so that the latter can change the way they act in the future to enable the eradication of pesticides with the alternative solutions (Chapter 6).

The third phase of the responsible translation process

In this chapter, I respond to the following research question: *How have the PPR-CPA researchers' visions changed from before their involvement in ASIRPA RT to after their involvement?* Hence, in this chapter I explore the data collected during both the T_0 - and the T_1 -phase of the PPR-CPA, by exploring the third phase of the 'responsible translation' process: **mobilisation**. This phase highlights a change in the researchers' visions from T_0 to T_1 of the expected contributions of the alternative solutions to the eradication of pesticides in society. It highlights the constitution of each alternative solution to pesticides as a 'spokesperson' of the heterogenous networks to perform the expected contributions to the 0-pesticides mission.

In this chapter, I will be building further upon the three previous empirical chapters (4, 5 and 6), by demonstrating a change in visions of how science with society – as a specific 'assemblage'- can be mobilised to achieve the 0-pesticides mission. I will thus explore how each alternative solution to pesticides is expected to become a spokesperson of a future association between the PPR-CPA projects and a 0-pesticides society; and thus, spokesperson of the heterogenous networks that are to

perform the expected contributions to the eradication of pesticides. In this chapter, I analyse how such visions have changed over time from before the ASIRPA intervention (T_0) to during the ASIRPA RT intervention (T_1).

This third phase of the responsible translation process is largely inspired by Callon's moment of 'mobilisation' in the Sociology of Translation. Callon explained the importance of mobilisation as follows:

Who speaks in the name of whom? Who represents whom? These crucial questions must be answered if the project led by the researchers is to succeed. This is because, as with the description of interessement and enrolment, only a few rare individuals are involved, whether these be scallops, fishermen or scientific colleagues (p.214).

For Callon, mobilisation is the result of interactions among 'chains of intermediaries'.

These chains of intermediaries which result in a sole and ultimate spokesman can be described as the progressive mobilisation of actors who render the following propositions credible and indisputable by forming alliances and acting as a unit of force: 'Pecten maximus anchors' and 'the fishermen want to restock the Bay'. The notion of mobilization is perfectly adapted to the mechanisms that we have described. This is because this term emphasizes all the necessary displacements. To mobilize, as the word indicates, is to render entities mobile, which were not so beforehand (p.216).

In Callon's case, the moment of mobilisation explains how the three researchers become spokespersons of the network they established with the other actors to restock the bay, i.e., the fisherman, the scallops and the scientific colleagues. However, in this mission-oriented context of the PPR-CPA, the situation is different as it represents 1) visions of a future society without pesticides; and 2) the performance of expected contributions to these visions, through chains of translation in heterogenous networks. Building further upon Chapter 5 and Chapter 6, mobilisation in this mission-oriented context is not about the PPR-CPA researchers becoming spokespersons of the heterogenous networks, but it is about how the alternative solutions to pesticides become the spokespersons for the future 0 pesticides society.

By comparing the T_0 - and the T_1 -phase, I argue that ASIRPA RT helped navigating the researchers' visions of the constitution of each alternative solution to pesticides as a 'spokesperson' of the networks to perform the expected contributions to a society without pesticides. This chapter documents the change in visions from one where the contribution to the societal mission occurs simply through transferring research outputs to 'society' (T_0), to one where a 0-pesticides society can be imagined as being achieved through the process of responsible translation (T_1). This represents a change from visions of a 0-pesticides society where both the problem and solutions reflect a scientific

way of knowing society, to visions of a 0-pesticides society that reflects the assumption of responsibilities for the mission by (non-) human actors as a result of their associations in heterogenous networks.

Hence, in this chapter I compare the T_0 -phase (based on Chapter 4) to the T_1 -phase (based on Chapter 5 and Chapter 6), to demonstrate how ASIRPA RT enabled the PPR-CPA researchers a change in their visions. In this comparison, I discuss three major changes in the visions concerning the expected contributions to a society without pesticides. I argue how these changed visions reflect the researchers' responsibility through the translation process of their visions of alternative solutions into a society that eradicates pesticides. I develop this argument by exploring how the researchers expect to mobilise a 0-pesticides society, whereby the alternative solutions to pesticides become spokespersons of networks to perform these expectations.

Visions that mobilise a 0-pesticides Society through the contribution of responsible research on alternative solutions to pesticides

Therefore, in this dissertation I explore how such changes in visions reflect how researchers assume responsibility for the societal mission, and particularly how a formative evaluation approach as ASIPRA RT contributes to this change. As I elaborated in my literature review (Chapter 2), in the past decades Responsible (Research and) Innovation (RRI and RI) emerged in the policy context of the European Commission (EC) and in scientific literature with the aim to better align R&I activities with societal challenges we are currently facing (e.g., Owen et al., 2021). However, I identified various gaps that challenge the implementation of such efforts for the responsabilisation researchers: 1) the limited knowledge on constructing science-society associations; 2) the need to couple research and innovation; 3) the fact that R&I policy often pushes towards economic growth and competitiveness; and 4) the practice where 'responsibility' in R&I is often implemented as an add-on to projects instead of institutionalised in the way in which we do research and innovate.

Hence, before I conclude my response to these gaps in the general conclusion of this thesis, in this chapter I illustrate how ASIRPA RT accompanied the PPR-CPA researchers to mobilise their alternative solutions to pesticides as legitimate spokespersons of networks associating between their research projects and a society without pesticides. This highlights a change in how the researchers take on responsibility to perform the expected contributions of the alternative solutions they study to a society that is able to eradicate pesticides. At T_0 , the researchers demonstrated their awareness of their limited contribution to the mission, and thereby the need of other actors for the eradication of pesticides in society. However, they focussed largely on their responsibilities in their role as researchers to enable the eradication of pesticides, for example by studying the performance of the

alternative solutions through scientific questions. Instead at T₁, representing responsible research, the researchers demonstrate an increased consideration in the roles and responsibilities of other actors with whom they must interact, for enabling the eradication of pesticides in society.

I illustrate this in this chapter through three changed visions - each representing a sub-chapter - that demonstrate a change from the 'transfer of research outputs into society' (T₀) into 'the responsible translation of visions of alternative solutions into those of a society without pesticides' (T₁). This is summarised in Table 13. First, it reflects a change from visions of a '0-pesticides society' from a scientific point of view, to one that is co-produced with the researchers' expectations of the contribution of the alternative solutions to the eradication of pesticides (sub-chapter 7.1). Second, it reflects a change from visions of the impacts to society that are based on the scientific analyses of the multilevel performance of alternative solutions, to impacts as the result of shared responsibilities between researchers and other actors in enabling the eradication of pesticides (sub-chapter 7.2). Third, it reflects a change from visions of favouring acceptability of the use of alternative solutions through a scientific approach to study feasibility, to anticipating enrolling actors' responsibilities into the visions of the eradication of pesticides (sub-chapter 7.3). This leads to four constructive changes from T₀ to T₁ of how the researchers take on responsibility for the mission, which I illustrate in the conclusion of this chapter.

Table 13. A summary of the three changed visions that demonstrate a change from the 'transfer of research outputs into society' (T₀) into 'the responsible translation of visions of alternative solutions into a society without pesticides' (T₁).

Changed visions of:	T ₀ – Transfer of research outputs into society	T ₁ - Responsible translation
1. The constitution of a 0-pesticides society with the alternative solutions	Envisioned from the point of view of scientific questions	Co-produced with the researchers' expectations of the contribution of the alternative solutions to the eradication of pesticides
2. Impacting society with the alternative solutions	Envisioned through the scientific analyses of the multilevel performance of alternative solutions	The result of shared responsibilities between researchers and other actors in enabling the eradication of pesticides
3. Enrolling actors for the eradication of pesticides with the alternative solutions	Envisioned favouring acceptability of the use of alternative solutions through a scientific approach to study feasibility	Enrolling actors' responsibilities into the visions of the eradication of pesticides with the alternative solutions

7.1 How to contribute to a 0-pesticides society with research on alternative solutions

The PPR-CPA researchers have expertise and visions of how to enable the eradication of pesticides. Through their research activities (input and output phase) they address and study project specific alternative solutions to pesticides, which are accompanied by these visions. In this first section, I demonstrate how these visions of the expected contributions to the eradication of pesticides in society changed from T_0 to T_1 , and what this means in terms of responsibility of the researchers.

Since the PPR-CPA is about the contribution to an ambitious societal mission, the researchers' visions of a society without pesticides as a result of the alternative solutions to pesticides they study are essential. In the T_0 -phase the researchers illustrated visions that saw the transfer of research outputs into society and a straightforward expected 'interest' in the alternative solutions and thereby in the research outputs. Instead, the T_1 -phase reflected visions of the translation process from visions of alternative solutions into those of a society that eradicates pesticides with these solutions. This latter situation embeds visions of responsibilities of other actors for the expected contributions to the eradication of pesticides. These responsibilities require the actors to change how they act in the future, to enable the development and implementation of alternative solutions in society. Therefore, in this first section, I discuss a change in how the researchers assume responsibility to contribute to the eradication of pesticides with the alternative solutions. This requires a change to a society where pesticides are 'supressed' and alternative solutions are given space to become part of society (Jacquet et al., 2019).

7.1.1 Mobilisation through scientific breakthrough is insufficient

To start, at T_0 , 0-pesticides society with the expected contributions of the alternative solutions was largely envisioned through a scientific way of approaching such a society. This reflects visions of the contribution of research to the eradication of pesticides through the transfer of research outputs to society, as well as a straightforward interest in the use of the alternative solutions by actors in society. The envisioned responsibilities of the researchers are to conduct excellent science into alternative solutions to pesticides, and the responsibility of actors in society is to use the research outputs for the eradication of pesticides

Visions of the required changes in society – or visions of the constitution of society to enable the eradication of pesticides – are approached as scientific questions at T_0 . Instead of reflecting on how the researchers could contribute to such visions of society with their research on alternative solutions, the project documents put forward a scientific rationalisation. For instance, they propose studying the performance or efficiency of a change in farming practices - from different points of view

such as socio-economic, environmental or agronomic performance. Or, the researchers aim to study the potential effect of a change in farming practice on the eradication of pesticides. Hence, in this way expected contributions of the projects to a society without pesticides are framed as scientific questions. This reflects the consideration of a straightforward interest, adoption and use of the alternative solutions by its users in society. It illustrates visions that the responsibility of researchers in contributing to the mission is to conduct 'breakthrough' or 'ambitious' science, and transfer its outputs to actors in society to eradicate pesticides. The intermediary context between the research projects and a 0-pesticides society rather lacks visions. In literature such visions are described as 'blue sky science' (Sarewitz, 2012), whereby the focus is on fundamental research without necessarily applying it to the societal context. Sarewitz (2012) stresses that 'rethinking science' should lead to responding to societal challenges, "*not simply to protect science for its own sake*" (p.1).

To provide a few examples from the T₀ situation, one of the objectives of a WP of FAST states the following: "[...] *[red. we] will demonstrate that adoption of suitable production practices by farmers can significantly alleviate the impacts of drastic reductions in chemical pesticide uses on production levels and farmers' income*". In addition, considering the ambitious 0-pesticides mission, Be Creative and SPECIFICS aim for a 'multi performance' assessment of pesticide-free farming systems, which are framed as scientific questions. For example, the proposal of Be Creative highlights: "*To our knowledge, there is no study that assesses effects of combining biocontrol methods with biodiversity-based practices on ecosystem services and economic performance*". Similar studies are envisioned by SPECIFICS, but with a larger focus on trade-offs, as they state:

An original feature of the proposed scheme is to analyse the impacts of changes at different times in the transition to pesticide-free conditions, and to compare, for different situations of systems in transition, the trade-offs between agronomic (productive performance), agro-ecological, environmental and socio-economic performance criteria.

These quotes illustrate how the researchers approach a 0-pesticides society to which they expect to contribute through a scientific way of knowing such a society. They aim to scientifically study the potential multi-level performances of the alternative solutions to pesticides in society. They do not necessarily consider the role of other actors to enable the eradication of pesticides with the alternative solutions.

User interfaces mobilise beneficiaries

In their expected contributions to a society without pesticides, the researchers showed a strong focus on the user interface of their research outputs on alternative solutions, and lacks broader visions of the constitution of a 0-pesticides society. In this regard, non-academic actors are considered in terms of 'receivers' or 'beneficiaries' of the PPR-CPA projects; as the expected result of the transfer

of research outputs into society – who are expected to be part of a linear process of the transfer from research to alternative solutions. To provide an example, when the PI of DEEP IMPACT was asked during the T₀-interview what change in society he expects to contribute to in the eradication of pesticides, he responded as follows:

After the project, perhaps to put the good scientific knowledge to be able to move to the zero-pesticides system. Because we are going to replace or put biodiversity and plant microbiota interaction as a key driver of plant resistance and sustainability of the system. So, for me the expectation is clear to say to the technical institutes or the cooperatives, to the private companies, to the breeders to say: you have to take into account biodiversity parameters and how this biodiversity interact with the crop. But we have to give them some tools, we need to give them some demonstrations of the results.

This quote illustrates the expected contributions to the eradication of pesticides through the transfer of research outputs to actors in society. They focus on those actors who are expected to use their research outputs about the alternative solutions. In this case of DEEP IMPACT it is about 'plant-microbiota interactions', which is thus of interest for technical companies such as breeders. It also illustrates that the expected transfer of results requires the demonstration of their research results in order to interest these actors.

This focus on the transfer of research into alternative societal solutions, through the user interface of the research outputs, is reflected in the types of project outputs. First, the project outputs are not 'ready to be implemented alternative solutions', but instead are contributions to these alternative solutions that require further development and actor enrolment in the majority of the cases. Hence, the transfer of these outputs – such as prototypes of technologies, policy briefs, knowledge on levers of plant resistance, or new seed breeding lines - reflect rather linear visions of associations among actors in society who are 'next in line' in the transfer from research outputs to alternative solutions. Second, research outputs reflect the transfer from research to alternative solutions through the focus on skill development, for instance in the form of guides or tools for the users of the research outputs. Third, research outputs showed to focus on the dissemination of findings, such as in the form of scientific papers, (policy) reports, platforms and websites. To provide an example, the PI of BEYOND emphasised in this regard during the T₀-interview:

The farmers will have to be... there's no farmer today thinking about long distance aerial dissemination of pathogens from Iceland or whatever. OK, so they will have to be trained. And that's part of something we'll do in the programme where we have participatory workshops. We want to use the ESV platform to disseminate a lot of the simplified information about this.

Consequently, expected change in society to eradicate pesticides with the alternative solutions, is envisioned as a rather linear result from the transfer of research. It reflects straightforward interest, adoption and use of alternative solutions to pesticides, and the change of practice by other actors that this requires. Some examples of practice change are: a change in breeding techniques; a change in farming practices through the use of new (seed) technologies or pest management strategies; a change in the advice of the use and selling of farm inputs, etc. This is reflected in the following quote from the proposal of Be Creative:

At the socio-economic level, the territorial scale is needed to take into account the fact that farmers are not the only ones concerned by pesticide application. Agricultural practices are partially dependent on advisory practices, commercial practices of upstream and downstream actors, regulations issued by public authorities, as well as neighbourhood relationships.

This quote reflects visions that the eradication of pesticides in society goes beyond just a change in practice of farmers. It embeds the dependence of farmers on other actors as well. However, we do not see it largely reflected how the researchers assume responsibility to contribute to these changes in practice, and what is necessary to achieve a 0-pesticides society.

The researchers indicated that the 6-year duration of their research projects is too short to actually develop alternative solutions that are ready to be implemented and to eradicate pesticides. In their expectations about the contribution to the mission, this represents a gap between the project outputs and the actual eradication of pesticides in society with the alternative solutions. The researchers showed difficulties in overcoming this gap when they focussed on the transfer of excellent science, particularly to envision what happens – or should happen – in society for the research outputs on alternative solutions to be able to contribute to the eradication of pesticides. This shows the limited visions of research as part of society, but rather ‘science for society’.

7.1.2 Mobilisation through the emergence of “chains of changes”

In contrast, at the T₁-phase the PPR-CPA researchers share more detailed visions of the required changes in society that are necessary to enable the eradication of pesticides with the alternative solutions, and the role of other actors in this regard. Instead of the transfer of research outputs into society, visions at T₁ reflect the translation of visions of alternative solutions into a society that eradicates pesticides. Hence, this reflects an active role for other actors. Therefore, a key step in this translation process – and thus in the expected contributions of research to a society without pesticides – is envisioning the constitution of such a society. At T₁, the researchers envisioned what transformations are required in society to enable the eradication of pesticides with the alternative solutions. As I illustrate, this demonstrated a change in visions from the mere focus on the

responsibility of researchers to contribute to the eradication of pesticides, to visions of responsibilities for other actors to enable the development and implementation of the alternative solutions.

In Chapter 5, I discussed the two Obligatory Passage Points (OPPs) of the responsible translation in this mission-oriented context. These identified OPPs illustrate that the contributions of the alternative solutions that are being studied to the eradication of pesticides in society go beyond the responsibility of the researchers. Other actors in society have major responsibilities attributed by the researchers as well to enable the development and implementation of the alternative solutions to pesticides (i.e., societal transformations). This requires these actors to change the way they act in the future to enact the societal transformations. Hence, this illustrates that for researchers to contribute to the societal mission, it requires them to anticipate their visions of a society that is enabled to eradicate pesticides with the alternative solutions, and particular the changes this requires. In other words, the expected research contributions to the mission are embedded in the visions of society without pesticides - and thus when the contributions to impacts and transformations are envisioned, the 0-pesticides society is co-produced with it.

To provide an example, a researcher from MoBiDiv explained during the ASIRPA RT workshop their expected contributions to farm diversification through breeding activities for seed mixtures as follows [*translated from French^{cx1}*]:

In order to achieve transformations towards a diversification of agriculture and practices, with a modification of crop rotation and cropping systems, [requires] new technical itineraries. And, to achieve this upstream transformation, a transformation of reference production activities on the qualities of the mixtures is needed. [...] But the second part of the work that we have identified is rather everything that involves the identification of very genomic regions, plant ideotypes, tools that can be used in breeding, a certain number of which can be used by breeders, whether they are breeders in the traditional sense of the term or networks of farmers in participative breeding. And also, the organisations that supervise breeding activities, such as the CTP and GEVES, and these outputs used by these actors should allow transformations within the breeding activity, both through selection schemes adapted to the mixture, and therefore a modification or diversification of the selection objectives, a selection of varieties and species specially adapted to the mixture or selected in a mixture and a selection strategy for more local environmental conditions.

Consequently, as this quote illustrates, at T₁ the researchers envisioned their contribution to the eradication of pesticides beyond the transfer of their research outputs into alternative solutions. Instead, the translation process of research into a 0-pesticides society embeds transformative change in society, which are in the case of MoBiDiv situated around breeding activities. Hence, these transformative changes are key to be envisioned by the researchers, to understand what the

contributions of other actors could be and to be able to anticipate their involvement in the 0-pesticides mission.

Mobilisation requires coupling science and innovation through the process of translation

In their anticipation of these visions of societal transformations, the researchers went beyond exploring the scientific performance of the alternative solutions as described at T_0 . Instead, they focus on responsibilities they envision for other actors concerning the development and implementation of the alternative solutions to pesticides, and thus their large envisioned roles for the mission. For instance, the PI of MoBiDiv discussed their developed IP during the workshop, by explaining that [translated from French^{cxii}]:

We have also identified a large part of the impact on the economic dimension with the evolution of the professions, so the evolution of the breeding professions, the evolution of the advisory professions, the seed production site. So here is the emergence of new offers, new products, including diversified products, mixed seed offers, advice on mixtures must study new economic models for financing research and also, at the downstream level, a transformation of the sectors with new products, new outlets for production, the use of diversified production.

As this quote highlights, for research to contribute to the eradication of pesticides is not the mere result of the transfer of research outputs to ‘beneficiaries’. As I elaborated in Chapter 5, it requires transformations across five interdependent poles: market, technology, user context, policy & regulation, and science & education. The importance of such visions of societal transformations was highlighted by a researcher of SUCSEED during the workshop [translated from French^{cxiii}]:

This is surely one of the most blocking factors, the regulatory aspect. So what? Afterwards, if there is a way to discuss with people who can then make things progress, at least discuss it. The concern is to have the right people to talk to and to see what means might be available in the long term. Not necessarily in the short term, because that's not in the long term, to try to make things move forward and, if necessary, to remove a few obstacles without necessarily removing them, because even if I'm very optimistic, I'm not sure that it can be done within six years.

In the case of SUCSEED, regulations can be a blocking factor to the project's expected contributions. They study alternative seed technologies with a biocontrol treatment. Currently, such seeds cannot be registered in France, and thus not be marketed and used. Hence, for these researchers, constituting a 0-pesticides society requires a transformation of the seed registration system. If not, it can be blocking the translation process from their research on seed technologies to society that is able to eradicate pesticides with these seeds. This illustrates that research contributions to the eradication of pesticides go beyond the transfer of research outputs to other actors. Instead,

as this quote illustrates, it requires them to anticipate transformative change in society – and thus to anticipate responsibilities of actors to contribute to the mission.

To conclude, researchers' visions of how they expect to contribute to the eradication of pesticides with their research projects on alternative solutions illustrates a change in visions from: 'a scientific way of approaching a 0-pesticides society' (T_0) to 'a 0-pesticides society that is co-produced with the researchers' expectations of their contribution to the eradication of pesticides' (T_1). This reflects a change in emphasising their responsibilities for the mission as PPR-CPA researchers, to anticipating the responsibilities of other actors for the mission (I will build further upon this in the following two sub-chapters). Where the first reflects visions of the constitution of a 0-pesticides society from a scientific point of view, in the second active roles for other actors are envisioned in the eradication of pesticides.

At T_0 , responsibilities for the actual eradication of pesticides in society are hardly envisioned, instead focus is on excellent science and the transfer of outputs to actors in society. This reflects a straightforward use and interest of alternative solutions in society. For instance, the projects aim to study the potential performance of the alternative solutions in pesticide-free production systems. While this teaches us about the functioning and efficiency of alternative solutions, this is not highly explanatory of the expected contributions to the constitution of a 0 society without pesticides. In contrast, the responsible translation process illustrated at T_1 , embeds researchers' visions of required societal transformations, and visions of actors' responsibilities to enact these transformations. This reflects change of how actors are expected to act in the future to enable the development and implementation of alternative solutions to pesticides in society. This emphasises the envisioned constitution of a 0-pesticides society that the researchers anticipate with their research on alternative solutions. In the next two subchapters, I will be building further upon this, by illustrating how responsible translation is about anticipating actors' responsibilities in heterogenous networks.

7.2 How to impact society with research on alternative solutions

Mission-oriented research, such as in the PPR-CPA, has to go beyond scientific excellence, but aiming to contribute in impacting society with their research projects as well. In this section, I highlight a change in visions concerning the expected contributions to impacting society with their research on alternative solutions between T_0 and T_1 . Building further upon the results of the previous section, I have highlighted how visions of a 0-pesticides society are co-produced with the expected contributions of the researchers to the eradication of pesticides. This showed how research is part of society, and that research contributions to a societal mission not only embeds responsibilities for researchers, but also for other actors. These envisioned actors' responsibilities by the researchers,

reflect how they are expected to enact societal transformations in five interdependent poles. These transformations are essential to enable the development and implementation of the alternative solutions, which requires these actors to change how they act in the future.

These visions became visible to the researchers when they were asked to make explicit their visions of societal impacts. As the researchers illustrated (Chapter 5), impacts were considered as the potential benefits to society of the alternative solutions. This was envisioned as the societal consequence of the development and implementation of the alternative solutions. And thus, when the contributions to impacts and transformations are envisioned, the researchers' visions of 0-pesticides society is co-produced with it. Therefore, in this second section, I discuss a change in how the researchers envision benefitting society with their research on alternative solutions.

7.2.1 Mobilising impacts to society through excellent science

At T_0 the projects mainly expected to benefit society in terms of the societal challenges the mission represents: impacts as a result of the eradication of pesticides. Such benefits reflect rather general societal impacts as the result of an agricultural system without pesticides. They are not necessarily envisioned in a project specific way, as the result of the specific alternative solutions. The following two quotes are from the PIs of SPECIFICS and SUCSEED. They are a response to the question during the T_0 -interview how they expect to contribute to changes and impacts in society with their research projects. The PI of SPECIFICS responded as follows to the question:

And one objective of the WP3 is to find within the three thousand farms in France [red. Dephy farms] to find some farms that are economically performant but that also produce a high amount of protein. And so, for sure, by the end of the project will be able to identify which are these farms and what are the determinants of their performance. So, I think that through the short term we will be able to assess also this part. Then, try to use this knowledge in the long-term perspective to redesign the system and see how the farmer that are not as performant as the targeted system can move towards this. To the redesign at the country scale, for instance, the redesign part is with the long-term perspective, but with the short-term perspective is more the assessment of the performance of the system.

In addition, the PI of SUCSEED replied to the question:

It will be probably changing practical use. So, as I said... I mean post-harvest there is seed treatment, you treat with fungicides. The idea is to stop that treatment right now. So that's a first change, right. So instead of doing that we are hoping to...so either you change the practice when you grow your plants, right. So, during the seed development. So really during the growth period, pre-harvest.

These two quotes illustrate how the PIs reflected on how they expect to impact society, when other actors change their practices to use the alternative solutions. Hence, similar to the discussion in

sub-chapter 7.1, it largely reflects the responsibilities of the researchers to study the performance of alternative solutions to pesticides. For instance, the proposal of FAST emphasises: *“it is necessary to provide a precise and reliable quantitative answer to the question of the impact of pesticide reduction on the different sectors of the economy and at different scales”*. In addition, the project proposal of SPECIFICS states:

An original feature of the proposed scheme is to analyse the impacts of changes at different times in the transition to pesticide-free conditions, and to compare, for different situations of systems in transition, the trade-offs between agronomic (productive performance), agro-ecological, environmental and socio-economic performance criteria.

So, rather than a pathway to contribute, the researchers aim to study societal impacts as the quantitatively assessed performance of the eradication of pesticides with the alternative solutions to pesticides; or in other words: to provide the scientific proof of the performance. This does not reflect how to obtain such impacts, but rather how they aim to provide scientific analysis of the potential performance of the alternative solutions if used in society. This assumes the responsibility by the researcher to scientifically assess the performance of the alternative solutions, and thus how actors would benefit from the eradication of pesticides as a result of the alternative solutions.

7.2.2 Mobilising impacts to society through envisioning responsibilities of other actors

At T_1 , the researchers were guided to make explicit their visions of societal impacts that the mission represents. These impacts are envisioned as the societal consequences of societal transformations, and thus the result of actors assuming responsibilities to enable the development and implementation of alternative solutions in society. In other words, it reflects the benefits to a society that is able to eradicate pesticides with the alternative solutions, and is in this way the result of responsible translation from visions of a future society that eradicates pesticides.

In Chapter 5 I have discussed these impacts, through the five dimensions of ASIRPA (economic, environmental, policy, health and social). Examples of such impacts are for instance the increase of economic profit to companies or farmers, the increase in social connection and networking among farmers, or the evolvement of policies that support the transition to pesticide-free systems. To provide a specific project example, SUCSEED focusses on seed technologies (biostimulants), and the follow quote from their IP narrative explains how they expect to impact society [*translated from French^{cxiv}*]:

The development of the biocontrol/biostimulant market and the adoption of new seed production methods should generate job creation and enable farmers to become independent of chemical pesticides thanks to the involvement of experimentation networks (ITA, DEPHY, agricultural service providers, cooperatives, etc.) as well as industrialists,

specialised companies and seed companies. These societal impacts are closely linked to economic and environmental impacts. Indeed, the development of these innovations could generate significant economic gains and the development of companies (e.g., start-ups, mergers and acquisitions, extension of internal activities), which will surely lead to greater competition between companies positioned on the seed and seed treatment market. From an environmental point of view, this deployment will result in a reduction or even cessation of the use of conventional pesticides (fungicides) by farmers and therefore a reduction in the environmental damage linked to the use of these products.

As this illustrates, in contrast to T_0 , visions of societal impacts are project specific. They are not the mere result of the eradication of pesticides, but the benefits to actors when they contribute to the development and implementation of the alternative solutions. In this way, visions of impacting society with the alternative solutions embed a co-responsibility between researchers and other actors in their specific roles, which needs to be translated to be enacted.

Co-responsibilities in the societal mission

Compared to visions at T_0 , at T_1 the contribution to society, which is able to eradicate pesticides and benefits in this regard, is no longer seen as a linear process of the transfer of research outputs. Instead, it requires the researchers to anticipate various actors to assume responsibilities in the translation process, which is the result of associations in heterogenous networks (in the next sub-chapter 7.3 I build further upon this). Societal impacts are not envisioned through a purely scientific lens, but are project specific results of the associations between actors in heterogenous networks.

At T_1 , the PPR-CPA researchers are guided to reflect on the IP from research to impact, which also includes the intermediary context. In envisioning their contributions to societal impacts, they reflect on who is needed and what should be in place to achieve this. It thus reflects visions of co-responsibility between various for the societal impacts, which the mission represents. This is particular important as contributions to this societal mission, requires long-term thinking. Particularly as there will be a gap between the end of projects, and when the impacts will become visible, which might reflect a period between 10 and 20 years (Matt et al., 2017). This is for instance indicated by the PI of PheroSensor, who claimed that [*translated from French*^{cxv}]:

This is our project, it is longer term, it is more ambitious, it is... I would like to say it is riskier. But it also responds to the call for projects, which was for the long term, which required changes, paradigm shifts. It's really a breakthrough project that will certainly take time to materialize, 2030 is really the short term for this project.

Hence, these reflections of the long-term ambition to eradicate pesticides embeds visions of responsibilities of the researchers in their contribution to the mission, as well as that of other actors. However, the researcher also indicates that it was the call who made them think about the longer

term, and so the first ideas already started before T_0 . Beyond the role of science, the researchers showed awareness about the need to anticipate interaction with other actors, even though such reflections showed to be challenging at this early stage of the projects (T_1). Where the envisioned societal transformations were quite well defined at T_1 , the specific identification of actors who are expected to enact these transformations remained still relatively limited, and reflect rather general actor groups. This is for instance indicated by a researcher from MoBiDiv [*translated from French*^{cxvi}]:

What does that mean? That it's the breeders, the participatory selection networks, the contract sorters, the seed production team, the agricultural advisers and the technical institutes. And it is the public agencies and policies, so the agencies that implement regulations, some of which are partners of the project. But for me, whatever the final scenario will be, it must move on all these actors anyway.

Although at T_1 the identification of actors is not highly detailed yet, as this quote illustrates, the embeddedness of research in a network with other actors with responsibilities for the societal mission became more visible compared to T_0 . To provide another example, PheroSensor is able to develop a 'proof of concept' of their pheromone sensors within the six-year timeframe of the project. A project' researcher claimed that [*translated from French*^{cxvii}]:

We will demonstrate that we are capable of upscaling, i.e., that we have a manufacturing process that is compatible with mass production, but in no case, we will do it. Whether it's ESIEE, the CUA or INRAE. We are not intended to produce. We don't necessarily have the tools of control, quality, etc., that are adapted to this and it's not something that we can do. We don't have the tools for control, quality, etc., which are adapted to this and it's not our role. So, we will have to make a technological transfer. The objective is to transfer something, let's say ready-to-use or close to it, via a few adaptations that can be produced. But it will in no way be our role, nor that of ESIEE, to have a global approach to the production of sensors.

Hence, upscaling the Technology Readiness Level (TRL) of their sensors requires other actors to further develop and produce the sensors. It illustrates responsibilities of other actors with whom they must interact. However, at this early stage, their visions of this interactive process are still rather limited. They have not identified the specific actors that they expect to assume this responsibility, nor do they envision how to anticipate their associations in the network. This highlights the importance of the continuation of ASIRPA RT activities to make such visions visible.

Other researchers show similar reflections on the expected contributions to the mission, as part of a large network to perform visions of the responsibilities they hold in their role as researcher, as well as the roles and responsibilities of other actors with whom they must interact. But they also reflect on the difficulties the researchers faced in this regard, particular considering the early stage of

their research projects. For instance, SPECIFICS reflected on future advancements of their genetics research for the breeding of legume varieties. In their case, new breeding techniques are needed to develop new varieties more quickly, which is according to the researchers still resisted today in society. Although this issue goes beyond the responsibility and capacity of their project, the researchers aim to contribute to the development of the tools and technologies – even though society is not yet constituted in a way that is receptive to their technologies. Similarly, in the case of PheroSensor, the researchers do not yet know who the specific actors are and the anticipation of their responsibilities was thus rather limited at this early stage of the project.

Another example I would like to illustrate is from FAST, in which a researcher reflected the following during the workshop [*translated from French*^{cxviii}]:

But if we take, for example, the game that we are going to design with a participatory method, with the multiple actors, so the cooperatives, the agri-chemists, the farmers' unions, we will have done our part, i.e. we will put it in an open source. Everyone will be able to use it. The cooperatives, we know that there are already some cooperatives that we have co-constructed, that will use it. Some teacher-researchers have contacted us to use it, but it is certain that for upscaling, it is no longer us. That is to say? We have made the tool available. In fact, the instructions for use. We are ready to go and present the tool to anyone who wants it. Afterwards, it's up to them to mobilise and play with it. But that is not up to us.

Hence, FAST aims to anticipate the assumption of responsibilities by other actors with a game they are developing by adopting a participatory approach. This quote highlights their rather clear visions of the expected contribution of the tool in realising associations between the researchers and other actors that are meant to use the tool. However, at the same time, the actors are not identified in detail. It also reflects the vision of a rather straightforward interest of actors in their tool, and they expect to be contacted by the actors who want to use it. To an extent, they seem to shirk responsibilities in the mobilisation and upscaling of the tool.

Research is embedded in heterogenous networks

That such reflections on the anticipation of responsibilities of other actors are difficult is clearly illustrated by a researcher from BEYOND during the workshop [*translated from French*^{cxix}]:

I had a bit of a question, a concern about this, a bit naive, but I do not feel completely at ease about the degree of impact we have had in relation to the image I had of the project and our skills, in the sense that we are going, we are going very far. Talking about public policy actors of the Technical Institute, I have a vague knowledge of having worked with them and therefore, I don't feel personally very comfortable with it, but more than that... The BEYOND project didn't seem to me, seems to me fouler if you like than all that. And as a result, I wonder if, at times, we're not a bit out of our depth because there are impacts of

the project that we haven't looked into, that would be more direct and more modest impacts. And there, we got involved in ASIRPA. As for me, I see more SHS perhaps and in the longer term, and I feel a little out of my depth.

The difficulty after the paradigm shift, if you like. The move to scale 3, if I can manage to discuss with all this punctually on my data and to share a certain number of things to be put in place. A little thing on a particular case of my data. Then, if I want to move to a level where I'm going to make the EFSA platform and PSV collaborate, for example, I'll need much more political and strategic decisions than what I was able to do with my counterpart opposite. And it's this level, I think that we're going to have difficulties because it seems to me that in the project, we don't have this vision.

The quote illustrates how ASIRPA RT accompanies the researchers in envisioning their projects' contribution to the mission. It shows that knowing who to involve, and how to involve those actors, requires the researchers to envision societal transformations and impacts of the alternative solutions they study. In addition, involving actors requires more than (technical) research outputs, as is indicated by this researcher, it also requires political and strategic decisions. This, in turn, might require interaction with other actors to achieve such decisions. Hence, through the intervention of ASIRPA RT, the researchers made visible a more detailed imaginary of a society that eradicates pesticides, as the result of responsible translation. This allowed them to define responsibilities for the mission of various actors, as the result of interactions in heterogenous networks. Although, at this early stage of the projects, actors are identified as nodes in the network, their associations – and thus the anticipation of their responsibilities - are still rather limited. I build further upon this in the next section.

To conclude, visions of how society is expected to benefit from the research projects on alternative solutions, illustrates a change from: 'the scientific analyses of the multilevel performance of alternative solutions to benefit society' (T_0) to 'the benefits of society as the result of shared responsibilities between researchers and other actors in enabling the eradication of pesticides' (T_1). At T_0 , researchers emphasised scientific analyses of the alternative solutions to eradicate pesticides in 'real-life' situations, to assess the multi-level performance for society (e.g., economic, agronomic or technological performance). Instead, at T_1 , responsible translation from visions of alternative solutions into those of a society that eradicates pesticides with these solutions, emphasised co-responsibility between actors for the mission. As I will further highlight in the next section, this is the result of chains of translation in heterogenous networks. However, it should be noted, anticipation of actors in the network showed to be challenging at this early stage of their research. Nevertheless, the researchers started to reflect on the heterogenous networks in which their research is embedded.

7.3 How to enrol actors' responsibilities to enable the eradication of pesticides with the alternative solutions

The previous two sub-chapters highlighted how the expected contributions of the studied alternative solutions to the eradication of pesticides in society were largely defined as scientific questions in the T_0 -phase. In addition, the researchers demonstrated a rather scientific approach to understanding their contribution to a 0-pesticides society with the alternative solutions. Instead, at T_1 the researchers began to demonstrate how they take on responsibility for the envisioned contributions to the 0-pesticides mission. This was illustrated through a change in how their visions articulated the translation of their research on alternative solutions into a society that eradicates pesticides. It highlights their increased awareness of the embeddedness of their research in heterogenous networks where other actors are also responsible for delivering the mission.

As part of the translation process, in the previous sections, I have elaborated how a 0-pesticides society is co-produced with the researchers' visions of societal transformations and impacts. This made visible not only the responsibilities of researchers for the mission, but also the responsibilities of other actors to enable the eradication of pesticides. As discussed, this requires anticipation of the researchers, so that actors will actually assume these envisioned responsibilities. Therefore, in this current section I am building further on this, to highlight a change in visions of how the researchers expect to favour the acceptance of their research on alternative solutions by actors in society between the T_0 - and T_1 -phases. In the first case, it largely envisioned the role of (social) science to study the viability and acceptability of alternative solutions by actors in society. At T_1 , it builds further upon the envisioned responsibilities as discussed in the previous section, and how they result from chains of translations in heterogenous networks.

7.3.1 Mobilisation is not the result of scientific socio-economic studies

At T_0 , the researchers expect to favour acceptability of alternative solutions to pesticides by other actors in two main ways. The first is through participatory approaches in the input phase of the projects. The second is by studying the viability and acceptability of alternative solutions within dedicated work packages of the projects. Similar to the discussions of the previous sections, this also reflects a rather scientific way of approaching acceptability in society. In addition, it is largely envisioned as the role of social scientists to identify and define what is 'acceptable' and what society 'wants and needs', which reflects a 'research for society'-approach.

First, the majority of the PPR-CPA projects include participatory approaches in their research, such as MoBiDiv, Be Creative, CapZeroPhyto, BEYOND. This includes multi-actor processes like co-design workshops, action research or co-creation activities. By including these approaches, the

researchers aim to design, experiment and test innovations, farming systems, or tools that are adapted to the practical situation of actors, or to identify possible system lock-ins. Depending on the type of project, this reflects the involvement of other actors such as industries, breeders, cooperatives, extension agencies or farmers (through farmer networks). However, as the researchers show, these activities have a strong focus on the use of research outputs in the field. Such participatory activities are expected to result in scientific outputs, part of the transfer of research into society. Where the researchers aim to favour acceptability in this way, there is limited focus on activities that actually support acceptability nor that towards transformative change in society.

Second, at T_0 the researchers conduct research on the viability, acceptability and feasibility (e.g., willingness to pay) to favour the acceptance of alternative solutions, for instance in CapZeroPhyto, PheroSensor, FAST. Similar to the participatory approaches, such research activities are phrased as scientific questions. In addition, they are mostly envisioned to be conducted towards the end of the projects, and often involves social scientists' approaches. As discussed in Chapter 4, such studies reflect visions of the benefits to society, the costs for society, and the needs from society, and reflect the expected user context of the alternative solutions to pesticides. For instance, the PI of SPECIFICS explained during the T_0 -interview that they aim to analyse the profitability of legume-rich, pesticide-free farming systems:

There are some farmers that produce more protein and have the same, for instance, economic profitability as they have. So just to show them that there is no antagonism between producing high amount of protein and other viable, economically speaking, systems. And also find the factors that determine this this big challenge between production of high protein and economic profitability.

As this quote demonstrates, the projects include such a study, as the researchers expect that this scientific proof contributes to convincing farmers to change their farming practices. Such types of studies on feasibility and acceptability are particularly mentioned by researchers from projects who study technological solutions to pesticides, to help them select the technologies that users are expected to adopt. Also projects that do not study technologies themselves, but rather the impacts of technologies, do embed such studies. This is for instance explained in the project proposal of FAST:

The ultimate objective of our project is to effectively contribute to trigger and support a large-scale transition to pesticide-free agriculture that is both economically viable and socially acceptable. [...] They [researchers in a certain WP] will demonstrate that adoption of suitable production practices by farmers can significantly alleviate the impacts of drastic reductions in chemical pesticide uses on production levels and farmers' income.

Similar to the example of SPECIFICS, as well as examples from other projects, it illustrates that acceptability is aligned with the proof of the socio-economic benefits of the research projects. In addition, in the following example, the PI of SUCSEED explained their involvement of social sciences in the project and their envisioned role in prioritising the technological results of the project:

The way how we constructed the project is really to start with that. ... during the kick-of meeting, we have a 1-day discussion on that particular aspect. And the people from let's say the social or economic sciences, they really want to know what type of change you want to do on your product. I mean, just to understand...seeds: where are they coming from, for instance? The micro-organisms you want to apply externally or during the growth of your crops, and so on. In order really to understand at what point you want to make the changes. And from that they want to do the prospective study and I guess probably a couple of interviews with let's say seed growers, seed companies and consumers. And that will help, because...I don't know, maybe I am too optimistic, what I feel is that we have probably plenty of solutions from science, purely academic, and to me the most challenging part of the project will really be to have a decision tree or to have some priority. Because that will be almost impossible to release all these solutions in a field basis, that will be too many.

This quote illustrates that it is the envisioned role of social scientists in the project to study what other actors want in terms of the seed technologies they study. Even though such research activities reflect societal needs, they provide a response to scientific questions and result in scientific outputs. They do not necessarily reflect how to ensure that alternative solutions are actually accepted, and thus how to ensure the enrolment of other actors in the mission. Nor are they aligned with specific visions of transformative change that they expect from other actors to enact. This reflects a vision of the particular role of (social) scientists to define what users want. And in addition, that the researchers contribute to favouring acceptability when they can scientifically prove the efficiency of alternative solutions; i.e. if it is working according to science, there will be an interest by potential users.

7.3.2 Mobilising alternative solutions through chains of translation for raising interest and enrolling actors

The visions at T_1 are building further upon these research activities as reflected in the T_0 -phase. In line with responsible translation, the visions at T_0 could be considered as the scientific socio-economic studies of the interest of other actors. However, these visions of favouring acceptability reflect rather 'stand-alone studies' envisioned to contribute to the interest of actors. They do not highlight the chains of translation to interest and to enrol actors as at T_1 , and responsibilities of actors in this regard. The analysis at T_1 highlights that favouring acceptability is not just about the interest and capacity of other actors to adopt the alternative solutions. Favouring acceptability is no longer about the 'willingness' of actors to adopt the alternative solutions, but about enabling other actors to assume the envisioned responsibilities for them by the researchers for the mission.

As described in Chapter 6, at T₁ such visions reflect how the responsible translation process from research on alternative solutions to a society that eradicates pesticides, is envisioned to be performed through chains of translation in heterogenous networks. Hence, this network also involves intermediary actors who are responsible for the intersement and enrolment of other actors with envisioned responsibilities to enact societal transformations. This requires these actors to change how they act in the future, to enable the eradication of pesticides with the alternative solutions. This requires the researchers to envision the construction of heterogenous networks, by anticipating the association of intermediary actors with envisioned responsibilities for intersement and enrolment. The researchers highlight anticipating this for some responsibilities, through their research inputs and outputs phases. However, in the majority of the cases, ASIRPA RT helped navigating the researchers' visions of what is needed in this regard, but not yet the associations within the network. For instance, a researcher of SUCSEED reflected this as follows [*translated from French*^{cxix}]:

And in terms of acceptability. Afterwards, when we want to convince users that they should use these products rather than the products they are used to, I think we need to highlight the added value of these advantages compared to the few disadvantages that there may be. And [name] mentioned it on a post-it. And there are things that we still don't know much about, it seems to me, but [name] can contradict me, but it's the life span of these solutions. How long does it last? Because it will change things in the way we practice, something I put on another post-it. It has an impact on the way people will use them, perhaps in their usual practices. So, you have to think about all that when you want to convince or propose your solutions to users or farmers.

This quote highlights that if farmers are to accept to use the alternative seed technologies they study in SUCSEED – and thus to 'enrol' in the 0-pesticides mission by assuming their envisioned responsibility – the seed development has to be adapted to allow its use by farmers. It does not represent a scientific approach to understand what farmers 'want' or 'need', but rather a reflection of what is changing for farmers when they use the alternative solution, and what should be in place to enable this. In a similar way, a researcher from PheroSensor stressed [*translated from French*^{cxix}]:

If I may intervene, there are indeed things that can be put in place now because they will help us in the design of the sensor, such as [name], for example, allowing surveys to ensure stability. This is something that we need to anticipate and also have an idea of the price order. That a farmer is ready to put in good provisions because it can really guide the prototype if we see which farmer, it, is not ready to put more than 10 euros per hectare. This is an important constraint for us.

This researcher expressed that beyond the function of the pheromone sensor they develop (in terms of stability), it is important to consider the cost of implementation of their sensors by farmers. In addition to a scientific question, the researcher argues that these costs should be explored

in line with the willingness of farmers to make changes to pest management in their farming system. These two examples from PheroSensor and SUCSEED show how the researchers anticipate enrolling actors' responsibilities in their visions of the eradication of pesticides. However, as I illustrated, in many cases actors and their responsibilities for interestment and enrolment are also envisioned external to the research projects. For examples, this is the case for (non-)human actors who are considered responsible for enabling and valorising the use of alternative solutions to pesticides by actors. To provide an example, a researcher of CapZeroPhyto illustrated [*translated from French*^{cxvii}]:

Because I think, for example new variety up there, very good, but first, he proposed a new variety, there are huge constraints to varietal change. Because to sell a variety, you don't sell hazelnut, apple or apricot. You sell a variety and so you change one variety for another. You have to change the mindset of people who are no longer going to buy Golden or Granny Smith, but who are going to buy, I don't know what, a new name and so that means an impact... How can I put it, a commercial investment to launch a variety which is very important and it is a very strong brake on varietal renewal among farmers in the current marketing framework. There is marketing, that's what there is... the variety has to be carried somewhere as a brand. It's as if a new brand was being launched somewhere.

This researcher illustrates that new plant varieties require new marketing strategies if farmers are to use them, particularly in terms of branding. However, the researchers do not show to anticipate the development of such brands – and thus they do not show to associate this as a non-human actor in the network. Other examples relate to economic incentives, for instance in the form of subsidies or compensation measures for the transition to pesticide-free farming. Various researchers reflected on this, such as in FAST, MoBiDiv, SUCSEED and Be Creative, but do not show visions of how to anticipate such incentives.

So, at T₁ the researchers showed their visions of how they anticipate to interest and enrol actors with envisioned responsibilities to enable the development and implementation of the alternative solutions to pesticides. In some cases, the researchers anticipate this through their research input and output phases, while for other situations they envision such actor' responsibilities external to their projects. For instance, the IP narrative of FAST states [*translated from French*^{cxviii}]:

Their mission is precisely to collect research results on agricultural and environmental policy issues (CEP of the Ministry of Agriculture, DITP, France Stratégie, CGAAER). Where appropriate, they are already members of the expert committee that was set up at the time the project was set up to monitor its progress. For this type of interlocutor, the production of scientific publications will be accompanied by popularisation work in the form of policy briefs in French.

This example shows how FAST's researchers expect to raise interest and enrol decision makers in the policy solutions they are studying, through scientific publications and policy briefs. By including

them in the expert committee they anticipate the associations between the researchers, the policy briefs, scientific publications and the decisions makers. In this case it is about the main actors (policy makers) who are expected to change how they act in the future, which is in relation to their project' focus on policies to support the 0-pesticides transition. Like for the other projects, visions are in general clearer in such situations when the researchers have better identified the actors to enrol. Hence, this is the case for actors that are closer related to the topic of the projects, and/or when they have already collaborated with them in the past. However, as discussed in Chapter 6, the majority of the associations – that are realised through the envisioned responsibilities of actors - in the network are not envisioned in detailed yet at T_1 . This means that the networks are not yet performing the chains of translation. This is largely because the actors who are expected to change in the future, are not identified in detail yet at T_1 , and hence, this limits the visions of their associations in the network.

To conclude, change from a 'scientific approach to study acceptability' of the use of alternative solutions (T_0), to anticipating enrolling actors' responsibilities into the visions of the eradication of pesticides with the alternative (T_1). Hence, where favouring acceptability was just approached through conducting feasibility studies (e.g., willingness to pay, the study of viability etc.), it became also about anticipating intermediary actors with responsibilities for the interestment and enrolment of actors with responsibilities to enable the eradication of pesticides with the alternative solutions. This requires the researchers to anticipate the associations between different actors and their responsibilities in heterogenous networks to perform chains of translation.

Conclusion

To conclude this chapter, I illustrate how these changes in visions between the T_0 - and T_1 -phase reflect change of how PPR-CPA researchers take responsibility for the expected contributions to a society without pesticides. I showed a change from visions of the transfer of research outputs, to responsible translation by enrolling actors' responsibilities to mobilise alternative solutions as spokespersons of heterogenous networks. This change is synthesised in Table 14.

As discussed in the three sub-chapters, contribution to the 0-pesticides mission with the alternative solutions studied in the PPR-CPA projects, requires contributions of researchers as well as a variety of other actors, who all have responsibilities for enabling the eradication of pesticides in society. At this early phase of the projects, it reflects only the visions of the researchers of how they expect to mobilise the alternative solutions to pesticides as the spokespersons of heterogenous networks to perform chains of translation from research to a society that is able to eradicate pesticides. This reflects four constructive changes of how the researchers take on responsibility for the mission:

Table 14. A summary of the changed observed among the PPR-CPA researchers from visions of the transfer of research outputs, to the responsible translation process

Changed visions of:	T ₀ – Transfer of research outputs	T ₁ - Responsible translation process
1. The constitution of a 0-pesticides society with the alternative solutions	Focus is on blue-sky excellent science and the transfer of outputs to actors in society who will use it: reflecting a straightforward use and interest of alternative solutions in society	Researchers envision the necessary societal transformations, and actors' responsibilities to enact these transformations: reflecting change of how actors are expected to act in the future to enable the development and implementation of alternative solutions to pesticides in society
2. Impacting society with the alternative solutions	Researchers emphasised scientific analyses of the alternative solutions to eradicate pesticides in 'real-life' situations, to assess the multi-level performance for society (e.g., economic, agronomic or technological performance)	Researchers envisioned the co-responsibility between themselves and a heterogenous set of actors to enable the eradication of pesticides, and thereby to impact society. These other actors are not defined yet in detail at the T ₁ -phase
3. Enrolling actors for the eradication of pesticides with the alternative solutions	Favouring acceptability of the alternative solutions was approached through conducting feasibility studies (e.g., willingness to pay, the study of viability etc.)	Researchers anticipate the associations between different actors in heterogenous networks to perform chains of translation. The construction of these envisioned networks is based on visions of actors and their responsibilities for contributing to the mission

1. A future society without pesticides is no more envisioned from a mere scientific point of view of the performance of alternative solutions. Instead, such a future society is envisioned through the way it is expected to be constituted and how actors are associated to enable the eradication of pesticides with the alternative solutions studied in the projects.
2. A future society without pesticides is no more envisioned in isolation from the research projects on alternative solutions to pesticides. Instead, the researchers' visions reflect that their science and the envisioned society that eradicates pesticides are co-produced. To enable the eradication of pesticides, not only does research need to change to become more responsible for societal goals, other actors in society must change too how they act in the future.
3. A future society without pesticides is no longer envisioned as a linear process of alternative solutions from science to society. Instead, researchers envision the expected contributions to the eradication of pesticides in larger heterogenous networks with other actors, who are also envisioned to contribute in enabling the eradication of pesticides with the alternative solutions the researchers study. Hence, these networks are

envisioned to be constructed around actors' responsibilities for the 0-pesticides mission, to perform chains of translation to put into practice the alternative solutions.

4. Finally, a future society without pesticides is no longer envisioned through only blue-sky 'excellent science' on alternative solutions. Instead, the researchers showed their ability to conduct excellent science and direct it towards societal goals. I illustrated this as the process of responsible translation, to mobilise alternative solutions as the spokespersons of envisioned heterogenous networks. In other words, this process highlighted how contributing to the 0-pesticides mission is a collective process with other actors to enable the eradication of pesticides, which requires enrolling actors' responsibilities.

General Discussion and Conclusion

General Discussion and Conclusion

I'll say something and I think the members of ASIRPA will agree, anticipating it is also to avoid having the nose in the handlebars and having only the academic objectives in mind and forgetting everything else.

- **PI of PheroSensor during the ASIRPA RT workshop** [translated from French^{cxxiv}]

This quote illustrates a reflection from one of the PPR-CPA researchers on their participation in ASIRPA RT, and highlights that this PI has realised the importance of the formative evaluation exercises. It reflects that if they are to address societal challenges, their focus should move beyond blue-sky excellent science objectives, but consider the large societal context of their research project. By following the participation of the researchers of the PPR-CPA projects, I studied how the ASIRPA RT approach enabled researchers to envision their expected contributions to a future society without pesticides. Hence, I discovered how a formative evaluation approach like ASIRPA RT encourages researchers to take on responsibility for contributing to a societal mission through their research.

To synthesise, I compared how the PPR-CPA researchers envisioned contributing to the 0-pesticides mission with their research projects on alternative solutions, before and after the intervention of ASIRPA RT. I analysed this by comparing the researchers' visions between the T_0 -phase (before ASIRPA RT) and the T_1 -phase (after the first year of participation in ASIRPA RT activities), which I explored through four empirical chapters. First, I showed that the PPR-CPA researchers at the T_0 -phase envisioned contributing to the 0-pesticides mission by studying alternative solutions to pesticides, and how these visions influenced the construction of their projects. Second, at the T_1 -phase, I demonstrated that the researchers envisioned the expected contribution of the alternative solutions to the 0-pesticides mission, when ASIRPA RT helped them navigating their visions of societal transformations and impacts. Following, third, the researchers envisioned the construction of heterogenous networks of actors to enact the societal transformations, when ASIRPA RT helped them navigating their visions of the intermediary context. Fourth, I found that the PPR-CPA researchers' visions changed, from before their involvement in ASIRPA RT to after their involvement.

In this final chapter, I discuss and conclude my research findings and highlight how the notion of 'responsible translation' contributes to academic debates about Responsible Research, the Sociology of Translation and Responsible Innovation. I particularly emphasise what we can learn about the responsibility of researchers in a mission-oriented context, by demonstrating the inextricable links between responsibility, the process of translation and formative evaluation. This chapter is subdivided into four parts: In the first sub-chapter I discuss the main contributions of this thesis to the academic knowledge base. In sub-chapter two, I discuss the sociological implications of my research for

responsible research: responsible translation in a mission-oriented context. In the third sub-chapter I highlight my research limitations and future research directions. Finally, I provide final conclusions whereby I respond to the general research question.

1. The inextricable link between responsibility and translation: the contributions of the notion of 'responsible translation' and the role of formative evaluation

The PPR-CPA is an ambitious mission-oriented research programme, as a response to challenges in society, which have been caused by an overuse of pesticides. To take on responsibility by researchers who are part of this programme, requires them to envision associations between their research on alternative solutions and a society without pesticides. Hence, contribution to the mission required the researchers to envision the constitution of a 0-pesticides society and how they expect to contribute with the alternative solutions to pesticides. My results showed that ASIRPA RT helped the researchers in navigating such visions. I elaborate on how this contribution helps us to better understand mission-oriented research, and in particular, how science changes with society.

My research builds upon a conceptual framework that draws on the Sociology of Expectations (e.g., Brown et al, 2003; Borup et al. 2006; van Lente, 2012; van Lente & Rip, 1998), Actor Network Theory (e.g., Callon, 1986; Latour, 1984, 2005; Law & Urry, 2004), an understanding of role responsibilities (Vincent, 2010), and the four dimensional framework of RI (Stilgoe et al., 2013). I explored how the researchers construct envisioned heterogenous networks to perform the expected contributions of the alternative solutions to the mission. In this regard, I approach responsible research as the responsibility researchers assume for the construction of these future networks. I demonstrated that the network construction is based on their visions of responsibilities of themselves as well as other actors.

I developed the notion of 'responsible translation' in order to analyse the responsibility of the PPR-CPA researchers. Largely inspired by the work of Michel Callon (1986), I traced chains of translation in heterogenous networks. To do this, I focused on two unique situations of the 0-pesticides mission and the role of ASIPRA RT: 1) visions of a future society without pesticides; and 2) the performance of expected contributions to these visions in real-time. Responsible Translation thus describes the process of translating visions of alternative solutions into those of a society that has used these solutions to eradicate pesticides. Put differently, I explained how the researchers' responsibilities for eliminating pesticides become embodied by the alternative solutions. I described this process as the translation of visions in the following three phases:

1. Visions of establishing science-society associations through problematisation. This phase highlights the researchers' visions of the constitution of a '0-pesticides-society' to which

they expect to contribute with their research projects on alternative solutions to pesticides.

2. Visions of realising Science-Society associations through interessement and enrolment. This phase highlights how the researchers anticipate the construction of envisioned heterogenous networks to perform their expected contribution of the alternative solutions they study to a future society without pesticides, through chains of translations.
3. Visions of mobilising science-society associations in the mission. This phase highlights the constitution of each alternative solution to pesticides as a 'spokesperson' of the heterogenous networks to perform their expected contributions to the 0-pesticides mission.

Since I studied a change in responsibility of the researchers, the T_0 -phase represented an important step in this research in order to obtain a baseline measurement. Hence, in the first empirical chapter (Chapter 4), I explored how the researchers' visions of their contributions (i.e., alternative solutions to pesticides) to the 0-pesticides mission influenced the construction of the PPR-CPA projects. How did the researchers consider science-society relations before the intervention of ASIPRA RT?

At the T_0 -phase, the results show that the PPR-CPA projects demonstrate renewed and more ambitious scientific questions so to respond to the 0-pesticides mission. This illustrates the researchers' consideration of being part of a mission to eradicate pesticides, and not simply to reduce their use (like in the Ecophyto plan – see Chapter 1.3). However, the research proposals emphasise their focus on excellent science, which reflects visions of their contribution to the mission through a scientific way of knowing. This highlights a rather linear approach to the associations between science and society, as it shows visions of a straightforward interest, use and adoption of alternative solutions in society. Change in society is envisioned as the result of the transfer of research outputs into society. Hence, it reflects a rather scientific way of approaching a society without pesticides.

At the T_1 -phase, my results revealed the responsibility that researchers took on for the mission, through the analyses of the three phases of the responsible translation process. Each of the three phases represents an empirical chapter in the dissertation. In Chapter 5 and Chapter 6, I analysed the researchers' visions of the expected contributions of the alternative solutions to the 0-pesticides mission at the T_1 -phase. In the final empirical chapter (Chapter 7), I analyse a change in the researchers' visions between T_0 and T_1 in the responsibility they assume to contribute to the 0-pesticides mission.

In this first sub-chapter of the discussion, I demonstrate the contributions to academic literature of my research that explored responsible translation. In the first section (1.1), I discuss my contribution to the academic literature on responsible research, as I demonstrate that responsibilities are embedded in the process of translation. In the second section (1.2), I discuss my contribution to the academic literature on the Sociology of Translation and the four-dimensional framework of Responsible Innovation. I discuss this through my demonstration that visions of societal change become actors in the translation process, and that normative visions of responsibility need to be translated to be performed. In the third section (1.3) I discuss how ASIRPA RT contributed to operationalising the responsible translation process, and thereby responds to the knowledge gaps identified in Chapter 2. My results illustrated how ASIRPA RT, as a formative evaluation approach, supported the PPR-CPA researchers to navigate their visions, and thereby to translate their responsibility at T_1 .

1.1 Responsibilities in responsible translation: associating actors' responsibilities in envisioned networks

In this first section, I highlight the responsible translation that I explored throughout this dissertation, by demonstrating the contribution to the academic literature on responsible research. Responsible translation describes the process of translating visions of alternative solutions into those of a society that eradicates pesticides with these solutions. It emphasises the translation process that embeds visions of actors' responsibilities, as actants, in heterogeneous networks. The three empirical chapters (chapter 5, 6 and 7) describe the responsible translation process of the PPR-CPA researchers. These chapters thereby also describe what this means in terms of responsibility of researchers. In this part, I further deepen each of the three phases, which leads to this understanding that I illustrate at the end of this section.

Establishing associations between research on alternative solutions and a 0-pesticides society: shared responsibilities between researchers and other actors in enabling the eradication of pesticides

In the first phase of responsible translation (Chapter 5), my results show that the researchers envision establishing associations between their research on alternative solutions and a society without pesticides in this mission-oriented context. These visions were guided by ASIRPA RT, when the researchers were asked to make explicit the expected contribution of the alternative solutions to social impacts and societal transformations. Through this guidance, the researchers started to share visions of possible future societies. These visions reflect particular types of society that eradicate pesticides with the alternatives; i.e., how they envision the constitution of a '0-pesticides society' and what has to change in society to achieve this.

The results reveal that the researchers expect to eradicate pesticides - and to impact society – as a societal consequence of the development and implementation of the alternative solutions to pesticides in society. Hence, the expected contributions to a 0-pesticides society require transformations in society, to enable the development and implementation. This requires actors in society to change how they act in the future so to enact these societal transformations. I identified five interdependent poles in which these societal transformations are expected to take place: 1) market; 2) technology; 3) user context; 4) policy & regulation; 5) science and education.

This means that the Obligatory Passage Points (OPPs) in this societal mission are twofold. First, the eradication of pesticides requires the researchers to assume responsibility to conduct responsible research into alternative solutions to pesticides. Second, other actors are expected to assume responsibilities to enable the development and implementation of the alternative solutions to pesticides in society, which requires transformative change. These two OPPs demonstrate that researchers with other actors share responsibilities for enabling the eradication of pesticides in society. These shared responsibilities highlight that the expected contributions of the alternative solutions to the mission are embedded in the researchers' visions of society without pesticides - and thus when the contributions to impacts and transformations are envisioned, the 0-pesticides society is co-produced with it. In addition, the analysis demonstrates that the researchers envision four potential blocking factors to these OPPs, and thus to responsible translate visions of the mission: 1) Risks and techno-economic efficiency of alternative solutions to pesticides; 2) Policy and regulation of the alternative solutions; 3) Blocking Actors outside the processes; 4) Access to data for researchers and other actors.

Realising associations between research on alternative solutions and a 0-pesticides society:

Anticipating responsibilities for the interessement and enrolment of actors

In the second phase of responsible translation (Chapter 6), the results illustrate that the researchers envision realising the associations between their research on alternative solutions and a society without pesticides in this mission-oriented policy context. These visions were guided by ASIRPA RT when the researchers were asked to make explicit the intermediary context of their mission-oriented research projects. This highlighted how the researchers anticipate the construction of envisioned heterogeneous networks to perform the expected contribution of the alternative solutions to a 0-pesticides society. In particular it is based on the responsibilities they envision for intermediary actors for the interessement and enrolment of the actors that are hold responsible to enact the societal transformations, which requires these actors to change how they act in the future (as described in Chapter 5).

The results reveal how the researchers envision the construction of these networks. This shows considerations of how the actors are willing to and can change to enable the development and implementation of the alternative solutions, to eradicate pesticides in society. In other words, the envisioned construction of the networks is based on the envisioned responsibilities for different actors and their associations, to constitute a future society without pesticides. To achieve this, intermediary actors are brought in the heterogeneous networks with responsibilities to raise interest and enrol actors who should enact societal transformations, and thus with responsibilities for performing chains of translation through associations in the network. This is anticipated by the researchers in two ways.

In the first situation, the researchers anticipate three categories of intermediary actors that are associated to the research projects (input and output phases): 1) Convincing actors with demonstration and proof of the alternative solutions; 2) Adapting alternative solutions to actors' financial constraints; and 3) Building capacity of actors for the alternative solutions (e.g., skill development). In the second situation, the researchers anticipate two main categories of intermediary actors that are external to the research projects: 1) Enabling the adoption of alternative solutions to pesticides; and 2) Valorising the alternative solutions to pesticides. However, as it is about an analysis of the T_1 -phase, the researchers are still in an early phase of their research projects. They are able to reflect upon which actors they need to play specific roles in the future, but they are not yet able to anticipate how to construct those networks that extend beyond their projects. Hence, actors with their responsibilities are identified as nodes in the networks. But associations among actors that are based on their envisioned responsibilities are still missing. This means that at T_1 , the expectations are not (yet) performative, and thus research is not (yet) transformative

Mobilising associations between a 0-pesticides society and research on alternative solutions: a change in the assumption of responsibilities by the researchers to contribute to the mission

In the third and final phase of responsible translation (Chapter 7), the results illustrate that the researchers envision mobilising the associations between their research on alternative solutions and a society without pesticides in this mission-oriented context. These results were the outcome of the analysis of a change in researchers' visions of the expected contribution of the alternative solutions they study to the 0-pesticides mission between the T_0 - and the T_1 -phase. The results highlight how navigating the researchers' visions using ASIRPA RT contributed to the constitution of each alternative solution to pesticides as a 'spokesperson' of the heterogeneous networks. These envisioned networks are to perform the expected contributions to the 0-pesticides mission, and thus the alternative solutions become legitimate spokespersons of the associations between science and society. The translation that we observed is the movement from being interested only in the technical performance of the alternative solutions to a recognition of the future associations that need to be

made among the solutions and myriad actors in the network. If we explain this using the language of ANT, the emergent associations in the networks that ensure the use of the alternative solutions will have become stabilised. Put simply, we see movement from a technological fix to a future society that has used alternative solutions to eradicate pesticides.

Hence, the researchers showed a change from the 'transfer of research outputs towards society' (T_0) into 'the responsible translation of research on alternative solutions to a society without pesticides' (T_1). This was revealed through three changed visions of the researchers. First, it reflects a change from visions of a '0-pesticides society' from a scientific point of view, to one that is co-produced with the researchers' expectations of the contribution of the alternative solutions to the eradication of pesticides. Second, it reflects a change from visions of the impacts to society that are based on the scientific analyses of the multilevel performance of alternative solutions, to impacts as the result of shared responsibilities between researchers and other actors in society in enabling the eradication of pesticides. Third, it reflects a change from visions of favouring acceptability through a scientific approach to studying feasibility, to anticipating enrolling actors' responsibilities into the visions of the eradication of pesticides with their specific alternative solutions.

Hence, this results in the mobilisation of alternative solutions to pesticides as the spokespersons of the envisioned associations among the PPR-CPA research projects and actors in order to constitute a society that is able to eradicate pesticides. This reflects four constructive changes of how the researchers take on responsibility for the mission:

1. The expected contribution to a future society without pesticides is no longer envisioned from a mere scientific point of view of the performance of alternative solutions. Instead, such a future society is envisioned through the way it is expected to be constituted and how actors are associated to enable the eradication of pesticides with the alternative solutions studied in the projects.
2. The expected contribution to a future society without pesticides is no more envisioned in isolation from the research projects on alternative solutions to pesticides. Instead, the researchers' visions reflect that their science and the envisioned society without pesticides are co-produced. To enable the eradication of pesticides, not just research must change to become more responsible for societal goals, actors (e.g., regulations, markets, infrastructures) in society must change too how they act in the future.
3. The expected contribution to a future society without pesticides is no more envisioned as a linear process from science to society. Instead, researchers envision their expected contribution to the eradication of pesticides in larger heterogenous networks with other

actors who all hold envisioned responsibilities to enable the eradication of pesticides. The envisioned construction of these networks is around actors' responsibilities for the 0-pesticides mission, to perform chains of translation that put into practice the alternative solutions.

4. Finally, a future society without pesticides is no longer envisioned through only 'excellent science'. Instead, the researchers showed their ability to conduct excellent science and direct it towards societal goals. The responsible translation process illustrated this, through the visions of mobilising alternative solutions as the spokespersons of future heterogenous networks to perform a pesticides-free society.

The activities of ASIRPA RT have enabled the researchers to navigate visions of possible futures without pesticides. This has allowed researchers to moderate some of their transformative statements as well as to become more critical of their own responsibilities and capacities to achieve societal missions.

To synthesise what this teaches us for responsible research, my results demonstrate that visions of actors' responsibilities are embedded in responsible translation. Chapter 5 – the first phase of the process – describes the researchers' visions of societal change that would enable the eradication of pesticides, and the shared responsibilities between researchers with other actors in society to achieve this. Following the conceptual framing of my research, a change to society is the result of novel associations in heterogenous networks, which is described in the second phase in Chapter 6. Hence, this chapter highlights visions of actors' responsibilities and how this associates actors in envisioned reconfigured networks, as to enable the eradication of pesticides in society through chains of translation. Chapter 7 – the third phase - explores the change in researchers' visions from T_0 to T_1 , and thereby demonstrates that responsibility is embedded in the researchers' visions of change for the constitution of a 0-pesticides society. Society and science change together, and this change is represented by the alternative solutions studied in the projects.

Hence, researchers enrol actors' responsibilities into their visions of change of society to enable the eradication of pesticides, which is the outcome of associations in envisioned heterogenous networks. This means that the researchers assume responsibility when they associate these visions in the network, so that the alternative solutions can speak for the 'future' network that will put them into practice in the future society. I.e., responsibility is about associating actors in the networks through their envisioned responsibilities, which in turn perform (change towards) a 0-pesticides society. It is only then, once this has been completed, that the alternative solutions can legitimately speak for the network. This process is schematically outlined in Figure 20.

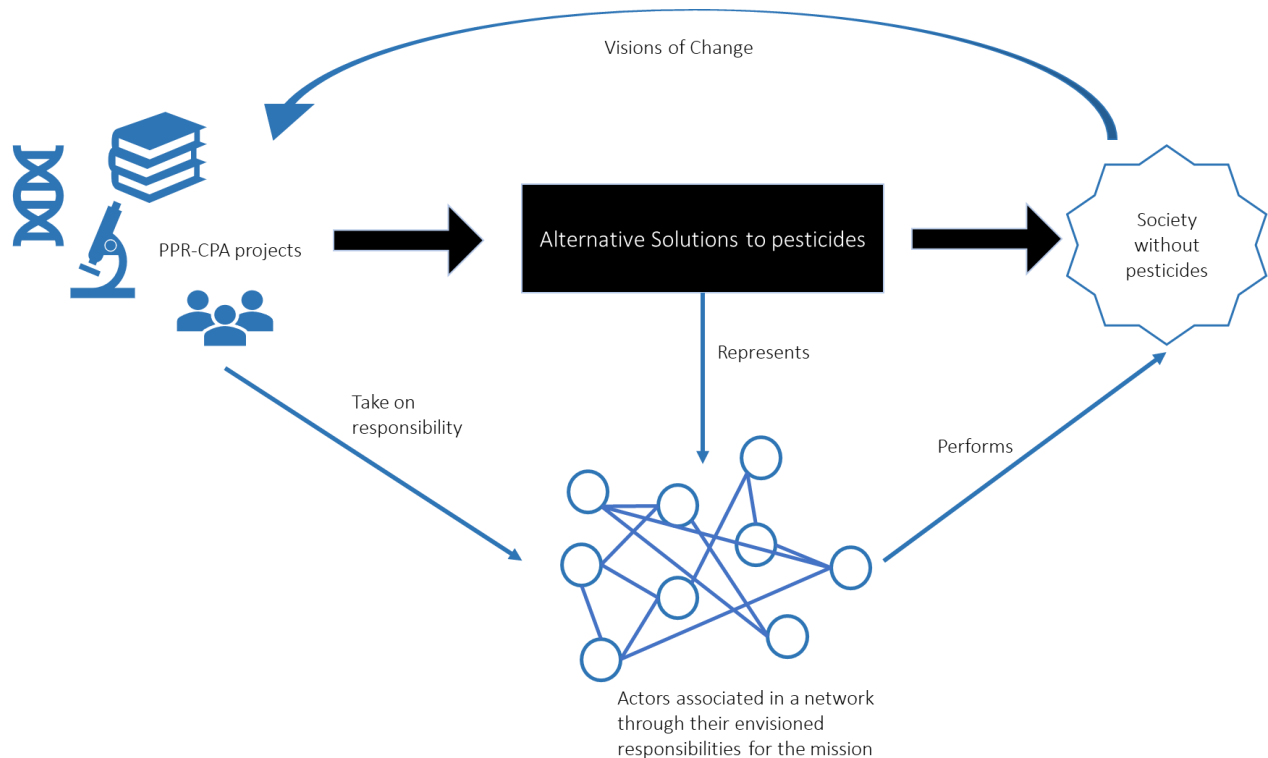


Figure 20. Schematic overview of how societal change gets represented by the alternative solutions studied in the projects

1.2 Normative visions of responsibility as part of responsible translation

Building further on the previous section - where I demonstrated how visions of responsibilities become embedded via responsible translation - in this second section I show how this contributes to academic literature on the Sociology of Translation and Responsible Innovation (RI). The mission-oriented and real-time context of my research contributed to adapting the translation process by Callon (1986). In particular, in assuming responsibility for the mission, the researchers associate actors in future networks based on the envisioned responsibilities of these actors. The four-dimensional framework of RI by Stilgoe et al. (2013) helps to understand the construction of the envisioned network – as normative visions of responsibility. However, my results demonstrate that these four-dimensions need to be translated to be enacted.

Throughout this thesis, I mobilised the notion of ‘responsible translation’ as a way to make sense of how researchers translate, in the sense of Callon (1986), their expected contributions to a societal mission. The need for this adaptation of Callon’s framework was made apparent through the real-time interventions that constitute the ASIRPA RT approach. As I interacted with the researchers, it became clear that the science-society associations that they were translating were not simply about their ‘engineering problems’, like that found in Callon’s example of the Scallops. Instead, they were dealing with this engineering type of translation as well as the translation of a particular policy instrument that is intended to direct their solutions towards solving a challenge in society. This made

me realise that I needed to adapt Callon's concept so to account for how the required 'responsibility' that researchers are supposed to assume became part of the translation process.

Consequently, the mission-oriented context of responsible translation highlights that chains of translation deal with the responsibilities researcher hold, as well as the roles and responsibilities of other actors with whom they must now interact if they want to achieve the mission. I demonstrate that science contributes with society, as researchers and non-academic actors change together to constitute a 0-pesticides society. In other words, as science changes and alternative solutions are developed, so does the society that must provide the conditions for its success. Hence, in this mission-oriented research context, responsible translation means that for translations to work – then the visions of the required societal change must also be actors in the network. In other words, rather than conducting translations where the researchers become the legitimate spokespersons, their alternative solutions to achieving the mission must become the legitimate spokespersons. The solutions, quite literally, need to speak for themselves. Here we are going far beyond Callon's scallops, we are entering into the realm where science is co-produced with society. But this society is not just something that is on the mind of a researcher, instead, society is understood as the associations that must be envisioned in the research and innovation networks if the given solution is to work in the future.

This conclusion brings us back to one of the conceptual starting points of this thesis: change in society is the outcome of associations in heterogenous networks. Therefore, responsible translation highlights that the researchers' visions of the associations among actors' responsibilities to perform a 0-pesticides society becomes part of this network too. Put simply, my results demonstrate that researchers take on responsibility when they associate their visions of actors' responsibilities with those of other actors in their future networks. It is thus in this way that visions of change become actors in the translation process.

I found this, as I studied the responsibility researchers assume in constructing envisioned heterogenous networks. My results demonstrate that these future networks consist of actors who are associated because of their envisioned responsibilities to perform a future society without pesticides. To better differentiate among responsibilities that act in the networks, I adopted the four-dimensional framework of RI by Stilgoe et al. (2013): 1) anticipation; 2) reflexivity; 3) inclusion; and 4) responsiveness (see Chapter 2.2). Stilgoe et al.'s framework provides normative values of 'responsibility' of researchers. Responsible translation showed that these values are captured in visions of change via new associations in the future networks. In this way, this framework of RI can be seen as normative visions of researchers' responsibility that should be brought in a mission-oriented research process. Hence, my demonstration of responsible translation shows that RI needs to be

translated to be actually enacted, and in this way, it brings in visions of actors' responsibilities for change into the heterogenous networks as well.

Hence, my results of responsible translation demonstrate that if formative evaluation is used, then the researchers are able to associate the actors, through the actors' specific responsibilities for achieving the mission. Hence, responsible translation is the ability to see the visions of their responsibilities and associations among actors in future networks to perform change of society. This process captures the four dimensions of RI, that need to be translated in order to be performed:

1. **Anticipation** is about R&I directionality and is, in this mission, about visions of possible future societies without pesticides to which the researchers expect to contribute with their projects' research on alternative solutions to pesticides. It thus represents anticipation by researchers of their expected contributions to the constitution of such an envisioned future society, and in particular anticipation of the transformative change in society this requires. In the case of the PPR-CPA, researchers anticipate the transformations required in society to enable the development and implementation of the alternative solutions; and thus, to enable the eradication of pesticides through the construction of heterogenous networks. In other words, researchers become responsible when they anticipate the envisioned outcomes of chains of translation in heterogenous networks.
2. **Reflexivity** is about the intervention of actors and institutions in this R&I directionality, and is in the mission about visions of roles and responsibilities of actors with whom the researchers must interact. It reveals the embeddedness of research in heterogenous networks with other actors around their proposed alternative solutions. The associations among actors in these networks change together to constitute a society without pesticides. In the case of the PPR-CPA, it is about how the researchers reflect on the responsibilities of other actors to enable the development and implementation of the alternative solutions that requires these actors to change (i.e., to enact the societal transformations). This is also about the responsibilities of intermediary actors for the intersement and enrolment of the other actors that are to enact societal transformations; i.e., reflexivity of actors and their responsibilities to perform chains of translation.
3. **Inclusion** is about involving actors in R&I processes, and is in the mission about visions of enrolling actors' responsibilities through establishing associations in the networks. This assumption of responsibilities is the result of interactions among actors (including research' actors) in the heterogenous networks. In the case of the PPR-CPA, it is about

constructing associations between actors (including the researchers) in the networks with the aim to enrol actors and their envisioned responsibilities in the 0-pesticides mission. Together these actors are envisioned to co-produce a society that eradicates pesticides with the alternative solutions; i.e., inclusion of actors through chains of translation.

4. **Responsiveness** is about the capacity to (re-)direct R&I pathways towards societal goals and, in the mission it considers the contribution of various actors – including the researchers themselves - at different points in time, to anticipate the chains of translations that might be performed by the networks. Responsiveness is thus about the capacity of the researchers to (re-)envision how to contribute with the alternative solutions to the mission over time, and to reconfigure the networks accordingly in real-time; i.e., responsiveness of changes in society through (re-)directing chains of translation. As the T₁-phase represent only the first attempt of the PPR-CPA researchers to construct an impact pathway, visions of this dimension were less present at this stage. In addition, at this point the networks only reflects visions of researchers, but as the ASIRPA RT continues to be used through until the end of the projects, anticipatory exercises will become more participative, including visions of other actors in society.

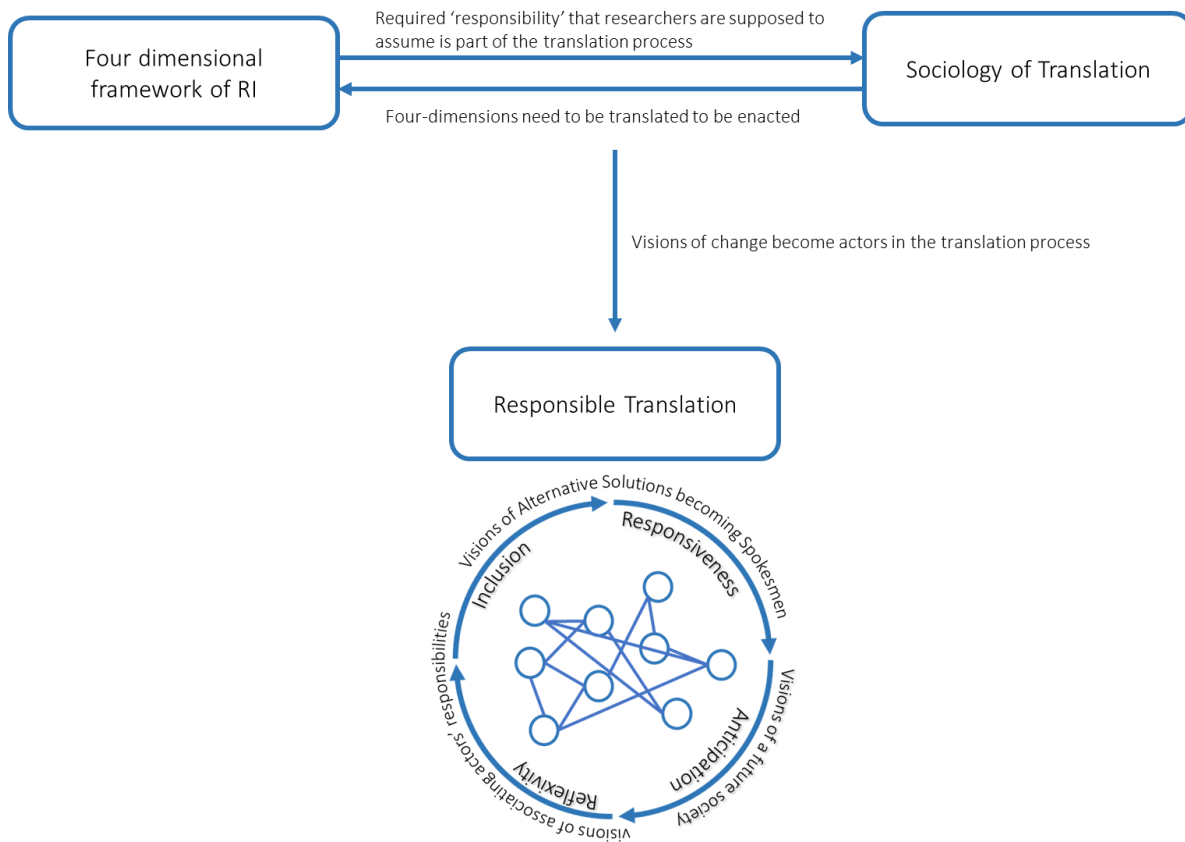


Figure 21. The inextricably interlinkage of the three phase of responsible translation and the four-dimensional framework of RI in the construction of future networks to perform visions of societal change (building further on Figure 20)

This highlights that these normative values of the responsibility of researchers – anticipation, reflexivity, inclusion and responsiveness – are captured in visions of actors' responsibilities for the 0-pesticides mission, that need to be translated. Responsible translation embeds this through visions of associations to perform chains of translations in the network and to enable the eradication of pesticides in society with the alternative solutions. It highlights that the assumption of responsibility by researchers in real-time in a mission-oriented context, is not a process with a fixed end. Instead, it represents an iterative process based on visions of possible futures and responsibilities to ensure that the alternative solutions contribute to the mission, which might change over time. The three phases of responsible translation form together this iterative process, and thus, the four dimensions of normative visions of responsibility it embeds should not be separated, but are instead inextricably interlinked. This is schematically outlined in Figure 21 (which build further on Figure 20).

1.3 ASIRPA RT as formative evaluation approach to support responsible translation

In the previous parts, I discussed the contributions of my thesis – and in particular the notion of responsible translation - to the academic literature on responsible research, responsible innovation, and the sociology of translation. ASIRPA RT – as a formative evaluation approach – helped navigating the PPR-CPA researchers' visions that are captured by this responsible translation process. Therefore, in this third section I discuss how the ASIRPA RT approach as a specific tool of formative evaluation encourages the researchers to take on responsibility for the 0-pesticides mission. Specifically, this highlights why there is the need for a formative evaluation approach like ASIRPA RT, to help directing research towards societal goals and bring in responsible translation in the research program. I.e., ASIRPA RT contributed to operationalising responsible translation.

On the operational level, in Chapter 2 I elaborated how the specific notions 'RI' and 'RRI' recently established as stabilised forms of knowledge or discourse about responsible research and innovation. As part of this exploration, I also identified various ongoing debates and challenges about these concepts – in particular in relation to RRI frameworks of implementation and institutionalisation in R&I processes. In this regard, my thesis contributes to understanding the operationalisation of responsible research in a mission-oriented context through the formative evaluation implemented by ASIRPA RT. These contributions highlight how ASIRPA RT contributed to the four knowledge gaps I identified in Chapter 2.1: 1) The lack of understanding how to support the responsibility of researchers in mission-oriented contexts; 2) the need for re-defining the associations between science and society; 3) the lack of coupling science, society and innovation; and 4) the challenges to the institutionalisation of responsible research in a mission-oriented context that need to be overcome.

The responsibility of researchers in mission-oriented contexts

My results show how a formative evaluation approach like ASIRPA RT accompanies the PPR-CPA researchers in navigating their visions of contributing to the societal mission with the alternative solutions they study. Hence, the 0-pesticides mission requires the involved researchers to assume responsibility in their role as scientists in the funded research projects. The knowledge they produce about alternative solutions has to become useable in society to enable the eradication of pesticides – and has thus to be translated into a society that eradicates pesticides. In this way, my analysis of ASIRPA RT in the PPR-CPA contributes to the academic literature by defining the ‘responsible translation’ paradigm in the mission-oriented context, which describes the process to mobilise science-society associations.

The ASIPRA RT formative evaluation approach contributed to a change in visions of the use of scientific outputs in society: from the transfer of scientific knowledge to responsible translation of scientific knowledge into a 0-pesticides society. Responsible translation highlights that responsible research is not limited to the research phase (research input and output), but includes the three phases of its translation process, which is based on visions of responsibilities of various actors. Responsible translation is adapted to include the complex context of mission-oriented research, which requires system changes, as well as the real-time situation to contribute to the future through the enactment of the envisioned networks.

These results might have particular implications for R&I policies with a transformative aim to address societal challenges, and the need to implement formative evaluation if researchers are to address complex challenges in society. Such transformative R&I policy approaches require the researchers to take on responsibility to contribute to change in the socio-technical system. Responsible translation emphasises transformative change in society as a result of the assumption of responsibilities by a variety of actors. Therefore, transformative R&I policies could benefit from embedding the three phases of responsible translation in research processes, and formative evaluation approaches to accompany researchers in this regard.

Defining the associations between Science and Society

Second, this dissertation illustrates how a formative evaluation approach, like ASIRPA RT, accompanies researchers to rethink their science-society associations. If the PPR-CPA projects are to address societal challenges caused by the use of pesticides, it requires visions of specific changes in society and the expected contributions of the research projects by exploring solutions to the problem. Hence, my findings illustrated how ASIRPA RT supported the researchers to envision the expected contribution of the alternative solutions to a particular type of society: a society that eradicates pesticides through the alternative solutions to pesticides.

Responsible translation highlights the importance of making explicit the visions of the societal transformations and the impacts that the mission embeds. Before the researchers got involved with ASIRPA RT, they approached a 0-pesticides society through a scientific way of knowing. The researchers' capacity to envision transformative change in society to enable the eradication of pesticides with the alternative solutions showed to be weak. Through their participation in ASIRPA RT they changed their visions of contributing to the eradication of pesticides through the alternative solutions they study. This moderated some of their transformative statements as they became more critical of their responsibilities in carrying out research as part of a societal mission. The expected research contributions to the mission are embedded in the visions of society without pesticides - and thus when the contributions to impacts and transformations are envisioned, the 0-pesticides society is co-produced with it.

This teaches us that responsibility for the mission is not just about the change of researchers' visions of the constitution of a 0-pesticides society, but also a change of other actors to co-produce this future society that eradicates pesticides. Society changes with the visions of science, and thus I demonstrated that science with society contribute to the societal mission. Hence, envisioning a future society without pesticides – and actors' responsibilities in this regard - defines actions and activities of the researchers in the present. In this regard, ASIRPA RT contributed to guiding the researchers in making explicit their visions of the change in society that is also needed.

Coupling Science, Innovation and Society

Third, my thesis illustrates how an intervention approach like ASIRPA RT contributes in coupling science, innovation and society. Discussions around responsible research have largely focussed on science and emerging technologies (such as nanotechnology), with a limited emphasis on innovation. My results reveal that the intervention of ASIRPA RT, as a formative evaluation approach, contributed to the responsibility taken on by the researchers as it made them envision the innovation systems or networks that embed their research projects. Through ASIRPA RT the researchers did not just approach alternative solutions as a scientific object of study, but as a potential innovation that should be developed and implemented by other actors to eradicate pesticides. This formative evaluation supported the researcher to understand the shared responsibilities between researchers and other actors to enable the eradication of pesticides in society with alternative solutions. Before they got involved, at T_0 , the researchers focussed on the roles and responsibilities of research for the mission. Hence, responsible translation illustrates the translation of scientific knowledge into potential innovations in society, and thus science-society associations are mobilised through innovation.

Creating an IP in real-time consists of three parts, and a retrospective type of reasoning, as discussed: 1) first, it includes a societal aspect through the visions of societal transformations and impacts, which the mission embeds and to which the projects expect to contribute. This is where visions of the active role of society to enable the eradication of pesticides became visible - by enabling the development and implementation of alternative solutions, and thus of innovations; 2) second, it contains a scientific aspect by outlining the input and output phases of the projects in relation to the mission; 3) third, it includes visions of performing a future society without pesticides through chains of translation in envisioned heterogeneous networks along the IP. It was during this development of their first IP that the researchers showed reflections of their embeddedness in the innovation system. It made them reflect on the associations between actors that are to perform the chains of translation – even though this was still rather limited at this early T_1 -phase.

This thesis showed how coupling science, innovation and society can be understood through responsible translation. This highlights that contribution to envisioned change for a 0-pesticides society is about anticipating roles and responsibilities of actors along the innovation pathway, through their associations within the network. However, it should be noted that at the T_1 -phase the researchers still face difficulties in defining what actors to involve and particularly when to involve them. They specified that they require their first results in order to better identify who and when to connect. Some actors are just identified as nodes in the network, but lack associations in the network, which might also indicate that to some extent researchers are shirking responsibilities at T_1 .

Overcoming challenges to the institutionalisation of responsible research in a mission-oriented context

Fourth, this thesis illustrates how a formative approach like ASIRPA RT provides a form of institutionalising responsible research in a mission-oriented context. I argue this because of two identified challenges in literature concerning the institutionalisation of responsible research, in particular of RRI in the EU. One of the challenges is the dichotomy between excellent R&I that is driven by market dynamics, and R&I that responds to societal goals. The second challenge is that responsible research frameworks, such as the RRI approach, are often implemented as add-ons or supplements to research processes.

First, ASIRPA RT accompanied the PPR-CPA researchers to navigate their visions of the expected contribution of the alternative solutions they study to the mission and the societal impacts this represents. Therefore, the focus of ASIRPA RT is to guide the researchers' visions beyond their contribution to excellent science, but to envision their contributions to transformative change in society; i.e., conduct excellent science and direct it towards societal goals. The results showed how their visions of impacts went beyond the negative consequences of the eradication to pesticides, but

was approached specifically as the societal consequence of the development and implementation of alternative solutions in society. It showed that researchers with other actors share responsibilities in enabling the eradication of pesticides with the alternative solutions. Hence, the researchers made explicit how to couple excellent science and societal impacts in the 0-pesticides mission.

Second, ASIRPA RT is implemented as part of the scientific animation in the PPR-CPA, with the specific aim to guide the researchers in envisioning their contributions to the eradication of pesticides. Through their participation in ASIRPA RT, the PPR-CPA researchers were challenged to change their visions of how to contribute to the problem of the overuse of pesticides in society. The researchers had to participate in the various activities, such as the MOOC and workshops, and develop a first IP. The active guidance of ASIRPA RT, through these activities, supported the researchers to make explicit specific visions of society without pesticides. However, in this thesis I only illustrated a comparison between the T_0 and the T_1 phase. We do not know how participation will be in future phases, whether the researchers continue to change their visions, nor to what extent it will eventually result in societal impacts.

In Chapter 2, through the literature on RI and RRI, I identified four possible contributions to overcome the challenges of institutionalising responsible research (e.g., Jakobsen et al., 2019; Novitzky et al., 2020; Owen, Pansera, et al., 2021; Tabarés et al., 2022). My results showed how these four elements are reflected in the change of visions of the researchers between T_0 and T_1 , and thus the contribution of ASIRPA RT to responsible research:

1. **The need for an evaluation or assessment framework** – ASIRPA RT is a formative evaluation approach, with a specific focus on the assessment of societal impacts of research in real-time.
2. **The need for adequate training** – Through the MOOC, webinars and workshops the researchers were trained to envision their responsible contribution to the mission. The researchers indicated that they require this guidance and help from ASIRPA, throughout the six years of their research projects. Particularly the identification of actors and their associations seemed to be challenging, still at T_1 .
3. **The support and adaptation from funding agencies and calls** – As ASIRPA RT is part of the scientific animation of the PPR-CPA, the participating researchers have access to the tools it provides. In this way, the researchers are challenged to study solutions to the ambitious societal mission, and they receive support from the programme in the form of the ASIRPA RT approach.

4. **The governance of research** – For the responsibility of the researchers for the mission, my results illustrated how their participation in the ASIRPA RT approach contributed to changing norms and values of the researchers. Even though T_1 is too early in the research process to identify an actual change in practice, the researchers did show that they reflected differently on the knowledge they envisioned to translate in society. In addition, the researchers strongly emphasised their contribution to the training of future research(ers) in the context of 0-pesticides research.

2. Sociological implications for responsible research: responsible translation in a mission-oriented context

My research, which explores responsible translation in the mission-oriented context of the PPR-CPA, brings to the fore interesting insights that inform sociological theories of responsibility and science-society relations. I structure this sub-chapter according to the three phases of responsible translation to discuss the sociological implication of the findings of this thesis research. Hence, in the following three sections I discuss: 1) a paradigm shift to a mission-oriented responsible translation (section 2.1); 2) co-responsibility in the mission-oriented responsible translation process (section 2.2); 3) ontology in the mission-oriented responsible translation (section 2.3).

2.1 Establishing science-society associations: a paradigm shift to a mission-oriented responsible translation process

My results reveal that the first step in responsible translation is envisioning research contributions to possible futures without pesticides. In terms of responsibility, this is thus about the constitution of the 'future society' to which the researchers expect to contribute with alternative solutions. At T_0 , this showed to be largely about the contribution of research to reduce the risks caused by pesticides use. In their research proposals, the PPR-CPA researchers elaborated the negative consequences of pesticides – like biodiversity loss or water pollution – and how they planned to respond to this with their research projects. This is in line with the argument by Strydom (1999) about the 'risk society', which states that 'responsibility' and 'risk' often occur together. And thus, that our visions of society and the responsibility of research in this regard link to 'risk'.

However, this changed at T_1 , when the researchers made explicit their visions of societal transformations and impacts, which the mission represents. This highlighted how the researchers expect to impact society through the alternative solutions they study in their research projects and the active role they envision for other actors. In this way, it tells us something about their paradigm of responsibility in a mission-oriented context. My results reveal that the researchers envisioned societal impacts in two ways, as a societal consequence of: 1) the eradication of pesticides to which

the research projects expect to contribute through the alternative solutions they study; and 2) the development and implementation of the alternative solutions to pesticides in society. The first point, which was only reflected in a limited way, shows a link to visions of responsibility to prevent or reduce risks from pesticides use in society. The examples given by the researchers are about a reduction of the negative risks of pesticides use in society; such as the negative effect on the environment (e.g., pollution), the reduction of residues on food products, or an independence of farmers from pesticides.

The second way – which reflected the large majority of the visions of societal impacts – highlights a more positive dimension. Societal impacts are envisioned as the societal consequence of the development and implementation of the alternative solutions to pesticides by other actors in society. Hence, in terms of their responsibility, the researchers aim for a 0-pesticides society, in which actors benefit not just by reducing negative effects (risks), but mainly by positively impacting (non-) human actors. Examples provided by the researchers are the increased income for breeders or farmers, increased cohesion among farmers in networks, or the evolution in regulatory frameworks. Such visions also embed the active role played by other actors, by enabling the ‘development and implementation’ of the alternative solutions as a condition for achieving these impacts.

Paradigms of responsibility

This thus shows a paradigm shift from T_0 and T_1 in the responsibilities assumed by the researchers, even though responsibility in relation to a ‘risk society’ paradigm remains in a limited way visible at T_1 . I align these results with the study by Arnaldi & Gorgoni (2016) that I already mentioned in Chapter 2.1. The authors discuss three paradigms of responsibility derived from Ewald (1993): 1) the paradigm of fault; 2) the paradigm of risk; and 3) the paradigm of safety. Eventually, the authors came up with the idea of a fourth ‘emerging, distinct responsibility paradigm’: the paradigm of RRI. Even though they do not extensively elaborate this idea, nor do they demonstrate it empirically, they provide four characteristics why this would work as a paradigm of responsibility: 1) Responsibility is oriented to the future; 2) Responsibility is proactive more than reactive; 3) Responsibility is a collective and participative process; and 4) Different levels of Responsibility are strictly intertwined.

The authors’ comparison of these four paradigms of responsibility are found in

Table 15. Where the responsibility paradigm at T_0 – and as discussed in a limited way also at T_1 – relates evidently to the paradigm of risk, my results showed a shift to a paradigm that might be in line with the fourth ‘RRI paradigm’. This paradigm-framework provides a good way to understand responsible research in a mission-oriented context through the anticipation of possible futures by researchers.

Table 15. Four paradigms of responsibility; extracted from Arnaldi & Gorgoni (2016)

Paradigm	Criterion of ascription	Mean of realisation	Target Outcomes	Dimension	Orientation in time	Responsibility dimensions
Fault	Liability	Sanction	Negative	Individual	Retrospective	Liability-responsibility
Risk	Damage	Compensation	Negative	Systemic	Prospective/ Retrospective	Causality-responsibility
Safety	Uncertainty	Precaution	Negative	Collective	Prospective/ anticipative	Capacity-responsibility
RRI	Responsiveness	Participation	Negative and positive	Collaborative	Prospective/ Proactive	Virtue-responsibility

In their paper, Arnaldi & Gorgoni (2016) distinguish six conceptual dimensions of responsibility, adapted from the taxonomy of responsibility by Vincent (2010) (see Chapter 2.1). In this thesis I talked about ‘role responsibilities’, as the other five dimensions would indicate a certain relationship between the ‘problem’ for which the researchers take responsibility (e.g., negative effects of pesticides use) and the researchers themselves (e.g., the cause of the negative effects). Instead, as Vincent (2010) argues, role responsibilities refer to “duties – to what a person should (not) or ought (not) to do” (p.2). So, the PPR-CPA researchers have a certain variety of duties in their professional role as part of the 0-pesticides mission, as well as other actors in their specific roles in agri-food systems.

Hence, to put this into dialogue with the (shift in) responsibility paradigms, Table 15 highlights that the ‘risk paradigm’ is related to ‘causal-responsibility’.⁹³ Even though this causal-responsibility suggests a certain recognition in the origin of the cause (i.e., negative effects of pesticides), Arnaldi & Gorgoni (2016) instead argue the following:

The idea of risk, and the mechanisms of risk management through insurance, have the effect to disconnect responsibility from fault, making indemnisation independent from liability. This view on responsibility rests on the idea of social solidarity rather than individual responsibility. It separates the idea of responsibility from those of action, author and fault, and it links this notion to alternative references such as an event, a victim and risk (calculation), leading to the paradoxical de-responsibilisation of the agent, as their contribution to the production of the damage is irrelevant for the compensation mechanism to operate. Compensating victims against damages, without any reference to somebody’s fault, prevails on sanctioning those who are ‘responsible’, whose influence on a specific,

⁹³ The authors define this as: “Causal-responsibility results from being recognised as the origin (the “cause”) of a particular event”.

adverse state of affairs becomes irrelevant according to this 'objective' logic of compensation (p.7).

So, in this situation that is largely in line with visions at T_0 – by disconnecting the researchers from the cause – the responsibility of the researchers can then be understood to reduce the damage caused by another actor: the pesticides. Hence the focus and anticipation lie in reducing the *negative* effects of pesticides use.

In contrast, I argue that the T_1 -phase is more in line with the ‘RRI paradigm’. However, my results do not fit neatly into the criteria established by Arnaldi and Gorgoni, which offers a chance to revisit this particular paradigm of responsibility with a rather unique empirical example. The result is what I call the ‘responsible translation’ paradigm of responsibility (Table 16).

Table 16. A comparison between the RRI paradigm by Arnaldi and Gorgoni (2016) and the Responsible Translation paradigm in the PPR-CPA; adapted to the authors’ framework

Paradigm	Criterion of ascription	Mean of realisation	Target	Dimension	Orientation in time	Responsibility dimensions
RRI	Responsiveness	Participation	Negative and positive outcomes	Collaborative	Prospective/ Proactive	Virtue-responsibility
Responsible Translation	Transformation	Association	Mainly Positive outcomes	Interactive	Prospective/ Anticipative	Role-responsibility

A new paradigm of responsibility in a mission-oriented context

First of all, in the RRI-paradigm, the authors refer to ‘virtue responsibility’.⁹⁴ My findings revealed that this is not expressed in the same way in the 0-pesticides mission of the PPR-CPA researchers. As I argued earlier, the responsibilities in the mission are better understood as ‘role responsibilities’. In the definition of virtue-responsibility, Vincent (2010) states that *“the opposite of calling someone ‘responsible’ in this sense is to call them ‘irresponsible’”* (p.16). This makes me wonder how to define ‘irresponsible’ or ‘unethical’ research, particularly in the mission-oriented situation of the PPR-CPA? Where Arnaldi & Gorgoni (2016) speak about “actors’ capacity of self-commitment towards some goals’, this is not the case in the PPR-CPA. The researchers are part of a mission-oriented programme, which is imposed on them, in the sense that the mission was created by the ministry,

⁹⁴ The authors define this as: “Virtue-responsibility implies a proactive engagement going beyond the compliance with an obligation mandated by the law. Whilst within the law clear reference is normally made to an ethics of (mere) compliance with the duty, the idea of virtue implies the reference to an “ethics of excellence” (Fuller 1969). Virtue responsibility, then, refers more to some valuable personal qualities of the agent”.

with the mandate to be 'responsible'. In addition, their participation in ASIRPA RT further emphasises their 'requirement to act responsible' as part of the 0-pesticides mission.

Second, I do find that the authors address a prospective/proactive orientation of responsibility in time, in this paradigm, about which Arnaldi & Gorgoni (2016) stated earlier in their paper:

Prospective responsibility therefore emphasises the (pro)active dimension of responsibility that is captured by the idea of virtue-responsibility. In this sense, the idea of prospective responsibility appears to be more complex than that of a duty as it includes dimensions that are typically ethical (as capacity, virtue, moral obligation) as well. In this active sense, responsibility implies actors' "responsibilisation". That is actors' capacity of self-commitment towards some goals which are not mandated by rules (legal or of other sort) (p.6).

In this regard, according to the authors the RRI responsibility paradigm is about "*steering innovation processes according to societal values and needs*" (p.9). However, in line with the previous argument, in the PPR-CPA the mission is already set. Within this mission, the researchers envision a particular type of society, which eradicates pesticides with the alternative solutions, and how they anticipate this 0-pesticides society. The results showed that the researchers envision shared responsibilities of (enabling) the eradication of pesticides in society between researchers and other actors. Hence, contributing to the mission is not just about the researchers' assumption of responsibilities to conduct research on alternative solutions. It is also about how the researchers envision responsibilities for other actors in society to enable the development and implementation of these alternative solutions, and the change this requires in the way these actors act in the future. As illustrated in phase 2 of responsible translation, the researchers need to anticipate the these responsibilities of the actors to enact the societal transformations. Therefore, I keep the 'prospective' aspect, but replace the term 'proactive' by 'anticipative'.

Moreover, in their description of the RRI paradigm, Arnaldi & Gorgoni (2016) argue the following: "*The priority is here on steering the innovation process from the inside towards societal goals rather than on coping with its (actual or anticipated) unwanted and unintended externalities*" (p.9). In this regard, my results show that responsibilities as part of the 0-pesticides mission are defined in relation to the roles of researchers and other actors. Indeed, the visions of the researchers and how they define their expected contribution to the eradication of pesticides shifted away from just thinking about reducing the risk of damage caused by pesticides. Moving R&I efforts 'towards societal goals' showed to be not only about changing to responsible ways of conducting research (e.g., adding complexity, ambitious questions, etc.), but about how other actors are envisioned to change

so that society can eradicate pesticides use, and benefit from the alternative solutions in this regard. In this way, responsibilities envisioned for other actors in enabling the eradication of pesticides, showed to be about enacting transformations in society; This requires these actors to change how they act in the future. Therefore, instead of speaking about responsiveness of researchers, the responsible translation paradigm is about transformations.

Finally, the dimension of the responsible translation paradigm shows to not be about 'collaborating', nor the 'means of realisation' to be about 'participation' (see Table 16). Instead, this paradigm of responsibility is rather about translation as a process of associating actors' responsibilities for the mission. The enactment of a future society without pesticides will be the outcome of the assumption of responsibilities by actors that are associated in heterogenous networks, and thus a result of chains of translation. The researchers anticipate the construction of these future networks by associating actors through their envisioned responsibilities. However, for science to contribute with society, we can question if it is enough to just envision the required new associations. To become transformative, participations and collaboration are elements that have to come in as well. Hence, responsible translation is an iterative process. Over time, in other iterations, the construction of the networks should not be based anymore on visions of the researchers only, but should progressively become based on a more participatory process.

A shift from the risk paradigm to the responsible translation paradigm

This discussion – the shift from the 'risk paradigm' (T_0) to the 'responsible translation'-paradigm (T_1) – explains three particular results in relation to the researchers' responsibility for the 0-pesticides mission. The researchers' visions about their contributions to the 0-pesticides mission – and the societal impacts and transformations this represents – shows a particular shift from T_0 to T_1 . It shifts from visions about contributing to the undesired societal consequences of **pesticides use**, to the desired societal consequences of **the alternative solutions**. In terms of anticipating a 0-pesticides society, this highlights the following three results:

1. The shift in anticipation of undesired to desired consequences could possibly explain the researchers' positive visions about societal impacts. The projects' IPs only highlight positive societal impacts. In addition, health impacts are rarely mentioned, which might be because it is largely related to risk.
2. This shift could be explained as an anticipation of the discrepancy between the short-term projects (six year) and the ambitious mission to eradicate pesticides. The timeframe and size of the projects is not sufficient to make a solid contribution to pesticides eradication. Hence, the researchers envision contributing to the mission by providing

knowledge (and prototypes etc.) about alternative solutions, which have to be developed and implemented by other actors who also benefit from the alternative solutions in this way.

3. This shift defines the researchers' visions, which consist of anticipating the associations between their research on alternative solutions and a society that eradicates pesticides with these alternative solutions. In this regard, the PPR-CPA researchers envisioned the contribution of the alternative solutions they study to a particular society with an active role of other actors: a society that is enabled to eradicate pesticides, for which researchers and other actors share responsibilities. Hence, these responsibilities are based on visions of how society is expected to be impacted by the alternative solutions, and the transformative change this requires in society.

2.2 Realising science-society associations: co-responsibility in the mission-oriented responsible translation process

My results revealed that the second step in responsible translation represents a phase of realising the science-society associations by anticipating the interestment and enrolment of other actors for the mission. Hence, it is about the responsibility that researchers assume - or potentially shirk – to include their visions of societal change in the envisioned networks, and thus embedded in chains of translation. As earlier discussed, change in society is the outcome of associations in these networks, and consequently, visions of change are about the associations of actors through their envisioned responsibilities to perform a 0-pesticides society with the alternative solutions.

At T_0 , the realisation of the associations between the research projects on alternative solutions and a society without pesticides were approached in a scientific way, without necessarily including reflections on responsibilities and involvement of other actors. At T_1 , the researchers were guided by ASIRPA RT to make explicit the intermediary context of their mission-oriented research projects. This reflects a shift in approaching the realisation of the associations between science and society as the result of an interactive process.

This change in visions of science-society associations in the mission can be considered in line with the rethinking of the role of science versus society in the EU's RRI policy approach. As I discussed in Chapter 2, this is described by Owen et al. (2012) and it can also be seen in the evolution of the RRI approach in the EU's research framework programmes from SaS, to SiS, to SWaFS. It showed an evolution from the idea of 'Science for Society' to more complex understandings of how science and society interact and co-produce each other. The scientific ways of knowing of a 0-pesticides society at T_0 , reflect visions of 'science for society' based on the idea that scientifically proving the benefits of

alternative solutions will contribute to eradicating pesticides in society. Even though at T_0 participatory approaches or studies about acceptability were already included, participation was largely envisioned simply as a means to deliver scientific outcomes. The idea that participation could also be a means to envision change in society and deliver societal outcomes was not articulated.

The T_1 -phase reflects visions in line with what Owen et al. (2012) called 'Reframing responsibility', which is about rethinking responsibilities and roles of other actors. This framing is no longer based on providing the scientific proof of the benefits of alternative solutions to pesticides for society. Instead, the impacts to society are envisioned as the consequences of the development and implementation of alternative solutions by other actors, which requires change in how actors act in the future to enable this. As discussed previously, the researchers made explicit these visions of societal impacts, transformations and the intermediary context thanks to ASIRPA RT. This made visible the responsibilities of actors to enable the eradication of pesticides with the alternative solutions.

This highlighted that envisioning actors' responsibilities for this mission represent two phases of responsible translation. First, it is about the responsibilities of other actors to enact the envisioned societal transformations to constitute a society that is able to eradicate pesticides with the alternative solutions. Hence, this requires these actors to change how they act, to enable the development and implementation of the alternative solutions to pesticides. Second, it is about envisioned responsibilities of other, intermediary actors to contribute in performing chains of translation from visions of alternative solutions into those of a society that eradicates pesticides. Responsibilities in this regard concern the interestment and enrolment of the other actors, so they can change to enable the eradication of pesticides. In other words, responsibilities of actors are continuously taken into consideration from research to the use of innovation in society, and thus science, innovation and society cannot be decoupled from one another.

Social embeddedness of responsibility

These visions of responsibilities of various actors in the network link to an important discussion about the assumption of responsibility by researchers and other actors in this ambitious mission to eradicate pesticides. Responsible translation highlights that responsibilities are situated along the entire process from research, to the development of innovation and to its implementation in society. This is in line with the literature on RI, which stresses the need for better coupling of science, innovation and society (Owen & Pansera, 2019; Robinson et al., 2020). For instance, Wittrock et al. (2021) argue that the implementation of RRI might be limited by this division, and so will the focus on societal goals. Hence, my thesis contributes to reinforcing the STS understanding of the

embeddedness of science and innovation in society, as it demonstrates that researchers **with** other actors in society share responsibilities for the mission.

This shows that responsibility in the mission is socially embedded. In this regard, Arnaldi & Gorgoni (2016) argue:

Responsibility is a collective and participative process: rather than being merely individual, responsibility is shared among different actors with different roles and powers along the innovation process. These actors are considered mutually responsible (p.9).

So, in line with my findings, these authors state that contribution of R&I processes to societal challenges involves shared responsibilities between researchers and various actors. This refers to different actors with different responsibilities along the innovation process. However, as I discussed in the previous section, I do not consider responsibility as a collective participative process, but instead my results show that the responsibilities of actors are embedded in the associations they construct with other actors in heterogenous networks. As my dissertation demonstrates, a changed society that eradicates pesticides as the outcome of these networks, would be the result of new associations and thus of the assumption of responsibilities by a heterogenous set of actors.

The envisioned network construction by researchers is based on visions of the responsibilities the researchers hold in their role as researcher, as well as the responsibilities of other actors with whom they must interact. At T_1 , these networks show to be not performative yet, as associations are not yet anticipated and realised, and thus limited interactions take place. This also means that the research is not yet transformative. The contribution to the mission – and the transformations in society this requires - is thus not the sum of responsibilities of individuals through their participation in R&I activities, but should be seen as an interactive process, which is embedded in a social context of the mission. In addition, Strydom (1999) emphasised that “*duties of responsibility accrue to individuals on this level due to their possession of special knowledge, abilities, judgment, power or influence in particular domains of social life*” (p.68). Responsibility for the mission is thus never about an individual actor (group), but about shared responsibilities of ‘science with society’, which are made through responsible translation from visions of alternative solutions into those of a society that eradicates pesticides.

Co-responsibility in the mission-oriented context

Considering Strydom's (1999) typology of responsibility, my findings are in line with what the author describes as ‘co-responsibility’, which he adapted from the work of Apel (1993). Strydom provides an essential difference between ‘collective responsibility’ and ‘co-responsibility’. The notion of collective responsibility, which the author adapted from Jonas (1984), refers to the responsibilities

of society to respond to the challenges we are facing, and consequently moving away from individual responsibility. Strydom (1999) argues about co-responsibility:

Responsibility, in these terms, applies to human beings as members of a community of communication and cooperation, and it can be fulfilled only by a world-wide network of formal and informal communications -- from discussions and dialogues through round tables and ethics committees to boards and commissions of all kinds at local, national and international level. [...] co-responsibility brings a public level of responsibility for common or shared problems into play without disburdening individuals of their personal responsibility (p.67).

Hence, I highlight a case of co-responsibility as I am talking about a specific problem in society that needs to be addressed, which is represented by the mission, i.e., the overuse of pesticides uses. And so, as I largely elaborated in my thesis, I am speaking about a specific envisioned society by the researchers: a 0-pesticides society, which is constituted of actors who act in such a way as to be able to eradicate pesticides by implementing alternative solutions. My results have shown that responsibilities are situated in these specific visions of a society, which eradicates pesticides, and not in an abstract generic vision of society. Hence, in line with the co-responsibility concept, visions of the responsibilities they hold in their role as researcher, as well as the roles and responsibilities of other actors, are socially situated in their specific R&I pathways of the alternative solutions they study.

Consequently, my results illustrated that the responsibility the PPR-CPA researchers take on embedded visions of co-responsibility for eradicating pesticides. Thereby it shows their visions of realising science-society associations as the contribution of science with other actors to the mission. The researchers' visions highlighted the embeddedness of their R&I pathways in networks with other actors. Hence, talking about the responsibility of researchers in this mission-oriented context means envisioning the researchers' embeddedness in a network with other actors to enact or perform visions of co-responsibility through their associations. The responsibility researchers assume thus showed to be about their visions of the performance of co-responsibility through associations between actors in responsible translation. Based on my findings, I emphasise four points in this regard, in line with responsible research in the mission-oriented context:

1. Responsible research in the mission is situated in the context of envisioned co-responsibility, which is understood through an ANT perspective – the heterogeneous networks associate actors through their envisioned responsibilities along the entire process of research, innovation and society;
2. Responsible research in the mission embeds multiple-levels of envisioned co-responsibility: 1) responsibilities of actors to enact the five poles of societal

transformations. This requires these actors to change how they act in the future to enable the development and implementation of the alternative solutions to pesticides; 2) responsibilities of actors for the interestment and enrolment of the other actors so they can change. Together with the researchers, all these actors are associated in the network to perform the chains of translation. However, at T_1 , these actors and their associations are not all defined in detail yet;

3. Responsible research in the mission embeds visions of co-responsibility of researchers with other actors, and these responsibilities are to enabling together the eradication of pesticides in society. At this stage of the research projects this is only about the visions of researchers, without the other actors necessarily being aware or having accepted these roles and responsibilities yet; i.e., they have not assumed their envisioned responsibilities. ASIRPA RT play as a guiding role, so that visions of a future society will become more collective and participative, and that future associations can be realised;
4. Responsible research in the mission embeds visions of co-responsibility as it is about performing shared contributions to a changed society through their associations in the network. Change in society is thus performed through these associations, which requires the researchers to envision the construction of these network based on visions of enrolling actors' responsibilities. Even though, at T_1 , some of these actors and responsibilities are identified as nodes in the network, the associations among actors are still rather limited; and thus the network is not yet performative nor transformative in society.

These points lead to a striking question, which I am unable to answer at this stage: do the PPR-CPA researchers actually assume responsibility as part of visions of co-responsibility, or are they rather shirking responsibility for the 0-pesticides mission? The researchers showed that following the ASIRPA RT intervention, they could anticipate three categories of responsibilities for interestment and enrolment through their research projects (inputs and outputs): 1) Convincing actors with demonstration and proof of the alternative solutions; 2) Adapting alternative solutions to actors' financial constraints; and 3) Building capacity of actors for the alternative solutions (e.g., skill development). In the second situation, two main categories of envisioned responsibilities for the interestment and enrolment are envisioned for external actors: 1) Enabling the adoption of alternative solutions to pesticides; and 2) Valorising the alternative solutions to pesticides.

To provide an example, several researchers highlighted the need for subsidies to support the 0-pesticides transition by, for instance, farmers. However, the inclusion of subsidies in the network – and thus part of the co-responsibility for the mission – represents an external non-human actor that

is needed to achieve the objectives of the research projects. Visions of associating subsidies are still rather limited: how will the subsidy become a performative part of the network? So, this questions to what extent the researchers will eventually assume responsibility – anticipation, reflexivity, inclusion, responsiveness – to ensure the performance of these visions of co-responsibility, or are they rather shirking responsibility by claiming that other actors will do the work once they have delivered their results? At the same time, what is realistic to expect from researchers in their role as responsible scientists, or in other words, what are the boundaries of their responsibility? Answering this question requires collecting and analysing more data at subsequent phases of the ASIRPA RT intervention (e.g., at T₂ or T₃).

2.3 Mobilising science-society associations: ontology in the mission-oriented responsible translation process

My results reveal that the third step of responsible translation is about mobilising science-society associations with the alternative solutions to pesticides they study. In terms of responsibility, it is about (re-)directing their R&I pathways of ‘excellent science’ towards societal goals. Both at T₀ and T₁, the PPR-CPA researchers were aware that the eradication of pesticides will not be the sole result of their research projects. However, the largest difference between the two phases is how the researchers envisioned themselves in relation to the responsibilities of other actors in the mission. This reflects a shift from a focus on excellent science to a focus on directing their science to societal impacts.

In her essay, Douglas (2003) debates the moral responsibility of scientists, and the boundaries in this regard. The author argues: *“the moral responsibility of scientists hinges on issues particular to professional boundaries and knowledge production. The question is what we should expect of scientists qua scientists in their behaviour, in their decisions as scientists engaged in their professional life”* (p.59). The ten research projects study alternative solutions to pesticides. The question of responsible research highlights the responsibilities researchers assume in their visions of how these alternative solutions can actually lead to the eradication of pesticides in society. For the PPR-CPA researchers this moral responsibility reflects the use of their gained knowledge in society to eradicate pesticides, and the boundary of their role as researchers in such an ambitious societal mission, which we tried to support with ASIRPA RT.

A shift in relational ontologies in the mission

We can understand the shift from T₀ to T₁ of how researchers assume responsibility, by understanding how they envision the expected contribution of the alternative solutions to change in society. This thus depends on the way the researchers envision a future society without pesticides

based on alternative solutions. In this section, I discuss the responsibility of the researchers through a perspective of 'ontology'. The responsibility assumed by the researchers showed to be related to their visions of constituting a future society without pesticides, and thus changing relations between humans and nature. Consequently, the researchers responsabilised as they changed their visions of the expected contribution to the eradication of pesticides in society between T_0 and T_1 . My findings show that responsibility is embedded in a shift in the ontology of a 0-pesticides society. Where at T_0 the main emphasises was on the contribution of their research projects, T_1 highlighted a shift to the contribution of the alternative solutions.

More specifically, what my results revealed was a shift in *relational ontologies* (Loconto & Constance, forthcoming 2023), in terms of the envisioned associations between the PPR-CPA projects on alternative solutions and society that eradicates pesticides with the alternative solutions to pesticides. Escobar (2016) provides an applicable definition of this concept, as the author states: "*To put it abstractly, a relational ontology of this sort can be defined as one in which nothing pre-exists the relations that constitute it. Said otherwise, things and beings are their relations, they do not exist prior to them*" (p.18). In the case of the PPR-CPA, the researchers' visions of a 0-pesticides future, and their contribution in this regard, does not exist until they mobilise the associations between their research and their visions of a 0-pesticides society with the alternative solutions to pesticides.

Changing scientific reality versus societal reality

In Chapter 2, I discussed the dichotomy found between excellent science and societal goals, as R&I activities are still often aiming at achieving economic growth and ensuring market competition among firms and nations (Jakobsen et al., 2019; Owen & Pansera, 2019; Novitzky et al., 2020; Dabars & Dwyer, 2022; Fuenfschilling et al., 2022; Tabarés et al., 2022). I did not necessarily find proof of this for the PPR-CPA projects. Already at T_0 , the researchers showed awareness of their participation in a research programme with an ambitious mission. As a response to the 0-pesticides mission, the projects' PIs confirmed that they constructed their projects differently compared to previous projects they have been involved in, where they did not have a mission like the PPR-CPA. I have illustrated this in Chapter 4 by describing the complex character of their research projects: 1) multidisciplinary of the consortium; 2) multiple dimensions of research; 3) multiple levels of analyses; 4) multi-actor research; 5) multiple (knowledge) resources.

This illustrated the researchers' baseline-visions that contributing to the eradication of pesticides requires a change in how science is done on multiple levels; e.g., moving from lab to field level, solutions against multiple pests, including multiple research disciplines and actors, etc. Hence, it reflects a change in the 'reality of science' compared to previous research projects, which lacked

such an ambitious mission. However, it also reflects the visions that this change in science will lead straightforward to a change in the 'reality of society' without having clear visions of what this societal reality without pesticides entails. It emphasised the contribution of the researchers and their projects for the mission.

From an ontological point of view, at T_0 , the five characteristics highlight thus a scientific way of knowing a 0-pesticides society. The envisioned mobilisation of associations between science and society with the alternative solutions to pesticides reflects change in how research is constructed, but much less about change in society. This grounds in the idea of a 'user-society', which embeds the role of researchers to study alternatives to pesticides and scientifically proof their efficiency, acceptability and usability in society. Hence, a 0-pesticides society in this regard, reflects a society that is willing and able to use the alternative solutions to eradicate pesticides. However, the projects did not approach this through societal questions, but rather 'research for society'.

Visions at T_1 reflected more an ontological perspective of co-production of science with society (Jasanoff, 2004c). Hence, the responsibility of the researchers was revealed to be about rethinking how a 0-pesticides society and their research projects on alternative solutions were co-produced: the expected contributions to the mission are embedded in the visions of society without pesticides. The researchers made explicit their visions of the constitution of society that is able to eradicate pesticides with the alternative solutions they study. This is not about society constituted according to scientific knowledge. Instead, it is a two directional shaping – as illustrated by responsible translation - by (re-)directing research pathways to (changing) societal goals. Society changes with the visions of science, and this change is represented by the alternative solutions to pesticides. Beyond the role of researchers, it is about the expected contributions of the alternative solutions they study to a society without pesticides.

Two ontological framings of responsibility in the mission

I would like to highlight two particular interpretations, which further explain how responsibility can only be understood if we adopt a relational ontology, which reflects a change in visions of co-produced associations of science with society. First, responsibility reflects a shift in relational ontologies through a change in researchers' visions of their expected contribution to the mission. In the introduction of their edited book on visions of agroecological transitions, Magda et al. (2021) talk about 'ontological relationships to change' to capture 'visions of change' in such transitions. The authors argue:

When dealing with concrete transition processes, this relation to change is the foundation of the interpretations and proposals of the various involved stakeholders (researchers,

farmers, advisors, facilitators, decision- makers) upon mechanisms of change and modalities for conducting transitions. They guide decisions on why, how and by whom changes are, or should be, enacted and implemented (p.33).

In line with this argument, my results illustrated how researchers' visions of societal change, necessary for the eradication of pesticides, are performed in their envisioned associations with other actors' responsibilities for the mission. Specifically, it reflects the chains of translation so that actors in society can change to enable the development and implementation of the alternative solutions. To provide an example, instead of just providing scientific proof of the cost efficiency of an alternative solution – which reflects a change in science – the researchers anticipate the change among actors they expect to occur once there is an alternative solution to pesticides. For instance, by adapting the alternative solutions to the needs or context of the users, by anticipating support in the implementation of the alternative solutions, or by anticipating incentives to actors.

Second, the assumption of responsibility by the researchers reflects a shift in relational ontologies through a change in interactions. As I elaborately discussed, the mobilisation of such a society that eradicates pesticides with the alternative solutions, embeds visions of co-responsibility between research and various other actors. Taking an interactionist approach, the assumption of responsibilities by actors to perform the expected contribution to a 0-pesticides society, is the envisioned outcome of associations in heterogenous networks. Change in society will thus be performed through the envisioned associations in these networks. At T_1 , this only reflects visions of researchers, but it is an iterative process whereby visions of other actors should become embedded as well. Hereby I am in line with, Loconto & Constance (2023) who argue in this regard:

Relational ontologies are not new in sociology, however they are far from being accepted as the main ontological approach to understanding the social (see Latour, 2005). Emerging as a response to a functionalist vision of social structures and agency, interactionists have long argued that a social fact is not a static, predetermined reality of society; but rather a process that is constructed within the framework of concrete situations that have a range of institutions (understood as discourses and rules) that frame the possible range of actions (Carr, 1945; Znaniecki, 1963) (p.27).

This embeds Latour's (2005) perspective of a relational ontology and thus to use symmetry when analysing human and non-human actors. It does not mean that all actors have equal power, but it does mean that they are all actants as envisioned by the researchers, they must all be brought to contribute as part of the 0-pesticides mission. If the actors are not becoming part of the network, it will cause obstacles in contributing to the mission. For instance, if the seed registration framework will not get updated in France, some of the envisioned seed technologies or seed varieties will not get to the market and thus they will not be able to grow in the field.

However, all these actors who should get involved are part of – or only existing in – a reality of the mission based on the visions of the researchers at T₁. Latour (1984) argued that power is in the associations between actors, and so, the question is how to form associations that embed the power to contribute to the mission? I draw upon the work of Star (1990) to challenge this question. Star proposes that heterogeneity in networks is taken into account, because: 1) it requires associating multiple interests in a network; and 2) associating actors in the network might mean destructing something else or another network. Star (1990) argues:

Because we are all members of more than one community of practice and thus of many networks, at the moment of action we draw together repertoires mixed from different worlds. Among other things, we create metaphors - bridges between those different worlds. Power is about whose metaphor brings worlds together, and holds them there (p.52).

I find this quote key in discussing responsible research contributions to the mission. As largely discussed, responsible translation is about translating visions of alternative solutions to pesticides into an envisioned 0-pesticides society. However, to use a term mentioned by Star, this process does not start at a 'Point Zero'. Currently there is already an existing reality in which pesticides are a dominant actor in agricultural systems in France. This reality already consists of networks with powerful relations among pesticides, machines, practices, farmers, breeders, industries, markets, regulations, infrastructures, etc. This might even concern rather stabilised networks. As Star (1990) emphasises: *"Every enrolment entails both a failure to enrol and a destruction of the world of the non-enrolled"* (p.49).

So, what the process of responsible translation captures, is that association actors in the researchers' visions of the eradication of pesticides, means also destabilising existing realities. This highlights the importance of formative approaches like ASIRPA RT for the researchers to assume responsibility in mission-oriented contexts, by associating their visions of change in the network. The researchers are not guided to substitute pesticides - and thus to change society - by themselves. Instead, the researchers are accompanied to associate themselves in an envisioned network with other actors, including the ASIPRA RT team, in order to establish the power to destabilise and transform existing networks or structures of pesticides use in society.

Still, several of the PPR-CPA researchers did question their role and legitimacy in the 0-pesticides mission when they participated in the ASIRPA RT activities. What we tried to explain is that their responsibility in this mission is not about solely changing society, but it is about changing their visions of a future society they expect to contribute to with their research on alternative solutions. In terms of moral responsibility, and the boundary of research and knowledge, the researchers will not change the practice of all farmers in France. Nor will they change the dominant pesticides system with

just their research projects. Instead, their responsibility is about envisioned associations between various human and non-human actors that hold responsibilities for the mission, in the network that embeds their research.

3. Research Limitations and future research directions

My thesis research on responsible research in mission-oriented context should consider some limitations, and also triggered questions for future research that I will highlight in this sub-chapter. In this first section (3.1) I will discuss the research limitations, and in the second section (3.2) I highlight some future research directions.

3.1 Research limitations

The interpretation of my thesis research should also consider some limitations. I studied the how a formative evaluation approach – ASIRPA RT – encourages research to take on responsibility for contributing to a societal mission, and in this light, I want to discuss some possible research limitations. In this part, I discuss this through two main categories: 1) the dependence of the data collection on the active participation of the researchers; 2) the guidance of ASIRPA RT as formative evaluation to the assumption of responsibility by the researchers for contributing to a societal mission.

First of all, the data collection of this research highly depended on the participation of the researchers. Even though participation in the activities of ASIPRA RT was one of the requirements for taking part in the PPR-CPA, for some researchers it might have been conflicting in terms of resources (time and availability) with other research activities. The majority of the researchers indicated to be new to such an impact assessment approach, and particularly in the beginning, they might not have well considered the benefits for their research. At T_1 , various projects faced challenges to start their research projects. The official start of the PPR-CPA was delayed as a consequence of the COVID-19 pandemic, and the projects were focussed on starting up their research activities. Participating in ASIPRA RT might not have been their priority. However, eight out of ten projects did participate, and prepared a detailed first IP. Participation takes motivation and discipline from the researchers.

Various projects also indicated to be constraint in terms of human resources, particularly at the start of their project, which delayed their participation in ASIRPA RT. One of the projects, which did not participate at T_1 indicated the lack of a project manager and availability of the researchers at the start to take part in the 'impact team' as the main reason why they did not manage to participate. Eventually, we found that the projects who hired a project manager early on in the project were able to participate more actively in the ASIRPA RT activities. This also gave us a contact point for the project to discuss ongoing activities and difficulties.

This might indicate that some project' researchers still perceived ASIRPA RT as an add-on to their research activities, as I discussed as a challenge in the previous part. However, when the researchers participated they did this actively and took the exercises seriously. Despite this, the projects' participation and (internal) organisation were rather heterogenous. Especially the 2-hours workshops were for some projects led by an actively involved project manager or PI, while others were more silent, which required more efforts of the ASIRPA team to animate the discussions.

Finally, the results presented in this thesis just highlight a change at the T₁-phase, and thus very early on in the process of the projects and their participation in ASIRPA RT. Especially the stakeholder analysis and associations between actors seemed to be particularly challenging at this early stage: who to involve, how and when? The researchers themselves addressed two main challenges. First, they mentioned it was too early in their research projects, they expressed that they require their first results to be able to envision what stakeholders to involve. Second, various researchers questioned their legitimacy in such reflections about the contribution of other stakeholders for the 0-pesticides mission. Yet others questioned their competencies to think about the entire IP, particularly the intermediary phase.

These challenges are important to be considered by the ASIRPA RT team, as they might affect the assumption of responsibility by the researchers. Particularly in comparison to the future T₂- and T₃-analysis, we might find that the researchers are more used to the ASIRPA RT-style of reflections. In addition, they will have their first research results and might be better organised in their project management. With ASIRPA RT, we will need to adapt our animation style and communications to consider these challenges. For instance, we challenged the researchers to rethink: who more than the researchers themselves have to capacity to anticipate, reflect and involve stakeholders when it is about the alternative solutions to pesticides they study?

Second, drawing conclusions about the contribution of ASIRPA RT to the assumption of responsibility by the researchers for the societal mission should be considered in relation to potential limitations of the ASIRPA RT approach. For instance, the findings revealed a positive approach of the researchers when they made explicit the expected societal impacts. The envisioned societal impacts only reflect positive impacts, but not potentially bringing new risks or challenges to society by the research projects (e.g., reduced production). Nor does this reflect those who will be the 'losers' of the 0-pesticides mission, or negative impacts due to the eradication of pesticides. This leads to potential bias of this research: did the PPR-CPA researchers become techno-optimists? Or is this a result of the guidance by ASIPRA RT? We did request them to reflect upon potential negative impacts, but in the face of the entire IP, we might have navigated their positive visions, to the detriment of the negative

impacts. I observed similar reflections in the potential blocking factors to their research' contributions to the mission. Such reflections were also limited. For ASIPRA RT it is key to reflect upon our influence on the visions of the researchers.

In addition, my results demonstrated that researchers' visions of expected contributions to the 0-pesticides mission did change with ASIRPA RT. However, at this stage it assumes that this would actually lead to researchers changing practices and to societal impacts. It is based on the hypothesis that a change in visions – and the responsibility researchers assume – will actually lead to a transformations in society and the impact this would bring. It is therefore key to analyse and observe the PPR-CPA researchers in the coming years if they actually continue to change their research practices, interactions, and visions in relation to their contribution to the 0-pesticides mission.

Finally, we found that participation in such type of real-time impact assessment requires a lot of guidance. The researchers had to familiarise themselves with the ASIPRA RT approach and the structure and visions necessary to create an IP. For future implementation, this is key to consider, that it takes a lot of effort to develop autonomy of the researchers to participate in such activities. This might imply that encouraging researchers to taken on responsibility for the mission, requires active guidance through formative evaluation. Particularly in the timing of doing the exercises and the iterative process of the real-time approach. In addition, ASIRPA RT is a new approach and as a team we were learning as well. For the future, we should well consider what type of exercises fit what stage of the research projects. For instance, the detailed stakeholders analyse we intended to do at T₁ turned out to be too challenging at that stage. Communication, animation for collective intelligence, facilitation, and the development of clear activities will be crucial in the future development of ASIRPA RT.

I already shared reflections on my position as a researcher, in the methodology - Chapter 3. Considering limitations in this regard is key, as I have been wearing various hats during my thesis research and I have been embedded in different contexts: a PhD candidate in sociology, a member of the ASIPRA RT team, observer of the ASIPRA RT team and the PPR-CPA researchers. From a perspective of the inside-outside dualism, if I did not subdivide and change well my different hats it could have been a limitation to the research process. In addition, at the start of the PhD I had limited experience in such animation exercises as well as in large research projects, and depended in this way on the colleagues from the ASIRPA RT team. In a short time, I had to familiarise myself with the terminology, methodology and literature background of ASIRPA RT and implement this in operational case study to guide researchers. Concepts such as societal transformations where also challenging to fully comprehend for myself at the start.

Also, the limited timeframe of the PhD programme (3 years), made me focus on short-term data collection. This resulted for instance, that I could not go beyond an analysis of T_1 , which limits my research outcomes in this regard. We also had to adopt the activities to the (short-term) needs of my PhD research, which required me to reflect carefully on the needs of the ASIRPA team as well as the PPR-CPA researchers.

3.2 Future research directions

The discussions in this chapter triggered new questions for future research about responsible research, and in particular on the role of formative evaluation to encourage researchers to take on responsibility. I suggest three main future research directions that I would want to continue to explore: 1) the future exploration of responsible research with ASIRPA RT, both in the PPR-CPA and in other contexts; 2) Exploring the contexts of responsible translation; 3) Addressing responsibility in mission-oriented, and transformative science and innovation policy contexts.

First, I want to further explore the ASIRPA RT approach, in three situations: 1) further exploration of the PPR-CPA; 2) further exploration of multi-actor research settings; and 3) further explorations in domains or sectors other than agriculture. To start, as this thesis reflects only on a comparison between the T_0 and the T_1 phases, it would be interesting to further discover changes in the researchers' visions at T_2 , T_3 , etc. In addition to the exploration of these visions, the continuation of following the PPR-CPA researchers will also reveal to what extent the researchers actually change their practices, and establish associations with other actors. I am also interested in their future reflections of their associations to other actors – who, when, and how to involve them – since this still remained rather limited at T_1 . Eventually, it would be interesting to have an overall comparison of the researchers' visions at different phases of their research projects. This would not only contribute to drawing conclusion about the researchers' responsabilisation processes, but about how to adapt formative evaluation approaches like ASIRPA RT to these different phases in research and the needs for guidance of the researchers in this regard.

In addition, the implementation of ASIRPA RT in the PPR-CPA reflects a very particular research case with a clear mission. Only research institutes and universities are funded in the programme, and the creation of the IP thus only reflects the visions of researchers. I would like to re-think the ASIPRA RT approach in other contexts. Examples would be to adapt the approach to participatory, multi-actor or co-creation research processes, and/or to situations where the envisioned future (*i.e.*, *the mission*) is not clearly set yet. This would thus be about situations in which the visions of multiple actors have to be considered. This raises the questions how it would change the process of envisioning contributions to societal challenges? How would this adapt the construction

of the IP? But also, how does it require to adapt the ASIRPA RT activities to capture these multiple visions? Additionally, I want to understand such participatory research activities, and thus the involvement of multiple actors in research processes, in the context of societal transformations. I question what the envisioned results or aims are of such participatory processes; i.e., is it aiming towards the transfer of scientific outputs or responsible translation?

Similarly, this thesis discusses a case study within the agricultural domain. I would also like to further explore the intervention of ASIRPA RT in missions of other domains and other challenges in society, with other organisational structures, other stakes at play and other actors concerned (e.g., mission related to liveable or sustainable cities, or challenges related to mobility). As each domain is confronted with other particular societal challenges, it would be interesting to discover these and compare researchers' visions of their expected contributions to these challenges between these domains or sectors.

Second, I want to further explore the social context of responsible translation. Particularly the researchers' anticipation of the assumption of responsibilities by other actors is an interesting process to explore further. As I discussed, in the case of the PPR-CPA, visions of responsibilities of actors to enable the eradication of pesticides are based on the visions of the researchers only. The actors concerned are thus not necessarily aware, nor do they accept these responsibilities by default. I would like to further explore these visions of the researchers, which raises questions such as: are these visions based on knowledge of these actors? Were these actors at some point involved in the process? Have they been collaborating with these actors before? What are the boundaries of the envisioned networks by the researchers; i.e. who is considered inside and who is considered outside the network?

In addition, in line with these previous questions, I want to further explore the concepts of assuming responsibilities vs shirking responsibilities by the researchers. During the ASIRPA RT activities, various researchers question their legitimacy to envision responsibilities of other actors. They questioned if they have the competencies and legitimacy to reflect on this, and thus tamed their own role in contributing to the 0-pesticides mission. Are the researchers' reflections based on the shirking of responsibilities for the mission? Or do they just not know how yet how to anticipate the assumption of responsibilities by other actors?

Third, I want to explore responsible research in the context of transformative innovation policy, as I mentioned in the introduction chapter. R&I policy has been often framed by 'linear' thinking, focussing on economic growth and competitiveness. In the past decades, transformative R&I policy has been an upcoming rediscovered policy paradigm. It discusses the framing of R&I for transformative change aiming to better align innovation with societal challenges (e.g., Kuhlmann and

Rip 2018; Schot and Steinmueller 2016; Weber and Rohrer 2012). In the context of this shift in R&I policy, I would like to study the question of responsible research in the development and implementation of such R&I policy frameworks. This raises questions such as about 'responsible research' in the context of 'transformative science', how such policy programmes aim to responsabilise researchers in their contribution to societal challenges. In addition, I want to explore the implications of the intervention of ASIRPA RT for responsible research in the context of TIP as well as transformative science.

Also, I believe that there is also an important work to do on responsibility of programme managers on the level of the programme. With ASIRPA RT we have started some of this work, which is out of the scope of the PhD, but what would be interesting to further explore in the future. This is about 'multilevel' or 'nested' responsibility of researchers at the project level and manager at the programme level. I think it is not enough to only have responsible researchers, it is also important to encourage responsibility at the programme level. This might for instance be a lever to enrol stakeholders in the envisioned networks of the projects, and enable to find synergies between different projects.

4. Final conclusions

To conclude this thesis, throughout the dissertation I have demonstrated how ASIRPA RT – as a formative evaluation approach – encouraged the PPR-CPA researchers to take responsibility for contributing to a societal mission through their research projects on alternative solutions to pesticides. The PPR-CPA is an ambitious mission-oriented research programme aiming for a future society in France that does not use pesticides. The French Government is making a concerted effort to achieve a pesticides-free agricultural future by its significant investment in this research programme (30 million euros over six years). This reinforcement of research efforts highlights the responsibilities that the Government delegates to researchers for resolving the problem of the overuse of pesticides. They must find alternative solutions to pesticides.

By conducting my research as part of the ASIRPA RT team in the PPR-CPA, I had unique access to the intervention of a formative evaluation approach to support the responsibility of researchers in a mission-oriented setting. As I collected data on how the researchers envision the expected contribution of the alternative solutions to the eradication of pesticides before and after the intervention of ASIRPA RT, I was able to do a comparison between these two phases. Pesticides use is embedded in complex socio-technical systems. If research is to contribute to the eradication of pesticides, it requires their science to be transformative. My results indicate that at this early T₁-stage of the PPR-CPA projects, the research is not (yet) transformative. However, the researchers showed

to be able to envision how they expect society to be constituted in a 0-pesticides future with the alternative solutions to pesticides they study, and role responsibilities of actors to achieve this.

Hence, the ASIRPA RT activities made visible possible futures without pesticides, to which the projects expect to contribute. In his laboratory research, Latour elaborates on 'visibility' through the notion of 'instruments' (Latour & Woolgar, 1979; Latour, 1983, 1987). The ASIRPA RT formative evaluation approach can be considered as the implementation of an 'instrument' with the aim to make the 'invisible' constitution of a future society without pesticides 'visible' to the researchers – and thus what this means and how the researchers can contribute to the mission with their projects on alternative solutions to pesticides. ASIRPA mobilises the Sociology of Translation and Actor Network Theory (ANT) (Callon, 1986), to highlight the chains of translations that occur during the process of generating societal impacts. Hence through the chains of translation, ASIPRA RT guides to rethink the dichotomy between the research projects on alternative solutions and society without pesticides (inside vs outside) and inversion of the project and societal level (meso vs macro level). It showed how it contributed to the capacity of the researchers to conduct Excellent science and direct this towards societal goals.

Responsible Translation as a notion to understand expected research contributions in a societal mission

To show this, I introduced the notion of 'responsible translation' as a way to make sense of how researchers translate the expected contributions (i.e., visions of alternative solutions to pesticides), in the sense of Callon (1986), in societal missions. Responsible translation describes the process from visions of alternative solutions into those of a society that eradicates pesticides with these alternative solutions. By empirically exploring the three phases of this process in the PPR-CPA, I demonstrated the inextricable links between processes of translation, responsibility and the guidance of formative evaluation, in understanding responsible research as part of a societal mission.

My results showed that in this mission-oriented context, in contrast to Callon's Scallops case, it is not the PPR-CPA researchers, but the alternative solutions to pesticides who become spokespersons of the heterogenous networks to perform the expected contributions to the 0-pesticides mission. This leads to the question of indispensability in this mission-oriented context. If we consider the links between translation, responsibility and formative evaluation as a black box (e.g., Latour, 1983) of which the successful outcome is a society that eradicates pesticides, the alternative solutions to pesticides have become indispensable. Responsible translation demonstrated that a society that eradicates pesticides, is the outcome of chains of translation through which actors assume responsibilities to enable the eradications of pesticides with the alternative solutions.

Hence, responsibility of researchers is about associating actors through their envisioned responsibilities in the future networks to perform (change towards) a 0-pesticides society, which is represented by the alternative solutions. It is this heterogenous networks that should put the alternative solutions into practice in the future, generated through chains of translation. Hence, actors are associated through their envisioned responsibilities for enabling the eradication of pesticides for a future society, as the result of these chains of translation. At T_1 , this reflects only the visions of researchers, but the construction of these future networks is an iterative process, and should become more participative with other actors over time.

However, I also demonstrated that at T_1 , associations between actors in the envisioned are not there yet, and so the alternative solutions are not yet representing this envisioned network. It requires the researchers in following phases (e.g., T_2 and T_3) to continue their process of responsibility by associating visions of actors' responsibilities in their future networks, which should be realised over time by becoming more participative. It teaches us that technologies or innovation will not be adopted if associations are not established. At the moment that I am writing this concluding section of the thesis, with ASIRPA RT we continued working with the PPR-CPA researchers. Almost 1.5 years after their first attempt to develop an IP, they showed that their visions have changed, and that they are much better able to envision associations between their research efforts to transformations in society.

By showing the embeddedness of actors' responsibilities through associations in responsible translation, I prove the co-production of science with society. I have shown that science is in society and thus when the societal impacts and transformations are envisioned, the society is co-produced with it. This also highlights that 'science-society associations' as a concept is too vague if researchers are to take on responsibility in this regard. These associations are made through responsible translation, as it highlights that it is about envisioned networks that associates researchers with their responsibilities as scientists, and other actors with their responsibilities for the mission. It also puts into question the realisation of, for instance, transformative R&I policies. If research is to contribute to systemic change, is it realistic to attribute such a responsibility on the shoulders of researchers? In particular, as the PPR-CPA clearly indicated the large responsibilities of actors for the mission, and that this is embedded in associations.

With my thesis on the notion of responsible translation, I contribute to academic literature on Responsible Research, Responsible Innovation and the Sociology of Translation. I have demonstrated that normative visions of responsibility – anticipation, reflexivity, inclusion and responsiveness – guide research towards societal goals as it supports to envision associations between actors' responsibilities. However, I also showed that these visions of responsibility need to be translated to work. Also, the

real-time interventions of ASIRPA RT in the PPR-CPA made apparent the need to adapt Callon's translation process. The translation process that the researchers are dealing with in this mission-oriented context is about a complex contribution towards solving a challenge in society. I adapted the concept to this mission-oriented situation, to capture the researchers' visions of change that should become part of the envisioned networks. The researchers construct the envisioned heterogeneous networks to perform chains of translation, around visions of the actors' responsibilities, which should enact the envisioned change to society. As largely discussed, these responsibilities are about enabling the eradication of pesticides with the alternative solutions, and therefore these solutions become spokespersons of the networks.

The role of ASIRPA RT as a formative evaluation approach is to make visible possible future societies without pesticides and the researchers' expectations of the contribution of the alternative solutions they study in their projects, in real-time. This enables researchers to (re-)direct their research to contribute in resolving the problem of the overuse of pesticides and thereby to respond to challenges in society. The expected contributions to the mission are embedded in the researchers' visions of a society without pesticides - and thus when the contributions to impacts and transformations are envisioned with the guidance of ASIRPA RT, the 0-pesticides society is co-produced with it. It made explicit that if researchers are to take on responsibility for a societal mission, the expected contribution should be envisioned through 'science with society'.

However, it should be noted that my data also revealed that at this T₁-phase, the chains of translation are not (yet) performed, and thus the research projects are not transformative in society. The researchers did not identify yet in detail the actors to associate in the envisioned heterogeneous networks. At this phase I cannot be sure about the cause of this; whether they faced difficulties to identify associations between actors, or they might be shirking responsibilities. Further research at the T₂, T₃, etc.-phases is necessary, where ASIRPA RT should emphasise the identification of actors and their associations in the networks. Hence, there is the need to complete the six-year cycle of ASIRPA RT in the PPR-CPA to discover whether the research is actually transformative or not.

This thesis research highlights a unique case of the institutionalisation of responsible research in a French mission-oriented research programme. My research revealed that the researchers' capacity to envision their contributions to a 0-pesticides society is rather weak if they are not navigated into that direction. The outcomes might have implications for future mission-oriented and transformative R&I policies, and the need to implement formative evaluation if researchers are to address complex challenges in society. Considering the increasingly pressing concerns around sustainability in society today, researchers should be enabled to respond with their science through

approaches that support their responsibility. If research is expected to contribute to change in society, the researchers must change too: if society has to change, researchers' visions must change with it.

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Annex I – T₀ interview Protocol

Interview protocol PPR project T₀ - end 2020

These interviews will be held with (if possible) all PIs of the PPR projects before the actual start of their projects and before the start of the activities with ASIRPA: at T₀ of the PPR projects. The aim is to get insight into how the PIs constructed their projects, reflected upon (expected) impacts, and projected their visions in the actors needed to achieve the expected impacts – considering that they applied to a research program with a mission of a 0-pesticides future.

Introduction to the interview

Thank you again for having accepted to participate in this interview. I have invited you to participate as you are the project coordinator of [name project] of the PPR 'zero pesticides'. [Introduce ourselves]

As presented at the kick-off meeting in September, the PPR program level entails scientific animation activities. One of them is the ASIRPA approach on Impact Assessment in real-time. When the projects start, with the ASIRPA team, we will guide the projects in the development of their impact pathway as well as the assessment in real-time.

All projects have their visions of an agricultural future without pesticides. We want to understand how having these collective visions can contribute to the way how we conduct research (incl. practices, actors, networks, etc.) and eventually how this contributes to societal impacts. The aim of this interview is to understand how you expect that your project can contribute to an agricultural future without pesticides.

The interviews will take maximum 1 hour. The questions will be asked in English, but you can respond either in French or English. – I have sent you the consent form with the GDPR disclaimer, do you agree to participate in this research, and could I sign the form for you? Do you agree that this interview will be audio recorded for transcription to facilitate the analysis?

[Introduce ourselves and ask them to introduce themselves shortly]

Questions: [explain the sequence of the questions before starting the interview]

1. Short term contributions of the project
 - a. *In the context of a pesticide-free agriculture future, could you tell me a little about the changes you expect your project to contribute to during or at the end of the project?*
 - b. *How do you expect that your research activities could lead to these changes? What's the added value of your project in this process of change?*

- c. *What do you think will be the major bottlenecks and catalysts?*
- 2. Long term transformations to which the project contributes
 - a. *Think about transformations by 2050: What transformations do you foresee? How do you see your project contributing to these transformations?*
 - b. *What do you think is needed or what do you think should happen after the project that will contribute to these transformations?*
- 3. Construction of the project
 - a. *I am interested in the history of the proposal. Can you tell me about how and when the ideas in the proposal emerged?*
 - b. *I would like to know about the influence of the zero-pesticide objective on the project. Was this upfront in your minds when the idea for your project began emerging? Did you shape or construct your project in a different way as to contribute to this objective?*
- 4. Actors (network of knowledge production) – who is important for the project
 - a. *In your proposal you indicate... [use challenge from proposal in relation to **pest**]. Your project is responding to this challenge: who do you think are important to help your project in this challenge?*
 - b. *Who do you think are important to help your project reach the short-term and longer-term changes that you see your project contributing to? Are they project partners or others who are not part of project, but could influence or are affected by the results of the project?*
 - c. *What do you think will be their contributions to the project? When will they get involved or contribute to the project, from the beginning, or even after the project?*

Annex II – Transformations Table at T₀

Output de la recherche	Changements/transformations de court terme initiés par ces résultats chez les acteurs et dans la société	Conséquences mesurables de ces transformations/changements.	Changements/transformations de long terme chez les acteurs et dans la société
Démonstrateur d'un capteur olfactif artificiel (<i>PheroSensor</i>)	<ul style="list-style-type: none"> • Détection précoce des invasions • Traitement précoce, plus précis (meilleure temporalité, localisation) • Substitution des pièges à phéromone • Amélioration des effets du biocontrôle lié à la prévention de la reproduction • Nouveau marché de capteurs 	<p>Politique : Amélioration de la stratégie nationale et internationale de pilotage de l'épidémiosurveillance</p> <p>Economique : pertes évitées de cultures sinon détruites par des insectes (agriculteurs) ; gains économiques liés à la commercialisation des capteurs (industrie des capteurs à olfaction artificielle)</p> <p>Environnemental : diminuer les dommages écologiques dans l'agriculture, les zones forestières, urbaines et périphériques</p> <p>Sanitaire :</p> <p>Social : réduction de main d'œuvre en champs ; création d'emplois</p>	<ul style="list-style-type: none"> • Contrôler les invasions d'insectes dues au changement climatique et à l'intensification des échanges commerciaux • Une généralisation de l'usage de l'olfaction artificielle dans le domaine de la santé animale et humaine
Nouvelles approches technologiques pour développer des semences saines (sans pathogènes) (<i>SUCSEED</i>)	<ul style="list-style-type: none"> • Nouvelles approches de traitement des semences avec des solutions basées sur le microbiote, l'exsudation et le système de défense • Nouveaux modes de production des semences • Nouveaux marchés • Nouvelles pratiques aux champs, nouvelles gestion des cultures • Nouvelles semences sans pathogène • Changements de réglementations 	<p>Politique : nouvelles procédures d'évaluation et de qualification des produits biologiques</p> <p>Economique : gains économiques liés aux nouveaux marchés (nouvelles semences)</p> <p>Environnemental : élimination des fongicides utilisés sur les semences ; réduction des pesticides en champs ; baisse des dommages écologiques liés à une forte réduction des pesticides</p> <p>Sanitaire : baisse des effets néfastes sur la santé humaine</p> <p>Social : acceptabilité de semences incluant des produits issus du biocontrôle par les agriculteurs, les semenciers et les consommateurs ; nouvelles</p>	<ul style="list-style-type: none"> • Les semenciers produisent des semences sans pathogènes pour de nombreuses variétés • Des consommateurs pleinement sensibilisés sur la production de semences sans pesticide • Une alimentation sécurisée

<p>Nouveaux concepts, outils, guides et approches sur les interactions plantes-microbiote (DEEP IMPACT)</p>	<ul style="list-style-type: none"> ● Amélioration du management des systèmes agricoles : ● Nouvelles pratiques pour améliorer la biodiversité des sols ● Services écosystémiques basés sur le microbiote ● Développement de nouvelles solutions de biocontrôle (agents, inoculum) par des entreprises de biocontrôle (nouveaux marchés) ● Développement et sélection de nouveaux idéotypes de plantes qui interagissent avec le microbiote associé (nouveaux marchés pour les semenciers). 	<p>opportunités d'emplois dans l'industrie et la recherche</p> <p>Politique : Nouveaux outils permettant de maintenir ou renforcer la biodiversité pour les services écosystémiques</p> <p>Economique : Moins de pertes de récoltes ; gains économiques liés aux nouveaux inoculants ou aux nouvelles solutions de biocontrôle ; gains économiques liés aux nouveaux idéotypes ; atténuation des risques socio-économiques ;</p> <p>Environnemental : réduction de la contamination environnementale par les pesticides ; augmentation de la biodiversité (fonctionnelle) ; amélioration de la qualité des sols ; résilience des plantes au stress biotique</p> <p>Sanitaire : moins de risques pour la santé ;</p> <p>Social : Renforcement des collaborations multi-acteurs (capital social) ; renforcement de l'autonomie des agriculteurs (moins dépendants des apports extérieurs) ; Sensibilisation des citoyens sur l'importance de la biodiversité des sols pour une agriculture durable</p>	<ul style="list-style-type: none"> ● Seconde révolution verte ● Agriculture personnalisée/de précision ● Des consommateurs pleinement sensibilisés sur le rôle de la biodiversité des sols pour une agriculture durable ● Synergies entre la production agricole, la biodiversité fonctionnelle des sols et les services écosystémiques ● Compétitivité accrue de la production française d'alimentation humaine et animale et d'énergie (sur toute la chaîne de valeur) ● Emergence de nouveaux acteurs et activités industrielles ? ● Ajustement de la réglementation européenne sur les OGM
<p>Des modèles de simulation et des expérimentations sociales pour une meilleure définition des politiques menant vers le 0 pesticides, et des outils d'apprentissage collectif pour la gestion intégrée des nuisibles à l'échelle des filières et des territoires (FAST)</p>	<ul style="list-style-type: none"> ● Modification d'instruments de politique publique existants ou mise en œuvre de nouveaux instruments (ou de nouvelles combinaisons d'instruments) pour réduire l'usage des pesticides et augmenter la consommation de produits sans pesticides : instruments économiques (taxes, subventions, programmes d'accompagnement technique) et instruments règlementaires (législation, normes, labels) ● Mise en œuvre de solutions organisationnelles (structures collectives, réorganisation verticale des chaînes de valeurs) 	<p>Politique : Nouvelles procédures/règles d'allocation des financements ; Nouveaux designs de politiques publiques ; des instruments de politiques publiques plus efficaces</p> <p>Economique : redistribution des gains économiques le long des chaînes de valeurs ; un meilleur partage des risques le long des chaînes de valeurs ; gains économiques liés aux produits issus de pratiques culturelles plus soutenables ; pertes économiques induites par une augmentation de certaines taxes ou restrictions</p>	<ul style="list-style-type: none"> ● Une agriculture économiquement durable et socialement acceptable ● La valorisation d'une agriculture respectueuse de l'environnement et de la biodiversité. ● Adoption par les agriculteurs de formes alternatives de protection soutenables des cultures

		<p>Environnemental : une baisse de la contamination des sols et de l'eau ;</p> <p>Sanitaire :</p> <p>Social : plus forte capacité d'action collective (alliances verticales et horizontales dans les chaînes de valeur) ; effets sur les paysages</p>	
<p>Connaissance sur les fonctionnements et la transition agroécologique du secteur vitivinicole: nouvelles options de managements agroécologiques, chemins critiques vers le zéro pesticide</p> <p>(VITAE)</p>	<ul style="list-style-type: none"> • Création de nouveaux réseaux multi-acteurs et interdisciplinaires • Amélioration des méthodes existantes de contrôle de maladies • Développement de nouvelles options de biocontrôle • Nouveaux marchés pour les vins issus des nouvelles variétés • Nouveaux marchés pour les nouvelles variétés de cépages résistants, • Changement des pratiques managériales agroécologiques des systèmes viticoles • Nouvelles politiques et nouvelles normes 	<p>Politique : influence le débat politique et la formulation de nouvelles normes et instruments</p> <p>Economique : production accrue de vin (moins de pertes); gains économiques liés à la vente de vin de qualité accrue sans pesticides ; gains économiques liés aux nouvelles solutions de biocontrôle (inoculant) et génétiques (production de variétés) ;</p> <p>Environnemental : baisse des effets négatifs des pesticides sur l'environnement</p> <p>Sanitaire : baisse des impacts négatifs sur la santé des citoyens, consommateurs et viticulteurs</p> <p>Social : amélioration des conditions de vie des citoyens habitant à proximité des vignes;</p>	<ul style="list-style-type: none"> • Une production de vin durable • Des exploitations viti-vinicoles économiquement viables sans l'usage de pesticides
<p>Connaissances agroécologiques, agronomiques, biologiques et socio-économique et des méthodes de conception (outils de concertation territoriale, de diagnostic sociotechnique, de créativité, d'évaluation) : pour co-construire des territoires sans pesticides.</p> <p>(BE CREATIVE)</p>	<ul style="list-style-type: none"> • Nouveaux systèmes de cultures diversifiées (introduction de nouvelles espèces) • Nouvelles mesures de biocontrôle • Nouveaux modes de commercialisation, distribution et production • Nouveaux canaux d'approvisionnement locaux vers les villes (ou intra territoire) • Renforcement des collaborations de l'amont vers l'aval dans les territoires • Transformer les territoires • Construction des territoires « vitrine » pour la démonstration de solutions vers des territoires sans pesticides 	<p>Politique : Nouveaux instruments de politiques pour la gestion des paysages/territoires</p> <p>Economique : modification des gains économiques induits par les nouveaux modes de production et distribution ; réduction des inégalités de revenu dans la chaîne de valeur ; Nouveaux débouchés économiques pour de nouvelles espèces cultivées</p> <p>Environnemental : augmentation de la biodiversité en parcelles agricoles; baisse de la pollution des sols et eaux ; réduction des risques d'avoir des bioagresseurs ; baisse des IFT territoriaux</p> <p>Sanitaire : amélioration de la santé pour les agriculteurs et les citoyens ; le maintien ou</p>	<ul style="list-style-type: none"> • Une agriculture moins industrialisée • Coexistence de diverses formes d'agriculture • Une production agricole réduite en volume • Une agriculture sans pesticides rentable • Acceptation pour les consommateurs de mieux rémunérer une agriculture sans pesticides • Consommation relocalisée • Petites structures industrielles agro-alimentaires et de transformation centrée sur des produits locaux

	<ul style="list-style-type: none"> • Nouveaux modes d'évaluation (toujours multicritère) mais à différentes échelles 	<p>l'amélioration de la qualité sanitaire des aliments (locaux)</p> <p>Social : Autonomie des agriculteurs ; développement territorial, effets sur le paysage ; des nouveaux équilibres et relations dans les territoires (Attention à la favorisation et à l'exclusion)</p>	<ul style="list-style-type: none"> • Transformation des grands groupes agroalimentaires avec des cahiers de charges modifiés • Une industrie plus agile • Transformer les relations entre citoyens et agriculteurs et les relations à l'espace agricole et non agricole : cesser d'opposer agriculture et milieu naturel • Des agriculteurs – expérimentateurs qui essaient des innovations agronomiques et de nouvelles formes de commercialisation ou qui y contribuent • Des citoyens mieux informés sur le travail des agriculteurs
<p>Connaissances permettant d'augmenter la diversité intra-parcelle des espèces et variétés : modèles écophysiologiques, interaction plantes-plantes, outils moléculaires et schémas pour sélection, et nouvelles méthodes statistiques et participatives de sélection et d'évaluation.</p> <p>Connaissances en SHS et scénarios sur la réglementation des semences, sur la recherche en sélection des plantes et les services de conseil agricole. (MoBiDiv)</p>	<ul style="list-style-type: none"> • Evolution des schémas de sélection vers des variétés plus adaptées au mélange (sélectionneurs et réseaux d'agriculture participative) • Nouvelles manières de réaliser des mélanges (par les coopératives, les sélectionneurs, les agriculteurs et les trieurs) • Emergence d'une nouvelle activité professionnelle des assembleurs de variétés, à l'interface entre sélection/recherche/activité agricole • Changement de réglementation pour favoriser les mélanges • Augmentation de l'adoption des mélanges par les agriculteurs • OAD pour choix des variétés à assembler • L'émergence d'une activité de conseil sur les associations de variétés et d'espèces • Changement de réglementation et financement pour la coexistence sélection privée et sélection participative, en faveur de la diversification et du mélange des cultures • Changement de culture : meilleure reconnaissance des rôles mutuels des sélectionneurs privés et participatifs 	<p>Politique : Evolution de la réglementation sur l'inscription des variétés ; modes alternatifs de financement de la recherche et du conseil</p> <p><i>Au niveau du programme PPR</i> : durcissement des règles sur l'utilisation des pesticides, taxation pour l'impact environnemental et santé humaine</p> <p>Economique : gains économiques sur la vente de variétés adaptées au mélange ; gains économiques sur la vente de mélanges ; impact négatif sur la vente de produits phytosanitaire ; création de nouvelles activités économiques : conseil sur les associations de variétés et d'espèces, assembleurs de variétés ; impact pour les agriculteurs : augmentation de la marge, stabilisation ou croissance des rendements, minimisation du risque, augmentation de la qualité des produits (plus de protéines)</p> <p>Environnemental : baisse de la pollution des sols et eaux ; réduction des risques d'avoir des bioagresseurs ; diminution de l'utilisation de produits phytosanitaire ; augmentation de biodiversité « sauvage associée aux cultures » ; amélioration de la fertilité des sols ; Impact positif sur la qualité de l'air</p>	<ul style="list-style-type: none"> • Moins de maladies et bioagresseurs • Cultures mixtes (mélanges et cultures pures) • Moins de fongicides, forte réduction des pesticides • Pour les espèces en production mélangées : augmentation et stabilité de la production • Nouveaux paysages • Co-existence (et plus une opposition) de la sélection privée et participative avec appui et financement pour les deux • Les attentes des consommateurs concernant les cultures basées sur la biodiversité

	<ul style="list-style-type: none"> • Modification des critères sur le marché de la meunerie (coopérative) • Evolution de l'activité de collecte, de tri ; de transformation-commercialisation et d'étiquetage des produits mélangés • Modification des rapports de force entre semenciers et coopératives sur les «trademarks» des mélanges 	<p>Sanitaire : Impact positif sur la santé des agriculteurs et des citoyens</p> <p>Social : consolidation et reconnaissance accrues des réseaux de sélection participative ; coexistence accrue entre les différents types de sélectionneurs (privé et participative)</p>	
<p>A multifactor ES framework based on new epidemiological indicators on early pathogen prediction (beyond direct observation of pathogens), new decision processes and rationale for prophylaxis (BEYOND)</p>	<ul style="list-style-type: none"> • Early prediction of pathogens • Increased time for prophylactic practices • Novel prophylaxis • Increased sharing of data and knowledge to farmers and other stakeholders • Change in the attitude of consumers • Change in (national) surveillance plans and strategies for pathogen detection • Improved risk assessment • Development of decision-making tools and strategies on farms 	<p>Politique : enhanced surveillance strategies for pathogen detection ; improved regulation on the movement of plant material</p> <p>Economique : Less significant economic losses due to pests and pathogens</p> <p>Environnemental : Reduced environmental impacts</p> <p>Sanitaire : Increased plant health</p> <p>Social : Increased trust in science by the public ; transparency in knowledge flows and open science</p>	<ul style="list-style-type: none"> • Global governance on management of natural resources (e.g. watersheds) and on the movement of plant material • Changes in the Research and Knowledge regime in epidemiology: a change in content, research practices and training of the epidemiology of plant diseases and the "life cycles" of plant pathogens
<p>Connaissances scientifiques sur les différents leviers d'immunité des plantes et leurs synergies ou antagonismes (interactions entre la plante, les bio agresseurs et les mécanismes) et leur faisabilité et acceptabilité socio-économique.</p> <p>Outils pour la création variétale (marqueurs liés à des locus de réponse aux leviers et à des QTL de résistance) (CAPZEROPHYTO)</p>	<ul style="list-style-type: none"> • Développement des systèmes de cultures innovants basés sur les traits d'immunité des plantes • Développement de nouvelles stratégies de protection intégrée des cultures basées sur l'immunité agroécologique des plantes • Mise sur le marché de variétés répondant efficacement aux leviers promus dans le cadre du projet • Nouvelles opportunités pour les technologies comme le biocontrôle • De nouvelles opportunités pour les labels de produits • Meilleure protection contre une plus grande variété de bioagresseurs 	<p>Politique :</p> <p><i>Au niveau du programme PPR :</i> Normes plus sévères en termes de contamination par des résidus de pesticides ; Interdiction des pesticides les plus nuisibles pour la biodiversité ; Diminution des IFT</p> <p>Economique : gains économiques issus des solutions de biocontrôle ; gains économiques de produits vendus sous des labels ; réduction ou stabilisation de la production</p> <p>Environnemental : Préservation/augmentation de la biodiversité ; baisse des contaminations environnementales ; diminution des pesticides</p>	<ul style="list-style-type: none"> • Des vergers reconçus pour utiliser les leviers immunitaires • Diffuseurs de composés volatiles pour lutter contre les bioagresseurs ou attirer des auxiliaires • Une augmentation significative des surfaces agricoles cultivées en agriculture biologique ou, <i>a minima</i>, sans pesticides.

	<p>Sanitaire : risques sanitaires moindres pour l'applicateur et le consommateur</p> <p>Social : meilleure information des citoyens</p>
<p>Knowledge and resources for breeding grain legume varieties for pesticide free-system and knowledge on the performances of legume-rich cropping system prototypes tested in pesticide-free contexts. (SPECIFICS)</p> <ul style="list-style-type: none"> ● Evolution and awareness about the performance of the re-design of farming systems ● Diversification of farming systems ● Increased interdisciplinary collaboration ● Development of multi-resistant breeding lines ● Development of learning tools to guide farmers and advisers in the design and the adaptive management of farming systems ● Awareness for agrifood firms on the global legume market development, especially for small and middle firms to think about their competitive position on this market ● Consensus on the main conditions to shift towards free-pesticide and legume-rich agriculture ● Shift in stakeholders' beliefs on the possibility of free-pesticide transition ● Free-pesticide production and consumption increase 	<p>Politique : policies to promote production and consumption of grain legumes; new registration criteria and assessment methods for varieties suitable for pesticide-free systems</p> <p>Economique : Decreased reliance on importation of plant protein ; reduced crop yield loss from pests; overyielding with new varieties and/or reduced production costs may increase profitability; more legume-based food product innovations developed by firms in France; more investment from private R&D on pesticide-free solutions;</p> <p>Environnemental : Increased biodiversity; improved soil fertility; increase nutrient cycling; reduced greenhouse gas emissions; reduced water pollution; more engagement of firms in environmental-friendly claims; development of new labels</p> <p>Sanitaire : Decrease negative effect of pesticides on farmers' and public health ; increased plant-based supply of proteins in human food and more balanced sources of proteins in consumption (between animal and plant-based ones)</p> <p>Social : Improved interdisciplinary collaboration ; recognition on free-pesticide agriculture benefits</p> <ul style="list-style-type: none"> ● Multi-resistant grain legume cultivars ● Market transformation – change in demand and supply side of grain legumes ● Transition towards the redesign of pesticides-free, legume-rich farming systems ● Competitive advantage for French agricultural and food firms on domestic and global free-pesticide markets self ● Self-sufficiency of France in plant-based protein demand, particularly through legume development both for food and feed ● Less animal-based consumption and more plant-based consumption; regular/daily consumption of legumes

Annex III – Codebook data analyses

Category	Codes	Code description									
RRI dimensions	Anticipation	A description of what and how is being anticipated by the research project – relation to the/a desired future and how this is acted today (Hence it contains an act or action) . For example, towards certain outcomes, results, impacts, goals or a mission. How is this anticipation described in the design of the research agenda and research activities?									
	Reflexivity	A description which contains reflections on the research project itself - ' self-reference ' on the research design, process, activities, data collection, conclusions, outcomes etc.; contains a cause and effect/consequence . Such as the role of the researchers, the roles and influences of others, norms, values, beliefs, challenges, needs and what is done with this knowledge/reflections/ideas.									
	Inclusion	A description on the involvement of external stakeholders. For instance, who the other stakeholders are, why they should be involved and how they are expected to be involved.									
	Responsiveness	A description on the response of the researcher to a situation, problem, challenges or change. For example, if the context of the research changes - such as new insights, norms, ideas or values – how does the projects respond to this. Or a response to societal challenges. Compared to anticipation it's not about an expected future, but a response to a situation happening at that point in time. (also contains an action)									
Impact Pathway	Input	The productive configuration of the research project									
	Output	The expected research outcomes of the research projects									
	Intermediaries	The intermediary phase between research outcomes and transformations: who are the key (external) actors necessary for to result into impacts? How will they take up the output?									
	Transformations and impacts	<table border="0"> <tr> <td>Scientific</td> <td rowspan="5">and</td> <td>Definition of the desired futures and targeted transformations (in the six dimensions). What is expected to be changed at the end of the project?</td> </tr> <tr> <td>Economic</td> </tr> <tr> <td>Social</td> </tr> <tr> <td>Environmental</td> </tr> <tr> <td>Health</td> </tr> <tr> <td>Political</td> <td></td> </tr> </table>	Scientific	and	Definition of the desired futures and targeted transformations (in the six dimensions). What is expected to be changed at the end of the project?	Economic	Social	Environmental	Health	Political	
	Scientific	and	Definition of the desired futures and targeted transformations (in the six dimensions). What is expected to be changed at the end of the project?								
Economic											
Social											
Environmental											
Health											
Political											
Science	A description of what should be in place in the scientific part of the project as well as in other existing research projects towards the expected transformations.										
What is needed: STeaM UP	Technology	<p>A description of what should be in place on the level of technologies towards the expected transformations.</p> <ul style="list-style-type: none"> Is there a need for other technologies? 									

		<ul style="list-style-type: none"> • Should there be new technologies invented, are there already technologies existed and they are at scale? • What should be in place for the transition from pilot technologies or proof of concepts to industrialization (TRL)?
	Market	<p>A description of what should be in place on the market level towards the expected transformations.</p> <ul style="list-style-type: none"> • Do market channels already exist or should new markets be created? • Are existing markets sufficient or constrained? • What market infrastructures are requires (e.g. standards, label, distribution channels, business model)?
	User context	<p>A description of what should be in place in the user context towards the expected transformations.</p> <ul style="list-style-type: none"> • Who are the concerned users of new R&I outcomes: farmers, consumers, intermediaries, industrial users • What are users' awareness, prices, practices, willingness, concerns etc. that should be considered?
	Policy	<p>A description of what should be in place in policy and governance structures towards the expected transformations.</p> <ul style="list-style-type: none"> • Should there be new regulations or policy frameworks? • Does it require individual or collective incentives such as subsidies or taxes? • Is local/territorial/national or global coherence required?
Practice Theory for zero pesticides	Practice change	Changes in practices which are envisioned towards the expected transformations. Not only in science, but in the entire bundle of practice towards a zero pesticides future, such as farming, consumers, technology, policy making etc.
	Practicing actor	A description of the actor who is (or should be) practicing the practice change.
	Material component	<p>A description of the contribution of a material component to a practice change, e.g. bodies, things, technologies, and tangible physical entities.</p> <ul style="list-style-type: none"> • Towards which practice change does it contribute? • What does this material component include? With what goal?
	Competence component	A description of the contribution of a competence component to a practice change, e.g. skills, know-how, techniques. Towards which practice change does it contribute? What does this competence component include?
	Meaning component	A description of the contribution of a meaning component to a practice change, e.g. symbolic and social significance. Towards which practice change does it contribute? What is the significance of this meaning?
	Pesticides elimination	Eradication of pesticides

	Function of pesticides	A description of what function towards pest management is expected to change to eliminate pesticides, e.g. plant resilience, prophylaxis, natural defence system.
Stakeholder involvement in Research	Stakeholders for input phase	A description of external stakeholders who are needed for the inputs of the research projects, for example towards the provision of data, models, funding, existing knowledge, breeding lines etc. (e.g. through workshops). Who are the stakeholders? How are they expected to get involved? Why should they be involved – what is their expected contribution to the research project?
	Stakeholders in data collection	A description of external stakeholders who are necessary for data collection and results of the research projects, for example the willingness to pay of consumers, farmer preferences, etc. Who are the stakeholders? How are they expected to get involved? Why should they be involved – what is their expected contribution to the research project?
	Stakeholders for output phase	A description of external stakeholders who are necessary in the output phase of the research project, for example field demonstrations to potential users, co-authors, dissemination of results, testing/discussing of (pilot) results, etc. Who are the stakeholders? How are they expected to get involved? Why should they be involved – what is their expected contribution to the research project?
	Usefulness	A description or statement which contains the opinion of participating researchers on the usefulness of the ASIRPA activities. How they think it will be helpful or contribute (or not) to their research projects.
Responses to ASIRPA RT	Legitimacy	A description or statement about the legitimacy of the researchers with regard to the activities of ASIRPA. Do the researchers feel legit or not in reflection on the different phases of the Impact Pathway? [including insecurities on their ASIRPA work]
	Motivation	A description of statement on the motivation of the researchers in participating in ASIRPA. Why, or why not, are they motivated to participate?

Annex IV – Endnotes: French Translations of quotes

ⁱ Le plan Ecophyto a ainsi été lancé en 2008 avec l'objectif de réduire de moitié en 10 ans les usages de pesticides en agriculture. Cet objectif n'a pas été atteint. L'utilisation des produits phytopharmaceutiques en agriculture a continué d'augmenter entre 2008 et 2018. Aujourd'hui, l'impact des produits phytosanitaires sur l'environnement et la biodiversité, ainsi que leurs effets sur la santé humaine, sont de mieux en mieux documentés et inquiètent l'ensemble des citoyens. Cette situation a conduit le Gouvernement à accélérer l'action visant à réduire l'usage des produits phytosanitaires en agriculture et à renforcer les moyens mis dans la Recherche pour trouver des alternatives. Le Programme Prioritaire de Recherche (PPR) « Cultiver et Protéger Autrement » s'inscrit dans ce contexte.

ⁱⁱ produits de l'agriculture n'utilisant pas de produits chimiques de synthèse, dite « agriculture biologique »

ⁱⁱⁱ I. - Une politique d'enseignement, de formation permanente, de recherche et de développement ayant pour objectifs prioritaires :

- l'accroissement de la productivité et de la compétitivité de l'agriculture, des industries agro-alimentaires et agro-énergétiques ;

- une plus grande indépendance, par la réduction des coûts des facteurs intermédiaires de production et des matières premières importées ;

- la prévision et l'analyse des évolutions technologiques, économiques et structurelles et la définition des conditions d'adaptation aux données nouvelles.

^{iv} Les accords conclus dans le cadre d'une organisation interprofessionnelle reconnue peuvent être étendus, pour une durée déterminée, en tout ou partie, par l'autorité administrative compétente, lorsqu'ils tendent, par des contrats types, des conventions de campagne et des actions communes conformes à l'intérêt général et compatibles avec les règles de la politique agricole commune, à favoriser :

la réalisation de programmes de recherche appliquée, d'expérimentation et de développement, notamment dans les domaines de la qualité des produits et de la protection de la santé et l'environnement.

à la cohérence des actions menées en matière de recherche, d'expérimentation et de développement agricole, en liaison avec l'Association nationale pour le développement agricole.

^v La recherche agronomique et vétérinaire concourt au développement et à la compétitivité de la filière agricole et du secteur de la transformation des produits agricoles. Elle répond en priorité aux impératifs de la gestion durable de l'espace rural, de la valorisation de la biomasse, de la sécurité et de la qualité des produits alimentaires et de la préservation des ressources naturelles mondiales. Elle s'appuie sur le développement de la recherche fondamentale.

Elle est conduite dans les organismes publics exerçant des missions de recherche et les établissements d'enseignement supérieur. Les instituts et centres techniques liés aux professions et les centres d'innovation technologique répondant à des conditions fixées par décret y concourent. Les entreprises de la filière agricole et de la transformation des produits agricoles peuvent également y concourir. Le ministre de l'agriculture assure conjointement avec le ministre chargé de la recherche ou, le cas échéant, avec d'autres ministres intéressés, la tutelle de ces organismes publics exerçant des missions de recherche.

Le ministre de l'agriculture assure la coordination des activités de recherche agronomique et vétérinaire et veille à leur adaptation aux objectifs de la politique agricole.

Les organismes publics de recherche exercent auprès des pouvoirs publics une mission d'expertise, notamment dans les domaines de la préservation de la santé publique et de l'environnement. A ce titre, ils contribuent à l'identification et à l'évaluation des risques en matière de sécurité sanitaire des produits agricoles et de protection des ressources et milieux naturels.

L'évaluation de la recherche agronomique et vétérinaire repose sur des procédures d'appréciation périodique portant à la fois sur les personnels, les équipes, les programmes et les résultats.

^{vi} Le plan Ecophyto 1 n'est pas entré dans cette logique : ciblant essentiellement les agriculteurs et la R&D, il ne prévoyait rien pour inciter les sélectionneurs, les filières, les transformateurs, la grande distribution ou les consommateurs à changer leurs stratégies et leurs pratiques.

^{vii} L'ambition du plan Ecophyto, mais aussi son échec vis-à-vis de la réduction du NODU, invitent à repenser l'accès des agriculteurs aux connaissances et l'organisation du développement agricole.

^{viii} Les parties prenantes s'accordent à considérer que la recherche et l'innovation ont une contribution essentielle à apporter à cette transformation de la protection des cultures, mais cela passe par un

renouvellement des priorités et des méthodes pour répondre aux besoins nouveaux qui ont émergé du fait d'Écophyto : besoin d'explorer des champs de connaissances jusque-là négligés (tels que le lien entre système de culture et bioagresseurs ou entre biodiversité et régulation naturelle, mais aussi la dimension socioéconomique du changement et le rôle des politiques publiques) ; besoin de renforcer l'armature scientifique et méthodologique sur laquelle s'appuient les grands dispositifs du plan (épidémiosurveillance, réseaux Déphy,...) ; besoin de remettre sur le métier, dans le contexte du changement des pratiques promu par le plan, des questions liées aux méthodes de lutte (telles que l'innovation

^{ix} Son objectif premier est d'améliorer l'apprentissage en cours. Elle est complémentaire des activités de prospective et se fonde sur une identification des résultats scientifiques et de leurs éventuels premiers effets ainsi que sur le suivi des évolutions de l'environnement du programme. L'évaluation permettra ainsi à la fois de mesurer les impacts du programme et d'aider à sa gouvernance.

^x Il semble impossible que le NODU ait baissé avec une hausse des quantités de pesticides écoulées. L'indice de référence a donc plus vraisemblablement augmenté entre 2011 et 2012.

^{xi} Ce dispositif est conçu pour développer des solutions de remplacement agronomiques et technologiques aux pesticides et les déployer ensuite vers les agriculteurs. Mais les travaux sur les impacts des pesticides sur la santé humaine et environnementale et les coûts que ceux-ci impliquent pour la société sont exclus des appels à projets.

^{xii} L'analyse des effets et des impacts des pesticides doit être portée par la recherche publique, en toute indépendance et transparence, au service des citoyens et citoyennes et au nom du bien commun de la préservation de la nature et de ses écosystèmes.

^{xiii} Ces projets visent à la mise en place d'un dispositif renforcé d'épidémiosurveillance reposant sur le développement de méthodologies, d'outils et d'indicateurs appropriables par les agriculteurs et les acteurs du développement agricole.

^{xiv} Afin de permettre l'émergence ou le renforcement des compétences nécessaires à la transformation des systèmes agricoles et aux nouveaux métiers y afférant.

^{xv} On a besoin de l'équipe ASIRPA, pour avancer. On a besoin de relance, on est submergé de plein de choses. Et donc, il faudra que vous présentation et super gentil. Et continuer comme ça, c'était bien. Mais voilà, on a besoin de ces relances pour avancer.

^{xvi} Ce qui est intéressant, c'est que ça nous a permis de réfléchir vraiment aux acteurs et on et leur rôle. Moi, je crois que c'est assez intéressant de voir un peu est ce qu'on avait bien identifié toutes les personnes qui pouvaient être intéressées par les sorties du modèle et je pense que ce n'est pas peu dire aussi que dans la com qu'on va faire au cours du projet, etc. On a déjà en tête ce schéma là et ça peut nous aider à cibler finalement un peu plus finement le chemin d'impact du projet

^{xvii} Sur cet exercice c'est très bien. Il n'y a pas mal de choses qui ont été dites. Ça va servir à compléter le chemin d'impact déjà existant, comme a dit [nom] qu'on va travailler c'est plus...parce que l'idée, ce n'est pas de faire un chemin d'impact pour faire un chemin d'impact, c'est bien de s'en servir pour arriver au but visé aux objectifs visés. Donc, on va intégrer tout ça de manière à pouvoir construire ce plan d'action. Le plan stratégique et identifier les personnes à contacter la manière dont il faut procéder pour lever les verrous identifiés. Et on a pas mal. Donc il reste encore du travail à abattre et du coup, pour ça. L'idée, c'est de le faire avec l'ensemble des parties prenantes du projet. Donc, chacun ayant son expertise. Et voilà. Donc je pense qu'ensuite on reviendra vers chacun avec toutes ces informations digérées

^{xviii} Alors moi, j'ai participé déjà à un premier webinaire où j'ai présenté Pherosensor, dans un webinaire national. Mais il y avait énormément de boîtes phytosanitaires techniques. Voilà, on est invité tous les deux. Emmanuel et moi au Webinaires un peu dans la même mouvance, donc on commence à diffuser. C'est juste un début. Je ne suis pas en train de dire on a fait tout ce qu'il fallait, pas du tout du tout. Mais je crois qu'on est là, comme dit [nom], pour identifier des actions. Et puis pour, je crois que le rôle de ASIRPA, pas celle de nous empêcher de nous endormir et de rester sur nos impacts académiques. Comme je disais de toujours réfléchir, on aussi en termes de pouvoir, de transfert vers des réalités socio-économiques et politiques et autres

^{xix} Et effectivement, du coup, sur l'exercice n'est pas facile à faire dans le sens où on est encore au début du projet. On n'a pas beaucoup de choses qui se soulèvent parce que on le retrouve sous les verrous des besoins qu'on retrouve de manière générale dans biocontrôle ou dans des biocontrôle qu'on trouve dès qu'on parle de stimulation biostimulant, etc. Mais de toute façon, ça évoluera aussi. Comme tu le précisait en début de réunion, ça évoluera dans le temps et ça sera enrichi.

^{xx} Je pense que c'est peut-être trop tôt à ce stade, ça n'empêche pas de l'identifier, en tout cas. En tout cas, je prospecté chez nous. Effectivement, ça fait partie de notre façon de procéder au CUA et qu'on développe une nouvelle technologie. C'est la première chose qu'on regarde, c'est est ce qu'on va être capable ? Est-ce que quelqu'un va être capable de produire ? Et parce qu'effectivement, si on a une super techno, mais qu'on ne sait

pas produire, il y a parce qu'il n'y a pas de filière ou quoi que ce soit, ça va être forcément un frein au ou à l'exploitation

^{xxixi} Donc on lance des invitations, on aura un premier échange et donc on a décidé d'essayer d'avoir ces rencontres-là de manière annuelle. Et je pense que là, dans la manière d'échanger et d'avoir des retours, d'afficher un certain nombre de choses, on peut affiner cette vision de l'impact, du chemin d'impact et après, il faut faire des choses avec des acteurs. Donc voilà, c'est bien d'avoir le chemin, mais après, il faut en décliner. Des actions, quoi ?

^{xxii} Cette ambition va donc bien au-delà des enjeux sous-jacents à la plupart des projets de recherche et recherche appliquée conduits à ce jour et conduit à explorer des champs de recherche inédits. Se fixer un tel cap permet de développer dès aujourd'hui des connaissances pour avoir demain les solutions permettant de répondre à la demande de la société d'une agriculture sans pesticides. Il oblige à un changement de regard pour promouvoir une avancée sur des fronts de science porteurs mais inédits ou insuffisamment explorés et une évolution des disciplines scientifiques intégrant les nouveaux enjeux et les avancées des autres disciplines.

^{xxiii} Pour nous agriculture sans pesticides, c'est faire le pari qu'on a fait dans le projet, c'est que ça obligeait à penser à une échelle territoriale ou du système agroalimentaire territorial. Je pense qu'il y a encore un peu de flou, mais en tout cas, dire on ne peut pas se contenter de faire de la production de connaissances super fine sur les parcelles ou voir les exploitations.

^{xxiv} Du coup il peut y avoir des effets négatifs sur ces filières-là, très bien organisées aujourd'hui. Et c'est pour ça que je doute en même temps que je vous parle parce qu'elles sont déjà tellement verrouillées, tellement bien organisées que pour les déconstruire, il va falloir que les marchés de niche s'accrochent pour venir bousculer ces modèles dominants là. Notre projet a pour ambition de bousculer ce modèle dominant dans certains territoires pour en faire la démonstration ou pas.

^{xxv} C'est forcément quelque chose qui se pense, qui se construit avec les acteurs de terrain à l'interface entre recherche et action

^{xxvi} C'est un projet qui est en lien avec les instituts techniques pour justement faciliter la transition entre les aspects recherche et les aspects mis en application dans les systèmes de culture. Il y a aussi l'implication, alors là, en tant que partenaire académique, on a aussi prévu de sous-traiter des essais à des stations d'expérimentation, par exemple. Voilà pour être... pour tester l'efficacité de ces leviers dans des conditions de production.

^{xxvii} Cette phase fait partie intégrante du projet, donc, soit en réalisant des enquêtes, des enquêtes sur les pratiques actuelles sur le pommier et la tomate et puis...de faire des enquêtes de faisabilité en fait de l'utilisation de ces leviers dans les systèmes de culture pour les faire évoluer. L'idée aussi, c'est à travers cette enquête de faisabilité, en fait, c'est d'étudier aussi le choix des professionnels.

^{xxviii} Il y a des critères qu'on appelle la DHS - la distinction, l'homogénéité et la stabilité qui vont à l'encontre de l'utilisation de...de semences diversifiées, donc, un des changements qu'on attend du projet, c'est d'avoir une évolution de la réglementation sur l'inscription des semences qui permettent la commercialisation de mélanges, l'inscription ou en tout cas une évolution de la réglementation pour permettre une diversité de l'offre de semences.

^{xxix} C'est une durée de vie de capteur dans les champs. C'est un problème qui va être compliqué à gérer peut-être. Donc ça c'est très technique. [...] Je pense que le projet va justement nous permettre d'optimiser...autant que j'ai des restrictions sur le projet sur l'application en court terme autant que je suis totalement convaincu sur l'importance du projet pour optimiser ce type de capteur l'aura plus opérationnelle et réduire le cout. Alors, réduire jusqu'à niveau acceptable ou économiquement viable...je ne sais pas, mais réduire oui. Et je suis totalement convaincu que tôt ou tard c'est une très bonne stratégie. Je n'ai pas une boule cristal, je peux me tromper, mais je pense que c'est une très bonne stratégie

^{xxx} Je vais dire sans honte : là je glisse sur...je sors de ma zone de confort. Je trouve que là ça peut être intéressant d'avoir vous feedback et d'être en liens avec les autres projets et les autres partenaires. Alors... ma vision des impact, ce que...I am trying to switch to English...the objective is early detection of insect.

^{xxxi} Ce qu'on espère c'est apporter des preuves empiriques et théoriques solides parce que notre projet est tourné vers la quantification des effets. On espère pouvoir apporter un faisceau de présomptions sur l'efficacité d'un groupe d'instruments de politiques publiques. Dans ce groupe d'instruments il y a différentes choses : les incitations économiques et les instruments réglementaires, ce qui est très standard en éco de l'environnement. Notre idée ce n'est pas de réinventer les instruments de politiques publiques qui existent depuis toujours mais c'est de tester leur efficacité en mobilisant les outils méthodologiques les plus récents.

^{xxxii} Alors, le projet a pour but de stimuler l'immunité naturelle des plantes par différents leviers. En particulier des pratiques. Pour atteindre peut-être le zéro pesticide, en tout cas, allez vers ça.

Alors, le projet se fait sur deux espèces majeures. Un modèle qui sent le pommier et la tomate. Et puis, le projet prévoit aussi de regarder l'effet de ces leviers... Sur d'autres espèces cultivées, soit de la famille des Solanaceae, soit de la famille des Rosaceae. Pour essayer de voir si ce qu'on trouve sur Pommier et Tomates peut être transféré à des espèces de la même famille botanique. Je ne sais pas, il faut que je développe plus ?

^{xxxiii} Il peut y avoir des contributions de Fast, des choses qui ont été initiées dans ce projet-là et qui pourront avoir des répercussions très fortes en 2050 ; et ça peut aussi être zéro. Ce projet peut avoir des impacts soit très forts, soit zéro. Est-ce qu'il peut avoir des impacts intermédiaires ? Oui, j'aimerais bien. C'est ce qu'on disait quand on parlait de la programmation nationale d'Ecophyto et du Green Deal de la PAC. Si on peut influencer par nos résultats la manière dont l'argent sera alloué à Bruxelles entre le premier et le deuxième pilier, on serait contents. Mais ça ce n'est vraiment pas immédiat, c'est vraiment à long terme.

^{xxxiv} Il y a de résistance...alors, je ne suis pas un homme du terrain comme vous avez compris. Je suis au départ plus fondamental. Mais, ça me plaît bien, je suis à la fin de ma carrière dans un dizaine année, ça me plaît bien d'être sûr le plus appliqué. Ce que je comprends...ce que je vois, c'est que oui il faut convaincre les agriculteurs, mais je vois aussi que.....comment dire...c'est général...il sont...le plus en plus des gens sont convaincus de bien faire, de aller vers les méthodes plus respectueuses environnementales. Donc on est dans un contexte qui est favorable. L'usage de tout pesticides je crois que tout le monde est d'accord.....maintenant il faut proposer des solutions. À partir du moment qu'on a des solutions tout le monde comprends potentiellement c'est bien, il faut avoir des solutions qui soit économiquement viable. C'est pour ça que j'étais content de pouvoir expliquer qu'on envisageait d'aller vers de réduction de cout de production. Et cette réduction de cout production serais d'autant plus important que l'échelle de production de ce capteur sera large. Alors en suite.....par rapport aux résistances des agriculteurs on n'émet rien dans l'environnement. On ne relâche aucune molécule. On ne fait que détecter la présence de molécule. Donc ça c'est assez facile à expliquer et comprendre je pense.

^{xxxv} C'est d'abord la constitution d'une communauté scientifique qui est centrée sur cette question de la sortie des pesticides. Bien sûr, il y a des gens qui se travaillent dans Pathologie en phyto pathologie, mais il y a aussi des gens qui travaillent sur la génétique, travaillent sur l'économie, en tout cas des réseaux interdisciplinaires. Ça, c'est un premier impact. C'est quand même la création d'une espèce de consolidation, la mise en réseau d'une communauté scientifique centrée sur la sortie des pesticides, avec un impact secondaire qui peut être non seulement se mettre en réseau, c'est à dire capable d'avoir un [objectif] commun, mais surtout de commencer à parler le même langage. C'est à dire à travailler, à s'orienter vers un travail qui ne sera pas achevé d'un seul coup, mais un travail de plus en l'interdisciplinarité.

^{xxxvi} On est parti d'un concept ...d'écologique, l'immunité en fait pour aller vers un concept d'agro écologie, l'immunité en fait, dans lequel on pouvait combiner...l'idée, c'était de combiner ces différents leviers qu'on étudiait par ailleurs dans les différents laboratoires pour aller vers le zéro pesticide

^{xxxvii} Sachant que ...une innovation où plusieurs innovations combinées peuvent avoir des... bénéfices d'un côté, mais en même temps, elles nécessitent par exemple une mise en place, un certain coût, etc. L'idée, c'est de...de faire une analyse, je ne suis pas spécialiste, mais essaie de faire une analyse de choix, des professionnels en tête, pour comprendre ceux qui sont prêts à perdre et pour...pour gagner en aller vers le zéro pesticide.

^{xxxviii} Et actuellement, un verrou important, c'est pour les sélectionneurs, la transformation de leur système d'évaluation avec un système d'évaluation qui est assez lourd et derrière actuellement des marchés qui sont assez faibles. Il y a un verrou central qui est qui est de l'incitation et le financement de la recherche en obtentions végétales. Donc, [nom] parle mieux que moi. Mais le système est centré sur les espèces dominantes du marché sur lesquelles on a un retour d'investissement. Le plus important, donc ça, c'est un verrou central qui va être étudié dans le projet, mais plutôt du côté SHS, financement de la recherche. Comment on peut changer ça? Et il y a le secteur, entre guillemets de la sélection conventionnelle, donc les sélectionneurs privés. Mais il y a tout le volet sélection participative et donc on va travailler cette coexistence des deux filières. Et ce renforcement de la complémentarité entre ces deux filières là.

^{xxxix} Quand on travaille comme ça dans des terrains, ça nécessite encore... pas mal d'agilité parce que les questions qui vont être pertinentes pour le terrain et qui vont permettre de la production de connaissances scientifiques, ce n'est pas forcément celle qu'on a envisagée dès le départ. Il y a une part très inductive dans ces travaux. Et ça, ça colle assez mal à la façon dont la recherche en mode projet, elle, est structurée aujourd'hui. Typiquement, là, on a constitué un consortium avec des disciplines dedans. Et ça se trouve à se rendre compte dans les terrains que les bonnes compétences dans le projet. Il faudrait que le projet Be Creative nous permette de rajouter un partenaire scientifique dont on a besoin d'un anthropologue parce qu'il y a des questions vraiment clés autour de dynamique sociale ou qu'on ne sait pas traiter avec nos moyens et qu'il faudrait pouvoir en rajouter.

^{xi} En fait, on peut assembler quasiment une infinité de mélanges. Étudier les mélanges, c'est très compliqué. Et donc, cette combinatoire-là, une manière de l'approcher, c'est d'essayer de décentraliser l'évaluation et de faire plus confiance... pas plus confiance, mais s'appuyer sur des réseaux, soit de coopérative, soit d'agriculteurs, soit les deux qui expérimentent des mélanges et d'acquérir de l'information et de progresser sur la connaissance des mélanges. Par ce biais-là, il y a des approches participatives sur l'évaluation et aussi sur la sélection. Donc là, c'est pareil. Il y a des méthodes statistiques, des techniques de conception qui sont proposées dans le projet et sur lesquelles on attend un impact fort. Et on espère aussi avoir un impact sur la manière dont ça sera fait.

^{xii} Afin de permettre l'émergence ou le renforcement des compétences nécessaires à la transformation des systèmes agricoles et aux nouveaux métiers y afférant.

^{xiii} Je pense que les impacts du projet ne peuvent pas être à court terme s'agissant d'un projet amont sur la recherche fondamentale. Je pense qu'il faut être clair là-dessus. En revanche, l'idée, c'est d'ouvrir les nouvelles voies de recherche qui seraient sujettes à des innovations futures pour pouvoir atteindre cet objectif de réduction ou d'élimination des pesticides et celui de l'appel d'offres. [...] un impact que on aimerait bien voir c'est vraiment avoir des outils pour piloter ou conseillers, en tous les cas des politiques publiques et accompagner les viticulteurs dans cette transition.

^{xiiii} Au-delà des six ans, c'est une bonne question.

^{xliv} Je vais dire sans honte : là je glisse sur...je sors de ma zone de confort.

^{xlv} On n'a pas organisé le projet comme on aurait pu le faire ou peut être ça se faisait avant, c'est à dire un projet scientifique. En laboratoire, on ferme la porte et six ans après, on ouvre la porte et on se dit Oh là là comment faire pour que ça change des pratiques ? Voilà peut-être ça se poser avant. Je ne crois pas que ça se faisait déjà comme ça, en tout façon pas très fréquentes, mais il y avait un petit peu ce modèle. Il y avait un petit peu ce modèle, aujourd'hui ce n'est plus du tout comme ça qu'on fait de la science. Et en particulier, ce n'est pas du tout comme ça qu'on a conçu ce projet puisque dès le début, on veut que je vous le disse, que les scientifiques se parlent très rapidement et puissent engager un dialogue très en amont avec les parties prenantes, les acteurs de la filière, les consommateurs, les producteurs, l'organisation professionnelle.

^{xlvi} L'intérêt du PPR est de soutenir un effort de recherche dans la durée, par des projets de recherche longs et ambitieux, avec l'objectif de produire des solutions permettant le déploiement d'une agriculture sans pesticides à l'horizon 2030-2040. Il est cependant évident que son impact sera important à plus court terme, à la fois en favorisant la structuration d'une large communauté scientifique autour de cette ambition, et grâce à des livrables intermédiaires ayant une application dans une agriculture en transition.

^{xlvii} Je vais dire quelque chose et je pense que tu seras d'accord, [Nom] et tous les membres d'ASIRPA aussi, l'anticiper c'est aussi éviter d'avoir le nez dans le guidon et d'avoir uniquement les objectifs académiques par tête et d'oublier tout le reste.

^{xlviii} Préservation du patrimoine (palmiers emblématique), maintien du potentiel touristique (e.g. côte d'Azur)

^{xlix} Le développement du marché des biocontrôles/biostimulants et l'adoption de nouveaux modes de productions des semences devraient générer la création d'emplois et permettre aux agriculteurs de se rapprocher d'une indépendance envers les pesticides issus de la chimie grâce à l'implication des réseaux d'expérimentation (ITA, DEPHY, prestataires agricoles, coopératives, ...) mais aussi des industriels, des entreprises spécialisées et des établissements semenciers. Ces impacts sociaux sont étroitement liés à des impacts économiques et environnementaux. En effet, l'essor de ces innovations pourrait engendrer des gains économiques non négligeables et le développement d'entreprises (e.g. start-up, fusion-rachat, extension d'activité interne) ce qui induira sûrement une mise en concurrence plus fortes des entreprises positionnées sur le marché des semences et des traitements de semences. Sur le plan environnemental, ce déploiement aura pour conséquence la réduction voire l'arrêt de l'utilisation de pesticides conventionnels (fongicides) par les agriculteurs et donc la baisse des dommages environnementaux liés à l'usage de ces produits.

ⁱ Une agriculture plus diversifiée, moins dépendante aux phytos et mieux valorisée (label, circuits courts, plus forte rémunération, pression sociale du citoyen) notamment à l'échelle territoriale puis nationale ce qui lui permet d'être moins à la recherche de volumes tout en étant beaucoup plus rentable.

ⁱⁱ Les premiers effets sur la biodiversité fonctionnelle du sol pourraient se faire sentir bien que nous n'ayons à ce jour aucun recul sur les impacts négatifs de ces innovations déployées à grande échelle.

ⁱⁱⁱ Moi, j'ai une question sur les impacts. Est-ce que ça, c'est les conditions pour arriver aux impacts ? C'est parce que l'économie... parce qu'il est plus rentable de vendre aux agriculteurs, et cela, c'est un moyen. L'objectif ici, c'est d'avoir un impact sur le fait qu'il va y avoir plus de gens qui vont utiliser des solutions proposées en termes de prophylaxie. Ça, c'est un moyen. Il y a deux moyens pour changer les comportements, c'est la réglementation des politiques incitatives ou arriver à convaincre que c'est bien.

^{liii} Donc, le contexte initial on a mis un besoin identifié d'un changement radical des systèmes de culture pour un système agricole moins gourmand en ressources, plus respectueux de l'environnement et capable de répondre aux besoins alimentaires croissants. Comme contexte intermédiaire...des systèmes de cultures plus riches en légumineuses en graines, plus résistants et basés sur des régulations biologiques répondant aux besoins environnementaux et alimentaires de la France. Dans le contexte final, une agriculture sans pesticides et une transformation des habitudes alimentaires pour 2050.

^{liv} Les nouveaux indicateurs et la fenêtre d'opportunité élargie pour la prophylaxie permettront une meilleure mise en œuvre des méthodes de contrôle bien connues - comme le contrôle biologique - et des innovations en matière de prophylaxie. Par exemple, certains indicateurs permettront d'attirer l'attention sur les voies d'arrivée des agents pathogènes par le vent et l'eau ou sur l'historique de l'utilisation des sols qui pourrait prédisposer à certaines maladies.

^{lv} Et puis, dernier point en jaune ici, c'est l'agriculture de précision. Donc, le fait de détecter les odeurs émises par les insectes, ça va permettre de localiser plus précisément le site en Calissons et d'aller appliquer des moyens de contrôle de façon plus ciblée, à la fois dans le temps, mais aussi dans l'espace. Et donc, voilà, c'est ce qu'on appelle l'agriculture de précision.

^{lvi} Une autre transformation encore d'un autre degré, qui concerne le changement de mode de consommation pour aller vers un mode de consommation plutôt local unitaire sans phyto, et donc là, on agit plutôt sur les consommateurs. Et là, il faudra peut-être revoir un peu comment les outputs du projet agissent sur peuvent être réutilisés par les consommateurs et pour finalement arriver à cette transformation en mode de consommation des consommateurs.

^{lvii} Pour arriver à des transformations qui des transformations vers une diversification de l'agriculture et des pratiques, avec une modification des assolements et des systèmes de culture, de nouveaux itinéraires techniques. Et du coup, pour arriver à cette transformation en amont, une transformation des activités de production de référence sur les sur les qualités des mélanges. [...] Mais le deuxième volet de travaux qu'on a identifié, c'est plutôt tout ce qui est identification de très régions génomiques, idiotypes de plantes, outils utilisables en sélection qui sont là, un certain nombre d'entrées qui vont être utilisables par les sélectionneurs, que ce soit des sélectionneurs au sens classique du terme ou des réseaux d'agriculteurs en sélection participative. Et également les organismes qui encadrent les activités de sélection comme le CTP et le GEVES et donc ces output utilisés par ces acteurs devraient permettre des transformations au sein de l'activité de sélection, à la fois par des schémas de sélection adaptés au mélange, donc une modification ou une diversification des objectifs de sélection, une sélection de variétés et d'espèces spécialement adaptées au mélange ou sélectionnées en mélange et une stratégie de sélection pour des conditions environnementales plus locales.

^{lviii} Un partenaire industriel qui devrait nous aider à la fabrication des dispositifs une fois qu'on a fait des prototypes puisque dans le courant du projet, on aura différents niveaux de prototypes. On veut arriver à la fin du projet à des prototypes, donc on aura besoin de ces partenaires, un partenaire industriel pour optimiser les coûts [...] Et puis, à la fin des, on a marqué des instituts techniques pour...tirer le meilleur parti de capteur pour l'utilisation de méthodes prophylactique. Parce que le capteur, c'est une chance, mais ce n'est pas la finalité. La finalité, c'est une détection précoce pour mettre en place ou optimiser les moyens de lutte les plus le plus efficace, plus biologique

^{lix} On a également identifié donc un gros volet beaucoup d'impact sur la dimension économique avec l'évolution des métiers, donc l'évolution des métiers de la sélection, l'évolution des métiers du conseil, du site de production de semences. Voilà donc l'émergence de nouvelles offres, de nouveaux produits, dont des produits diversifiés, des offres de semences mélangées, du conseil sur les mélanges doit étudier de nouveaux modèles économiques de financement de la recherche et également, au niveau de l'aval, une transformation des filières avec des nouveaux produits, de nouveaux débouchés sur des productions, l'utilisation de productions diversifiées

^{lx} Une transformation qui est un peu différente et qui vise plutôt l'aval de la filière, c'était le fait qu'il y a une relocalisation des approvisionnements, notamment pour valoriser les productions plus diversifiées locales des agriculteurs, et donc ça, ça passe par quels sont les acteurs comparatifs, notamment les transformateurs, les acteurs agroalimentaires, il passe par la remobilisation, la réadaptation, des propositions de l'innovation coupé qui se produisent dans le cadre du projet.

^{lxi} Une étude qui va être conduite sur les standards de qualité en aval, qui devrait conduire à l'élaboration de scénarios d'assouplissement des standards de qualité pour l'aval et qui pourraient être utilisés par les coopératives et les acteurs des filières agroalimentaires pour adapter les filières en aval afin qu'elles acceptent des mélanges dans les filières de collecte et de transformation pour une diversification des débouchés et un développement de filières particulières comme la filière légumineuses, par exemple.

^{lxii} Les sorties attendues du projet SUCSEED seront industriels avec le développement de solutions alternatives aux pesticides et l'élaboration d'atlas de composés et d'agents pouvant servir à la R&D pour cette future génération de biocontrôle/biostimulant, mais aussi avec la projection des stratégies/trajectoires pour atteindre le marché en tenant compte du contexte réglementaire dont les recherches pourront servir à éclairer les futures décisions publiques et politiques ;

^{lxiii} Et on a également identifié des impacts d'ordre politique puisque le volet économique devrait nous permettre d'aller vers un assouplissement de la réglementation pour l'inscription des variétés et d'aller vers un design de politique publique favorable à la diversification.

^{lxiv} Des politiques publiques qui soutiennent 1) la diversification des activités, 2) la valorisation de produits agricoles locaux et sans phyto car des acteurs convaincus de l'intérêt économique long-terme d'aller vers le zéro-phyto en prenant conscience et en communiquant sur les coûts des externalités du tout phyto.

^{lxv} Mais est-ce que ça veut dire qu'il faut systématiquement avoir un itinéraire technique un peu imposé qui ne sera pas forcément accepté par le producteur si l'on veut favoriser une plus grande efficacité. Ça peut être aussi un frein s'il y a des contraintes trop grandes à l'utilisation de ces leviers. Ces combinaisons génétiques pratiques.

^{lxvi} Nécessité d'avoir de nouveaux référentiels pour l'évaluation de ces solutions innovantes (efficacité ou effets non intentionnels) afin d'identifier et de piloter au plus juste leurs effets que ce soit à des fins de criblage ou de garantie de valeur ajoutée à la semence.

^{lxvii} Mais j'avais mis un, c'est peut-être un gros post-it, mais repensé le référentiel avec lequel, finalement, on évalue. Mais il y a les aspects et les effets non désirés ou non intentionnels dont parlait Matthieu, mais finalement, il y en a d'autres. Je pense qu'on ne peut pas évaluer ses solutions avec le même référentiel que les produits conventionnels parce que c'est encore, il me semble, mais que c'est quelque chose qu'on fait encore beaucoup. Et il faut repenser ça parce qu'autrement, on aura du mal à quelque part à mettre en avant la plus-value qui est associée assez à ces solutions. Si on continue à utiliser les mêmes critères, les mêmes indicateurs, on peut penser c'est quelque chose d'important.

^{lxviii} Pour l'instant, les bio stimulants sont considérés comme des engrais. Oui, donc, ils ont des facilités de mise en marché, on va dire. Dossier qui coûte moins cher, qui passe plus facilement. Mais comme dit [nom] dès qu'un bio stimulant, il y a une publication ou si une entreprise a l'imprudence de dire qu'il y a un effet de protection des plantes contre les agents pathogènes ou des ravageurs, ça peut automatiquement passer dans la casse produits phytosanitaires où là, si, bien sûr, plus cher, compliqué, etc.

^{lxix} Donc on attend. On attend trois ans ou plus uniquement pour déjà déposer le dossier quelque part. Et après, on peut imaginer le temps qui est nécessaire pour l'évaluer et l'approuver. Il y a un vrai souci et pour nous, on en fait un des leviers, une des clés, c'est de reconnaître ces solutions de biocontrôle à l'échelle européenne et ensuite d'y adjoindre une série de mesures tenant compte des spécificités et importantes et des accélérateurs pour ça ira beaucoup plus vite.

^{lxx} Je suis effectivement d'accord avec Julie. C'est sûrement un des verrous les plus bloquants, l'aspect réglementaire. Et alors ? Après, s'il y a moyen de discuter avec des personnes qui peuvent alors faire avancer les choses, au moins en discuter. Le souci, c'est d'avoir les bons interlocuteurs aussi et de voir éventuellement quels sont les moyens dont on pourrait disposer à terme. Pas forcément sur le court terme, parce que ça, ça se passe sur le long terme pour essayer de faire avancer les choses et en cas de, de faire peut-être sauter quelques verrous sans forcément lui faire sauter, parce que même en étant très optimiste, je ne suis pas sûr que ça puisse se faire dans le délai de six ans.

^{lxxi} Il faut prendre conscience que là, on va avoir. On va avoir quand même des acteurs fortement opposés et beaucoup de circulation de l'information qui vont viser à réduire la décision à du binaire. Et ça, c'est un des gros risques, donc effectivement un processus de décision complexe avec de l'incertitude et utiliser le de tout ce qui est autour de et de décisions où il y a des fortes incertitudes.

^{lxxii} Chez les sélectionneurs, il y a des il y a des réticences, oui. Quand on entend chez beaucoup de obtenteurs le discours, il y a quelques pionniers dans des mélanges chez les sélectionneurs, mais ils sont peu nombreux. Et la réticence, c'est de dire les mélanges se font et se développent beaucoup en agriculture biologique ou qui sont des gens qui utilisent beaucoup de semences de ferme. Donc, on n'est pas là pour travailler pour des gens qui ne nous achètent pas dimanche, on n'entend quand même pas assez régulièrement. Concrètement, et donc chez les sélectionneurs qui sont quand même très réticents puisqu'on parle de zéro, je pense qu'on a vu à ce niveau-là. Ils ne sont pas bloquants, ils ne sont pas bloquants parce que des mélanges positifs issus. Les sélections n'ont pas nécessairement pour l'aptitude à l'association

^{lxxiii} Le développement d'une offre de semences mélangées ou adaptées aux mélanges pour les agriculteurs dépend des stratégies des acteurs en amont. Or, plusieurs acteurs peuvent prendre en charge la mise en œuvre du mélange (sélectionneur, distributeur, agriculteur). Cela limite donc le risque de blocage : si

une catégorie d'acteurs refuse de s'engager dans le développement d'une offre de mélanges de semences, une autre catégorie d'acteurs peut prendre la main sur cette offre. Le potentiel de diffusion des semences mélangées ou adaptées au mélange dépendra cependant des acteurs impliqués : ce potentiel sera limité si seuls les agriculteurs ou les distributeurs proposent des semences mélangées, car il n'y aura pas de sélection sur l'aptitude à l'association.

^{lxxiv} Comme le projet reposera sur la collecte/l'utilisation/le traitement de données massives de différents types (données textuelles aux images satellitaires) nous serons très investis sur les questions d'open science et notamment le respect des principes FAIR (en particulier l'interopérabilité). Par exemple, nous veillerons à développer des interfaces utilisateurs permettant de faciliter l'accès et l'utilisation des données que nous aurons collectées ou générées, pour l'ensemble des utilisateurs potentiels (partenaires du projet ou externes au projet jusqu'aux jardiniers, les gestionnaires de parcs et de jardins, etc).

^{lxxv} Il y a plein de données quand on est là et on devrait pouvoir stocker sur des plateformes gratos. Et on n'a pas le droit, je ne sais pas quoi. Il n'y a aucune infrastructure pour ça.

^{lxxvi} Il nous faut communiquer sur cette nouvelle démarche de surveillance des populations d'insectes, comprendre d'éventuelles réticences à la fois de la sphère scientifique et de la profession (instituts techniques, réseaux d'agriculteurs, ...) pour mieux convaincre de son potentiel. L'un des enjeux sera d'explicitier les possibilités qu'offrent les capteurs pour l'agriculture de précision et la réduction d'usage des pesticides.

^{lxxvii} Et il faudra aussi une couverture médiatique qui va se transformer très largement au-dessus de celle de ce nouveau concept. Informer, convaincre. On voit déjà que dans la sphère scientifique, il y a un certain nombre de réticences. Donc, j'imagine que c'est encore pire au niveau des agriculteurs ou... Voilà tout seul, de toute cette sphère, plus...toute la profession. Voilà ce qu'on a également identifié, c'est la nécessité d'avoir une enquête. Cependant, dans l'ordre dans lequel on a fait les choses pour pourvoir tout le marché qui existe. L'aspect économique, parce qu'évidemment, il faut, il faut, il faut que ça soit viable économiquement. Il ne faut pas que les capteurs soient trop chers, sinon, sinon, ça ne va pas le faire, bien comprendre les réticences, donc. C'est aussi en lien avec la couverture médiatique qui est au-dessus pour convaincre les gens, les agriculteurs, la profession, un des bénéfices de ces capteurs. Voilà donc ce qu'on avait listé en dessous, c'est à dire des relais à des instituts techniques. On se demandait un peu quel institut technique ou quels relais pouvaient nous aider dans ce partage d'informations. C'est peut-être quelque chose qu'on a besoin des oui, de chambre d'agriculteurs, des coopératives, etc.

^{lxxviii} Et en termes d'acceptabilité. Après, quand on va vouloir convaincre les utilisateurs, finalement, qu'il faut utiliser plutôt ces produits que les produits dont ils ont l'habitude et je pense qu'il faut, il faut qu'on mette en avant la plus-value ces avantages versus les quelques inconvénients qu'il peut y avoir. Et [Nom] est évoqué là où ça a été évoqué dans un sur un post-it. Et il y a des choses qu'on sait peu encore, il me semble, mais [Nom] pourra me contredire, mais c'est un peu la durée de vie de ces solutions. C'est finalement combien de temps ? Parce que ça va. Ça va changer des choses dans la façon dans les pratiques, quelque chose que j'ai mis sur un autre post-it. Ça a un impact sur la façon dont les gens vont les utiliser, peut-être dans leurs pratiques habituelles. Donc, il faut penser à tout ça quand on va, quand on va vouloir convaincre ou proposer ses solutions aux utilisateurs ou aux agriculteurs.

^{lxxix} Nécessité de mettre en adéquation efficacité et coût des solutions pour s'assurer du déploiement des innovations ainsi que de considérer les impacts et nécessités d'adaptation des process industriels des semenciers.

^{lxxx} Toute la question que vous venez d'évoquer l'acceptabilité de la technologie, mais aussi économique, de voir en quoi ce pas ces nouvelles semences sont ou seront plus chères que celles habituelles. Quel impact économique ça peut avoir aussi sur l'exploitation et le changement de pratiques en termes de culture qui vient d'être évoqué dans la manière de cultiver, les process, les et les utilisateurs. Ici, les agriculteurs seront prêts à changer ces pratiques et à adopter de nouvelles façons de faire ? Parce que bon, peut être que la semence ne réagira pas de la même manière que les semences qu'on pourrait qualifier de classique, de traditionnel.

^{lxxxi} Il y aura de plus en plus d'estimations (à travers des recherches en économie) qui confirment qu'il est plus rentable de vendre aux agriculteurs des conseils favorisant la prophylaxie que l'utilisation de produits chimiques de synthèse. En parallèle on observera que les initiatives privées visant à fournir des données sentinelles FAIR et ouvertes sont viables sur le plan économique. Globalement on observera une coexistence du conseil agricole privé et des consultants publics et que le rôle des chambres d'agriculture ou d'autres conseillers techniques (par exemple, le CTIFL) sera en croissance.

^{lxxxii} Des enquêtes sont nécessaires pour connaître le marché et le niveau de viabilité économique des capteurs, ce qui implique d'estimer la diminution des coûts d'intervention et de traitement résultant d'une détection précoce des ravageurs (à voir avec les instituts techniques).

^{lxxxiii} Moi, je si je peux intervenir, il y a effectivement, il y a des choses qui peuvent être mises en place dès maintenant parce qu'elles vont nous aider dans la conception aussi du capteur, comme par exemple [nom] permet des enquêtes à assurer la stabilité. C'est quelque chose qu'il faut anticiper et aussi avoir une idée de l'ordre de prix. Qu'un agriculteur soit prêt est prêt à mettre dans de bonnes dispositions parce qu'il peut vraiment guider le prototype si on s'aperçoit quel agriculteur, il n'est pas prêt à mettre plus de 10 euros par hectare. Ça, c'est une contrainte qui est importante pour nous.

^{lxxxiv} Leur mission consiste précisément à collecter les résultats de la recherche sur les questions de politiques agricoles et environnementales (CEP du Ministère de l'Agriculture, DITP, France Stratégie, CGAAER). Le cas échéant, ils sont déjà membres du comité d'experts qui a été constitué lors du montage du projet afin de suivre ses avancées. Pour ce type d'interlocuteurs, la production de publications scientifiques sera accompagnée d'un travail de vulgarisation sous forme de policy briefs en français

^{lxxxv} Je les prends pas mal de monde parce qu'on est sur l'identification d'outils d'apprentissage c'est aussi les résultats, des fois d'une partie du WP1 qui est plus sur la plante, une génétique qui WP2 et donc l'objectif étant de construire des outils d'apprentissage qui permettent d'atteindre l'objectif zéro phyto tout en insérant les légumineuses, une diversité de légumineuses dans les systèmes de culture. Je me disais ça, c'est pour qui ça va être pour nos fameux conseillers d'organismes stockeurs et les agriculteurs, bien sûr, d'un côté. Et puis d'ailleurs aussi d'avoir une valorisation de ces outils via l'enseignement, que ce soit technique ou ingénieurs, voire à mon bac pro dans un objectif au final, dans ces deux éléments là à la fois, d'avoir peut-être des bas, des conseillers qui sont plus au fait, en fait, de l'insertion des légumineuses dans les systèmes de culture. Parce que c'est ce qu'on a identifié comme étant que, mais quand même un gros frein et mais également d'avoir des agriculteurs informés et formés.

^{lxxxvi} « Une manière d'encourager/favoriser l'acceptation de nos solutions auprès d'un large public serait la mise en œuvre, pour le conseil agricole, d'une « Charte de Qualité/Bonnes Pratiques » reposant une traçabilité basée sur des données ouvertes FAIR et des procédures analytiques transparentes. »

^{lxxxvii} Donc, je vais dire les trois outputs de recherche quand ils sont en lien direct avec ces transformations de l'avenir à long terme. C'est que bien va établir des exemples qui illustrent qu'il est faisable et utile de déployer des données ouvertes, FAIR pour la surveillance épidémiologique et la prise de décisions en matière prophylaxie. Il faut vraiment illustrer que c'est possible et que c'est utile de faire ça. Donc je pense que ça peut être un output de recherche. Deuxième on va expliciter et faciliter des processus de décision complexes qui sont basés sur beaucoup, beaucoup de différents facteurs et qui conduisent à la mise en œuvre de prophylaxie pour les experts. Ça sert à outputs destiné aux experts, les scientifiques, les consultants en agriculture, les professeurs, etc.

^{lxxxviii} Le développement des mélanges suppose pour les agriculteurs la disponibilité de variétés adaptées, l'accès à des références techniques sur les performances variétales en mélanges, et l'accès à des conseils et outils d'aide à la décision sur le choix des mélanges et les pratiques culturales à associer.

^{lxxxix} Les connaissances qui seront générées donneront lieu à des outils d'aide à la conception des mélanges pouvant être directement utilisés par les agriculteurs, leurs conseillers ainsi que les trieurs à façon et les coopératives productrices de semences. MoBiDiv identifiera par ailleurs des caractères et régions génomiques impliqués dans l'aptitude au mélange, ainsi que des idéotypes de plantes. Ces outils de sélection seront testés chez les sélectionneurs et dans les réseaux de sélection participative, qui bénéficieront également de modules de formation. Le projet étudiera des scénarios d'évolution de l'organisation du secteur semencier, des réglementations et du financement de la recherche, qui permettent le développement des mélanges de semences. [...] Enfin, MoBiDiv s'intéressera à l'utilisation des productions mélangées par l'aval de la filière et proposera des scénarios d'assouplissement des standards de qualité en aval de la filière, qui seront diffusés aux coopératives agricoles et transformateurs.

^{xc} La transition vers de nouvelles façons de mener la surveillance épidémiologique et de mettre en œuvre la prophylaxie nécessitera que nous aidions les agriculteurs et les autres parties prenantes à comprendre les opportunités. Une approche sera de faire en sorte que les solutions soient coconstruites. Ainsi, le projet s'efforcera d'aider les parties prenantes à comprendre les options pour les décisions impliquant des paramètres de plus en plus complexes et des échelles d'espace et de temps qui vont au-delà de la ferme et d'une seule saison. Ensemble, nous explorerons de nouveaux types de raisonnement pour la prise de décision dans les cas où il y a plusieurs agents pathogènes simultanément et où les méthodes de prophylaxie peuvent être évaluées par des mesures coûts avantages plutôt que par le rapport coût-efficacité.

^{xcj} Et puis, si on continue dans les autres leviers, on a un levier qui concerne l'utilisation de flash du VC qui peut stimuler les capacités de défense des plantes. Donc, il y a à la fois, dans ce cas-là, des prototypes ayant été conçus. Donc ça va aller directement être en relation avec des agro équipementiers, par exemple, qui vont après, si c'est un levier efficace, diffuser ce levier vers les agriculteurs, par exemple.

^{xcii} Ouais, moi, je me suis trouvé dans la situation où on avait repéré un produit intéressant, mais qui était vendu en tant que bio stimulant. Je suis allée à le dire, en congrès, en réunion des agriculteurs etc. et la firme est venue me dire arrêtez d'en parler, vous allez nous causer des problèmes. Si c'est quand même où se trouve la situation est quand même stupide. Si on trouve des produits intéressants en protection des cultures, mais vendus en tant que bio stimulants, qu'on ne puisse pas en faire pas ni travailler dessus, finalement. Parce que parce qu'en fait, dans les firmes, ça les obligerait à les homologuer en tant que produits phytopharmaceutiques, ça leur coûte trop cher et veut pas le faire. Donc ça veut dire quoi ? Ça veut dire que quand on a des produits intéressants, il faut le dire, mais sans dire ça, c'est nul.

^{xciii} Nécessité de bien définir dès le départ un positionnement clair de ces solutions innovantes « Biocontrôle » ou « biostimulant » pour limiter les complications de mise en marché (règlementations différentes). Nécessité également d'établir les compatibilités avec les produits phytosanitaires conventionnels et de connaître les technologies concurrentes émergentes.

^{xciv} Nécessité de faire reconnaître le biocontrôle au niveau UE, surtout pour les substances actives qui ne bénéficient pas de procédures accélérées (un délai de 3 ans peut être nécessaire avant d'obtenir un premier RDV pour le dépôt d'une nouvelle substance active !). De manière plus générale nécessité d'actualiser et d'homogénéiser les réglementations FR et UE.

^{xcv} Des évolutions réglementaires favorables à la diversification (tout en garantissant la qualité des matériels hétérogènes) sont également nécessaires, et l'appui des sélectionneurs est essentiel pour permettre ces évolutions. Actuellement, du fait d'une absence de contexte économique spécifique promouvant la sélection sur l'aptitude à l'association (caractère non pris en compte pour l'inscription de variétés et impossibilité de commercialiser des mélanges de variétés non inscrites), les sélectionneurs n'ont pas intégré cet objectif. Il convient de noter que même sans faire de sélection spécifique pour les mélanges, certains sélectionneurs pourraient tirer parti de ces évolutions réglementaires favorables à une plus grande hétérogénéité des variétés, en inscrivant des variétés utilisables en mélanges qui auraient été éliminées sans ces évolutions.

^{xcvi} Déjà, est ce qu'il y a une obligation, déjà ? Est ce qu'on peut un agriculteur aussi faire une mesure et constate qu'il y a des insectes ? Mais il décide que, par exemple, il préfère continuer d'utiliser les pesticides. Ou alors, est ce qu'il est obligé de les déclarer ? Est ce qu'il est obligé de faire la mesure ? Parce que s'il y a un agriculteur, fait une mesure. Et encore une fois que le voisin n'est pas, peut être que ça peut influencer à moyen terme. La propagation de l'insecte ou c'est peut-être une question importante aussi de savoir qui est ce que ça va induire des obligations ou des aides directes, des normes.

^{xcvii} L'utilisation de mélanges d'espèces, notamment de céréales et de légumineuses, reste fortement contraint pas la nécessité d'un tri (mécanique ou optique) des espèces avant mouture. La mouture directe des mélanges céréales/légumineuses, et leur utilisation en agroalimentaire est en cours d'étude et pourrait contribuer au développement de ces pratiques.

^{xcviii} Ce que je que je disais, c'est que jusqu'ici, on réfléchit en termes d'application final en plein champ. Mais qu'il y aura une étape. On parle aussi d'étapes intermédiaires autour de réseaux de biosurveillance, pouvoirs publics, etc. On sent bien pour l'utilisateur final. Un premier sera pas l'agriculteur lui-même, mais des organismes plus réactifs, coopératifs ou publics, et un autre, un autre débouché potentiel.

^{xcix} Parce que je pense, par exemple nouvelle variété là-haut, très bien, mais en premier, Il proposait une nouvelle variété, il y a des freins énormes au changement variétale. Parce que pour vendre une variété, on ne vend pas de la noisette, de la pomme ou de l'abricot. On vend une variété et donc changé une variété par une autre, Il faut changer dans l'esprit des gens qui vont plus acheter de la golden ou de la Granny Smith, mais qui vont acheter de la, je ne sais pas quoi un nouveau nom et donc ça, ça veut dire un impact...Comment dire, un investissement commercial pour lancer une variété qui est très important et c'est un frein très fort au renouvellement variétal chez les agriculteurs dans le cadre actuel du marketing. Il y a du marketing, voilà ce qu'il y a... il faut que la variété après elle soit portée quelque part en tant que marque. C'est comme si on sortait une nouvelle marque quelque part

^c Parce que bon, peut être que la semence ne réagira pas de la même manière que les semences qu'on pourrait qualifier de classique, de traditionnel. Donc, il y a toute cette question-là d'identifier, nous ce qu'on propose. Evidemment, les freins en termes de représentation technologiques et économiques et sociaux aussi. Il y a le rôle du collectif là-dessus et on est sur des adoptions qui sont marginales ou plus massives. On sait que ça peut avoir des effets d'entraînement. Et puis, les parties prenantes peuvent contribuer à promouvoir ces nouvelles solutions.

^{ci} Si l'exercice doit nous aider aussi à réfléchir aux acteurs qui pourrait être influent et qui manque dans notre projet. Et auquel on n'a pas pensé. C'est en fait les assureurs. Parce que je, je me dis c'est encore une fois à la lumière des discussions que j'ai eues récemment sur cette histoire de colza sans Phyto. Je me dis que les coopératives ou les agriculteurs vont peut être demandeur ou rassurés de savoir qu'il y a un système

d'assurance qui leur permettra de compenser les pertes lorsqu'une même à eux ne compense pas toutes les pertes d'un zéro phyto, par exemple. Et on n'a pas le choix.

^{cii} Cette sensibilisation et changement de regards des acteurs participants sur les voies du changement est un tournant clé attendu du projet FAST, car ils permettraient de transformer ces acteurs participants aux travaux de recherche, en « grands témoins » susceptibles de partager et diffuser leurs visions auprès de leurs pairs dans leurs organisations professionnelles, voisinages ou réseaux. Cette essaimage et propagation de visions du changement possible et des voies d'accompagnement vers une agriculture sans pesticides pourraient avoir pour effet d'induire la création de niches territoriales ou de réseaux de projets d'agriculture utilisant les pesticides de manière parcimonieuse.

^{ciii} Par contre, à l'heure actuelle, nous n'avons pas identifié formellement les partenaires avec qui nous pourrions interagir pour nous accompagner dans cette démarche de sensibilisation des parties prenantes, de labellisation, etc.

^{civ} Mais c'est la même chose et ce sont les intermédiaires qui ont un impact. Et ça, oui. Voilà donc. Du coup, pour moi, c'est sûr qu'on a listé dans le chemin d'impact et sur l'amont. En tout cas, c'est les mêmes. C'est à dire ? C'est ça, les sélectionneurs, c'est les réseaux de sélection participative, c'est les trieurs à façon, c'est l'équipe productrice de semences, c'est les offreurs de conseils agricoles et les instituts techniques. Et c'est les organismes et les politiques publiques, donc les plus et les organismes qui mettent en œuvre les réglementations dont certains sont partenaires du projet. Mais pour moi, quel que soit le scénario final, ça doit bouger sur l'ensemble de ces acteurs là quand même.

^{cv} Nous visons à mettre en place un procédé de fabrication compatible avec la production de masse. Il y aura un transfert technologique à prévoir. L'identification d'un tiers exploitant est encore prématurée mais il faudra prospecter.

^{cvi} Et puis, l'originalité du projet, c'est de combiner ces différents leviers qui n'apportent qu'une résistance partielle de la plante pour aller vers une meilleure immunité et dont on espère avoir une certaine expertise pour le couplage et la combinaison des leviers. Y a aussi à partager et qui va intéresser fortement à la fois les instituts techniques - laissent place à l'expérimentation -, les chambres d'agriculture, les coopératives et les agriculteurs eux même. Et puis, cette expertise, elle va aussi être utilisée pour la formation par les organismes de formation dans les lycées agricoles pour former les futurs agriculteurs, etc.

^{cvi} Et du coup, tout ça qui devrait donner lieu à des outils d'aide, à la conception, au choix, aux règles d'assemblage des mélanges et donc tout, c'est tous ces outputs de ce volet output. On a déterminé que ça, ils pourront être utilisés par des acteurs intermédiaires que sont les agriculteurs, les organismes de conseil et de développement, les instituts techniques et puis les trieurs à façon, les producteurs de semences, les coopératives, etc. Pour arriver à des transformations qui des transformations vers une diversification de l'agriculture et des pratiques, avec une modification des assolements et des systèmes de culture, de nouveaux itinéraires techniques. Et du coup, pour arriver à cette transformation en amont, une transformation des activités de production de référence sur les sur les qualités des mélanges. Une..., un développement aussi de l'offre de conseil sur les mélanges et une modification du système de production distribution de semences pour avoir une offre de mélanges proposés aux agriculteurs. Voilà, donc, je passerai peut-être aux impacts après. Mais le deuxième volet de travaux qu'on a identifié, c'est plutôt tout ce qui est identification de très régions génomiques, ideotypes de plantes, outils utilisables en sélection qui sont là, un certain nombre d'entre qui vont être utilisables par les sélectionneurs, que ce soit des sélectionneurs au sens classique du terme ou des réseaux d'agriculteurs en sélection participative. Et également les organismes qui encadrent les activités de sélection comme le CTP, et le GEVES et donc ces output utilisés par ces acteurs devraient permettre des transformations au sein de l'activité de sélection, à la fois par des schémas de sélection adaptés au mélange, donc une modification ou une diversification des objectifs de sélection, une sélection de variétés et d'espèces spécialement adaptées au mélange ou sélectionnées en mélange et une stratégie de sélection pour des conditions environnementales plus locales

^{cvi} On a fait ce qu'on appelle un contexte intermédiation où on a listé ensemble de - comment dire - d'acteurs ou d'actions intermédiaires. Donc, un partenaire industriel qui devrait nous aider à la fabrication des dispositifs une fois qu'on a fait des prototypes puisque dans le courant du projet, on aura différents niveaux de prototypes. On veut arriver à la fin du projet à des prototypes, donc on aura besoin de ces partenaires, un partenaire industriel pour optimiser les coûts. [...] Voilà donc ce qu'on avait listé en dessous, c'est à dire des relais à des instituts techniques. Mais on se demandait un peu quel institut technique ou quels relais pouvaient nous aider dans ce partage d'informations. C'est peut-être quelque chose qu'on a besoin des oui, des chambres d'agriculteurs, des coopératives, etc. Et puis, à la fin des, on a marqué des instituts techniques pour...tirer le meilleur parti de capteur pour l'utilisation de méthodes prophylactique. Parce que le capteur, c'est une chance, mais ce n'est pas la finalité. La finalité, c'est une détection précoce pour mettre en place ou optimiser les moyens

de lutte les plus le plus efficace, plus biologique. Voilà où est le plus vite possible. Voilà donc, il y avait un centre de flash. Ça, ça se regroupe. Alors voilà donc tout ça. Ça doit mener à des l'acceptation de nouvelles pratiques dans des réseaux. Un réseau d'agriculteurs, voilà, la preuve de concept doit aider à les convaincre. Mais il faut être fort pour convaincre.

^{cix} Peut-être que l'exemple que j'ai pris et pas n'est pas le meilleur. Mais si on prend par exemple le jeu qu'on va concevoir des gens pour concevoir avec une méthode participative, avec les multiples acteurs, donc les coopératives, les agro chimistes, des syndicats d'agriculteurs, nous, on aura fait notre part, c'est à dire qu'on va le mettre en open source. Tout le monde pourra l'utiliser. Les coopératives, on sait qu'il y a déjà certaines coopératives qui on a co-construire, qui vont utiliser. Des enseignants chercheurs nous ont contactés pour l'utiliser, mais il est sûr que pour l'upscaling, c'est plus nous. C'est à dire ? Nous, on a rendu l'outil disponible. En fait, le mode d'emploi. On est prêt à aller présenter l'outil le juste à dire à qui veut. Après, c'est à eux de se mobiliser et de jouer avec. Mais ça, c'est plus nous en fait.

^{cx} Leur mission consiste précisément à collecter les résultats de la recherche sur les questions de politiques agricoles et environnementales (CEP du Ministère de l'Agriculture, DITP, France Stratégie, CGAAER). Le cas échéant, ils sont déjà membres du comité d'experts qui a été constitué lors du montage du projet afin de suivre ses avancées. Pour ce type d'interlocuteurs, la production de publications scientifiques sera accompagnée d'un travail de vulgarisation sous forme de policy briefs en français

^{cxii} Pour arriver à des transformations qui des transformations vers une diversification de l'agriculture et des pratiques, avec une modification des assolements et des systèmes de culture, de nouveaux itinéraires techniques. Et du coup, pour arriver à cette transformation en amont, une transformation des activités de production de référence sur les sur les qualités des mélanges. [...] Mais le deuxième volet de travaux qu'on a identifié, c'est plutôt tout ce qui est identification de très régions génomiques, ideotypes de plantes, outils utilisables en sélection qui sont là, un certain nombre d'entrées qui vont être utilisables par les sélectionneurs, que ce soit des sélectionneurs au sens classique du terme ou des réseaux d'agriculteurs en sélection participative. Et également les organismes qui encadrent les activités de sélection comme le CTP et le GEVES et donc ces output utilisés par ces acteurs devraient permettre des transformations au sein de l'activité de sélection, à la fois par des schémas de sélection adaptés au mélange, donc une modification ou une diversification des objectifs de sélection, une sélection de variétés et d'espèces spécialement adaptées au mélange ou sélectionnées en mélange et une stratégie de sélection pour des conditions environnementales plus locales.

^{cxiii} On a également identifié donc un gros volet beaucoup d'impact sur la dimension économique avec l'évolution des métiers, donc l'évolution des métiers de la sélection, l'évolution des métiers du conseil, du site de production de semences. Voilà donc l'émergence de nouvelles offres, de nouveaux produits, dont des produits diversifiés, des offres de semences mélangées, du conseil sur les mélanges doit étudier de nouveaux modèles économiques de financement de la recherche et également, au niveau de l'aval, une transformation des filières avec des nouveaux produits, de nouveaux débouchés sur des productions, l'utilisation de productions diversifiées

^{cxiiii} Je suis effectivement d'accord avec [nom]. C'est sûrement un des verrous les plus bloquants, l'aspect réglementaire. Et alors ? Après, s'il y a moyen de discuter avec des personnes qui peuvent alors faire avancer les choses, au moins en discuter. Le souci, c'est d'avoir les bons interlocuteurs aussi et de voir éventuellement quels sont les moyens dont on pourrait disposer à terme. Pas forcément sur le court terme, parce que ça, ça se pas sur le long terme pour essayer de faire avancer les choses et en cas de, de faire peut-être sauter quelques verrous sans forcément lui faire sauter, parce que même en étant très optimiste, je suis pas sûr que ça puisse se faire dans le délai de six ans.

^{cxiv} Le développement du marché des biocontrôles/biostimulants et l'adoption de nouveaux modes de productions des semences devraient générer la création d'emplois et permettre aux agriculteurs de se rapprocher d'une indépendance envers les pesticides issus de la chimie grâce à l'implication des réseaux d'expérimentation (ITA, DEPHY, prestataires agricoles, coopératives, ...) mais aussi des industriels, des entreprises spécialisées et des établissements semenciers. Ces impacts sociaux sont étroitement liés à des impacts économiques et environnementaux. En effet, l'essor de ces innovations pourrait engendrer des gains économiques non négligeables et le développement d'entreprises (e.g. start-up, fusion-rachat, extension d'activité interne) ce qui induira sûrement une mise en concurrence plus fortes des entreprises positionnées sur le marché des semences et des traitements de semences. Sur le plan environnemental, ce déploiement aura pour conséquence la réduction voire l'arrêt de l'utilisation de pesticides conventionnels (fongicides) par les agriculteurs et donc la baisse des dommages environnementaux liés à l'usage de ces produits.

^{cxv} Voilà notre projet, Il est plus long terme, il est plus ambitieux, il est... J'ai envie de dire il est plus risqué. Mais il répond aussi à l'appel à projet qui était sur le long terme, qui demandait des changements, des

changements de paradigme. C'est vraiment un projet en rupture qui va mettre du temps à se concrétiser certainement, 2030 c'est vraiment le court terme pour ce projet. Mais pire, par contre, qui a qu'il y a une. Comment dire des possibilités d'application pas illimitées, mais presque. Voilà, donc c'est différent et je pense que ça demande des explications. Ça demande de la patience. Si les gens jugent sur le court terme, ce n'est pas possible, ça ne va pas le faire. Et donc, la radiation, je me faisais celle-ci. Des collègues ne sont pas convaincus. Qu'est-ce que ça en est de chambre d'agriculture ou les instituts technique.

^{cxvi} C'est à dire ? C'est ça, les sélectionneurs, c'est les réseaux de sélection participative, c'est les trieurs à façon, c'est l'équipe productrice de semences, c'est les offreurs de conseils agricoles et les instituts techniques. Et c'est les les organismes et les politiques publiques, donc les plus et les organismes qui mettent en œuvre les réglementations dont certains sont partenaires du projet. Mais pour moi, quel que soit le scénario final, ça doit bouger sur l'ensemble de ces acteurs là quand même.

^{cxvii} On va démontrer qu'on est capable de faire de l'upscale, c'est à dire qu'on a un procédé de fabrication qui est compatible avec la production de masse, mais en aucun cas, on va le faire. Que ce soit l'ESIEE, le CUA ou INRAE. On n'est pas, on n'a pas vocation à produire. On n'a pas les outils forcément de contrôle, qualité, etc. Qui sont adaptés à ça et ce n'est pas notre rôle. Donc, il faudra effectivement faire un transfert technologique. L'objectif, c'est de transférer quelque chose, on va dire de clés en main ou proche, via quelques adaptations qui va pouvoir être produits. Mais ça sera en aucun cas notre rôle, ni celui de l'ESIEE, d'avoir une approche globale de production des capteurs.

^{cxviii} Peut-être que l'exemple que j'ai pris et pas n'est pas le meilleur. Mais si on prend par exemple le jeu qu'on va concevoir des gens pour concevoir avec une méthode participative, avec les multiples acteurs, donc les coopératives, les agro chimistes, des syndicats d'agriculteurs, nous, on aura fait notre part, c'est à dire qu'on va le mettre en open source. Tout le monde pourra l'utiliser. Les coopératives, on sait qu'il y a déjà certaines coopératives qui on a co-construire, qui vont utiliser. Des enseignants chercheurs nous ont contactés pour l'utiliser, mais il est sûr que pour l'upscaling, c'est plus nous. C'est à dire ? Nous, on a rendu l'outil disponible. En fait, le mode d'emploi. On est prêt à aller présenter l'outil le juste à dire à qui veut. Après, c'est à eux de se mobiliser et de jouer avec. Mais ça, c'est plus nous en fait.

^{cxix} Moi, j'avais un peu une question, une inquiétude à ce sujet un peu naïve, mais je me sens pas mal, complètement à l'aise sur le degré d'impact dans lequel on est allé par rapport à ce que l'image que je me faisais du projet et de nos compétences, dans le sens où là, on va, on va très loin. En parlant d'acteurs de politique publique de l'Institut technique, dont moi en particulier, j'ai une connaissance vague pour avoir travaillé avec eux et du coup, je ne me sens pas personnellement très à l'aise là-dedans, mais plus que ça. Le projet Beyond me semblait pas, me semble plus immonde si tu veux que tout ça. Et du coup, je me demande si, par moments, on n'est pas un peu en dehors de notre rôle parce qu'il y a des impacts du projet qu'on n'a pas creusé, qui seraient des impacts peut être plus directs et plus modestes. Et là, on s'est embarqué dans des aspics. Moi, je vois plus SHS peut être et à plus long terme, et dont je me sens un peu sortir de mon périmètre.

La difficulté après le changement de paradigme, si tu veux. Le passage à l'échelle 3, si je peux réussir à discuter avec tout ça ponctuellement sur mes données et à partager un certain nombre de choses à mettre en place. Une petite chose sur un cas particulier de mes données. Ensuite, si je veux passer à un niveau où je vais faire collaborer la plateforme de l'EFSA et PSV, par exemple, j'aurai besoin de décisions beaucoup plus politiques et stratégiques que ce que j'ai pu faire avec mon homologue en face Et c'est ce niveau-là, je pense que sur lequel on va avoir des difficultés parce qu'il me semble dans le projet, on n'a pas cette vision.

^{cxx} Et en termes d'acceptabilité. Après, quand on va vouloir convaincre les utilisateurs, finalement, qu'il faut utiliser plutôt ces produits que les produits dont ils ont l'habitude et je pense qu'il faut, il faut qu'on mette en avant la plus-value ces avantages versus les quelques inconvénients qu'il peut y avoir. Et [nom] est évoqué là où ça a été évoqué dans un sur un post-it. Et il y a des choses qu'on sait peu encore, il me semble, mais [nom] pourra me contredire, mais c'est un peu la durée de vie de ces solutions. C'est finalement combien de temps ? Parce que ça va. Ça va changer des choses dans la façon dans les pratiques, quelque chose que j'ai mis sur un autre post-it. Ça a un impact sur la façon dont les gens vont les utiliser, peut-être dans leurs pratiques habituelles. Donc, il faut penser à tout ça quand on va, quand on va vouloir convaincre ou proposer ses solutions aux utilisateurs ou aux agriculteurs.

^{cxxi} Moi, je si je peux intervenir, il y a effectivement, il y a des choses qui peuvent être mises en place dès maintenant parce qu'elles vont nous aider dans la conception aussi du capteur, comme par exemple Philippe permettent des enquêtes à assurer la stabilité. C'est quelque chose qu'il faut anticiper et aussi avoir une idée de l'ordre de prix. Qu'un agriculteur soit prêt à mettre dans de bonnes dispositions parce qu'il peut vraiment guider le prototype si on s'aperçoit quel agriculteur, il n'est pas prêt à mettre plus de 10 euros par hectare. Ça, c'est une contrainte qui est importante pour nous.

^{cxii} Parce que je pense, par exemple nouvelle variété là-haut, très bien, mais en premier, Il proposait une nouvelle variété, il y a des freins énormes au changement variétale. Parce que pour vendre une variété, on ne vend pas de la noisette, de la pomme ou de l'abricot. On vend une variété et donc changé une variété par une autre, Il faut changer dans l'esprit des gens qui vont plus acheter de la golden ou de la Granny Smith, mais qui vont acheter de la, je ne sais pas quoi un nouveau nom et donc ça, ça veut dire un impact...Comment dire, un investissement commercial pour lancer une variété qui est très important et c'est un frein très fort au renouvellement variétal chez les agriculteurs dans le cadre actuel du marketing. Il y a du marketing, voilà ce qu'il y a... il faut que la variété après elle soit portée quelque part en tant que marque. C'est comme si on sortait une nouvelle marque quelque part

^{cxiii} Leur mission consiste précisément à collecter les résultats de la recherche sur les questions de politiques agricoles et environnementales (CEP du Ministère de l'Agriculture, DITP, France Stratégie, CGAAER). Le cas échéant, ils sont déjà membres du comité d'experts qui a été constitué lors du montage du projet afin de suivre ses avancées. Pour ce type d'interlocuteurs, la production de publications scientifiques sera accompagnée d'un travail de vulgarisation sous forme de policy briefs en français

^{cxiv} Je vais dire quelque chose et je pense que tu seras d'accord, [Nom] et tous les membres d'ASIRPA aussi, l'anticiper c'est aussi éviter d'avoir le nez dans le guidon et d'avoir uniquement les objectifs académiques par tête et d'oublier tout le reste.
