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Reconceptualising translation in agricultural innovation: A co-translation approach to bring research knowledge and practice closer together

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ABSTRACT

Scientific research continues to play a significant role in meeting the multiple innovation challenges in agriculture. If this role is to be fulfilled, provision needs to be made for effective translation of research outputs, where translation is understood to be the process whereby science becomes part of useful knowledge for decision making. There is increasing interest in enhancing translation in the European agricultural innovation, research and policy context, and specifically in making it a more collaborative process. This new attention calls for a reorientation of how the concept is understood, theorised and operationalised. This paper considers these needs and specifically asks how can interactive innovation approaches be integrated with science-driven approaches to enhance translation; and how can this help to reveal the constituent translation processes? An interactive stakeholder methodology is described drawing on three agricultural case studies examined in the xx project which aims to make translation of existing bodies of scientific knowledge more effective. Analysis to date shows how this interactive methodology enables a communicative and reciprocal set of translation processes to evolve which comprise: identification, prioritisation, articulation, searching, retrieval, extraction and synthesis, and evaluation of innovation issues and solutions. These insights allow us to move beyond an understanding of translation as science- or innovation-driven to envisaging co-translation, where multiple processes interact in a fluid middle-ground, and where the actors involved develop the capacity to jointly analyse innovation issues and solutions. From the perspective of the EU's policy ambitions to stimulate collaborative translation, operationalising translation needs re-thinking with respect to requirements for new mind-sets and skills, and in particular for committed and well-resourced intermediaries who can foster these multi-actors approaches.

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KEYWORDS

Translation; Co-translation; Translational research; Translation processes; Agricultural innovation; Interactive innovation; Stakeholders; Farmers; Scientists; Researchers; Advisers; Knowledge transfer; Dynamic Research Agenda

1. **Introduction**

Although agricultural innovation is understood to encompass much more than Research and Development (R & D), science continues to be an essential ingredient, as international, European Union (EU), and national level policies reiterate (Beachy, 2014; OECD, 2010; Alston, 2010). These argue that there is a compelling need for scientific research to play a significant role in meeting the innovation challenges of increased demand for food balanced against the need to deliver other ecosystem services. If this role is to be fulfilled, provision needs to be made for outreach and translation of research[1] outputs to enable effective deployment of innovative research. Translation, the process whereby science becomes part of useful knowledge for decision making (Valdivia et al., 2014), in effect, needs to be seen as an essential part of the research process. These concerns are as relevant to research already produced, as they are to ongoing and future research. In particular a key challenge in knowledge translation in agriculture, as in other disciplines, is taking a large body of research-based knowledge and making it meaningful to the user audience (Baumbusch et al., 2008). This is in the context of a recognised disconnect between research and innovation processes, which presents significant barriers to effective outreach (Leeuwis et al., 2004; Hessels and Van Lente, 2008).

In line with this there is emerging interest in research translation in a European agricultural innovation and research, and policy context. Here issues of responsiveness of research to users' needs, improved access to results and the valorisation[2] of research results are highlighted as needing to be addressed (EU, 2012; OECD, 2015). Critically, it is envisaged that involving end-users[3] in the

[1] 'Research' is used in this paper to denote scientific research, the systematic investigation using formal scientific methodologies in order to establish facts and reach new conclusions. Specifically here it refers to the outputs of this process, scientific information in the form of papers, reports, technical notes etc. It is acknowledged however, that agricultural research describes a very broad set of disciplines, actors and institutions, is multi-dimensional, operates at different scales and levels of complexity, and constitutes more than scientific outputs in that research interventions can take many forms; it is therefore simplistic to refer to research as a uniform entity.

[2] 'Valorisation' is used here in the sense of giving meaning and (non-monetary) value to research.

[3] The term 'end-user' or 'user' is used to denote a (potential) user of translated information, it is acknowledged that end-users can also be involved in other knowledge processes.

research process is essential to achieving translation and boosting innovation by facilitating the uptake of formal knowledge, and its integration into farming practices (EU, 2012; Brunori et al., 2013; Knickel et al., 2009). This is in accordance with new ways of supporting innovation processes which have emerged as more suited to the complex challenges that research and development have to address; and new understandings of such processes, which are oriented to mobilising actors[4] with multiple perspectives and hybridising scientific and stakeholder knowledge (Berthet et al., 2016).

Despite the increasing interest in enhancing translation, and specifically in making it a more collaborative process, the mechanisms for achieving this, and their theoretical underpinnings have not been sufficiently analysed in the agricultural context. Typically translation concepts have been framed by linear *science-driven* perspectives where scientific knowledge is produced by research organisations, transformed and communicated to end-users. Associated studies have been oriented towards understanding knowledge utilisation and information seeking behaviours (Young et al., 2014), achieving effective communication and knowledge application (Roelofsen et al., 2011); and understanding how information can be used to enhance adoption of innovations (Feder and Umali, 1993). These approaches have neglected the multiple processes entailed in the interrogation, interpretation, utilisation and transformation of scientific outputs that often lay behind higher level translations. *Interactive* perspectives of research and innovation, and of translational research offer some insights into how collaborative approaches can be applied to enhance translation of formal research outputs by involving those operating outside the research subsystem (Douthwaite et al., 2001). Incorporating these approaches potentially provides the means by which translation can be a more dynamic, communicative or two-way relationship (Jacobson, 2007; McNie, 2007); and in doing so reveal the constituent translation processes which to date have not been widely elaborated.

The new attention given to translation, and the interest in using collaborative approaches to enhance translation in particular, call for a reorientation of how the concept is understood and operationalised. Indeed, in other disciplines, where similar debates are ongoing (Baumbusch et al., 2008), there is a call for “nothing short of a new unified science of translation, interdisciplinary at its core, and requiring an array of skills and new techniques” (Burgio, 2010 p57).

This paper explores these issues drawing on experiences in the VALERIE[5]5 project which aims to boost the outreach of *existing* research outputs in agriculture using an interactive stakeholder

[4] The term ‘actor’ is used to describe the multiple participants in agricultural innovation processes, they can also be thought of as stakeholders
[5] VALorising European Research for Innovation in agriculture and forestry (www.valerie.eu)

methodology. Specifically the paper asks how can *interactive* approaches be integrated with *science-driven* approaches to enhance translation; and how can they help to reveal the constituent translation processes of interrogation, interpretation, utilisation and transformation of scientific outputs? In doing this the paper aims to make theoretical and empirical contributions to the understanding of translation in three ways. Firstly by developing an interactive stakeholder methodology for translation, secondly by revealing the constituent translation processes, and thirdly by developing the concept of co-translation to describe the processes observed.

2. Re-thinking translation – integrating interactive approaches with science-driven approaches

This section first characterises models underpinning interactive approaches and science-driven approaches drawing on the translation and innovation literature. It goes on to explore opportunities for integrating these approaches and introduces the notion of co-translation. It next discusses how to operationalise this to enhance the translation of research generated within a science-driven paradigm using interactive processes, and concludes by considering constituent translation processes.

2.1. Translational research and innovation models

Broadly the term translation[6] in the context of research and innovation captures ideas about how science becomes part of useful knowledge for decision making, in agriculture it is equivalent to turning knowledge into action (Valdivia et al., 2014; Woolf, 2008). Here it is closely aligned with innovation, which is widely understood to be a process of generating, accessing, and putting knowledge into use (Botha et al., 2014; Hall et al., 2001). In scholarship in both translation and innovation fields, there is a broad distinction made between linear approaches, which privilege scientific knowledge production, and more interactive approaches that favour bridging knowledge systems.

Translation is usually associated with a simplified linear perspective and with transforming knowledge (from basic and strategic research) into technologies, products, and processes (through strategic, applied, and adaptive research). The concept of translational research has emerged in acknowledgement that research needs to be more responsive to users. However this approach is still

[6] The term ‘translation’ is used in other contexts, for example in the sociology of translation (Callon, 1984); in the translation of socio-technical practices between niches and regime (Smith, 2007); the diffusion or replication of ideas and practices (Klerkx et al., 2017); and concerning shared semantic meaning (e.g. Carlile, 2004). This paper deals with translation of scientific information with respect to knowledge and innovation processes.

largely characterised by a science-supply model, as this definition demonstrates: [translational research is seen as] “new scientific methods and technologies, interdisciplinary approaches, and collaborative institutional arrangements being developed to narrow the gap between basic science and its application to product and process innovation” (Wamae et al., 2011 p21). It covers a range of activities from basic science at one end of the spectrum where research plays a more significant role through to end-use or application. Some activities are mainly concerned with the creation of new ideas while others target the transformation of these ideas into novel products and processes (Bielak et al., 2008). End-users are usually consulted towards the end of the process in this transformation to assist utilisation of existing research outputs, often through user-panels or consultations (Roelofsen et al., 2011). Although translational research has also been described as a third category, beyond basic and applied research, in that it is characterised by multi-disciplinary approaches and by interaction between academic research and practice (Lords, 2011), it is nonetheless usually concerned with interaction within the research subsystem.

Moving away from this linear perspective some commentators argue the need for translational research to focus on the social and human dimensions of science developments “by enhancing a two-way communication and participatory process where farmers and researchers work together to bridge differences in knowledge systems, to build social and political capital, and to strengthen the capacity of farmers” (Valdivia et al., 2014 p4). This reinforces the notion that translation requires social interaction as Bennett and Jessani (2011 p3) state “Knowledge translation is the meeting ground between two fundamentally different processes: research and action. It knits them with communicative relationships”. This broadens and shifts the understanding of translation from one to two-way in which users engages positively in questioning and seeking out research, as well as utilising it. This phenomenon is not unique to agriculture, but has been noted in other fields, notably medicine where knowledge translation is increasingly conceptualised as a “dialogic, collaborative engagement between researchers and practitioners through which people come to reflect on what they do, and its consequences, and identify what they might do differently by drawing on research based knowledge” (Baumbusch et al., 2008 p134).

The distinction or shift in translation thinking mirrors that in research and innovation scholarship where science-driven and innovation-driven research are described (EU, 2012). The latter co-development model arose out of a realisation of the inadequacy of linear models to explain the actual process of innovation, and specifically the multiple sources of innovation (Douthwaite et al., 2001; Biggs and Smith, 1998). Here the involvement of all actors is central in determining, undertaking and translating research results into technologies and practices so that such knowledge is co-generated (EU, 2012). Innovation in this respect is regarded as an emergent product 'co-produced' through interaction between heterogeneous sets of actors (farmers, land managers, advisory services, brokers, intermediaries, consumers, private sector, policy makers) (Hall et al., 2001).

These models from translation, and innovation and research studies, of different knowledge production systems (science driven and interactive) correspond to distinctions between Mode 1 research (knowledge production), described as traditional, reductionist, discipline oriented, accountable to peers; and Mode 2 research (knowledge production), described as action-oriented, interdisciplinary and transdisciplinary research, oriented towards application (Gibbons et al., 1994; Nowotny et al., 2003), or research where "the context speaks back" (Nowotny et al., 2001). Such perspectives of 'traditional' versus 'new' knowledge production systems are used to frame discussions of the disconnect between research and policy and innovation processes (Hessels and Van Lente, 2008). This disconnect, attributed to fundamental differences at the interface between research and practice domains, is widely understood to present translation difficulties (Grimshaw et al., 2012).

Table 1 summarises the key dimensions of these parallel views.

Table 1 Dual interpretations of translational research and innovation in different literatures.

Model of how innovation operates in research	Translational research model	User involvement	Knowledge systems & processes	Modes of science
1. *Science-driven* Linear processes privilege scientific knowledge from research organisations (EU, 2012). Inside research subsystem	Collaborative processes to develop innovations	Users involved at the end of the cycle or process	Farmers and scientists utilise different knowledge systems.	Mode 1. Traditional, hard, empirical, reductionist, positivist.
	Supply-push from research		Distinguishes knowledge production and utilisation.	
	In medicine 'lab to clinic' (known as T1) (Woolf, 2008)		Transformation of new ideas from research into new practices/products relies on communicating science (Bielak et al., 2008)	Knowledge is generated by a research community accountable to its disciplinary peers Gibbons et al. (1994).
2. *Innovation-driven* drawing on Systems of Innovation (Smits et al., 2010) and Agricultural Knowledge Systems (Hall et al., 2006) approaches. Goes outside research subsystem	Focuses on the social and human dimensions of science developments (Valdivia et al., 2014)	Users involved throughout, agenda setting etc.	All actors produce and use knowledge	Mode 2. Science for tacking contemporary complex problems
	Demand-pull from users (farmers etc.)		Co-production of knowledge and finding shared meaning	
	In medicine 'implementation science' (known as T2)		Bridge farmer and scientist knowledge systems Co-innovation	Knowledge production promotes interaction of multiple actors and sources of knowledge with many iterations (Gibbons et al., 1994).

2.2. Towards a concept of co-translation

Although clear theoretical distinctions can be made between the two generalised models, arguably this is overly simplistic and functional and does not adequately explain the observed diversity and inherent complexity of translation and innovation processes. The models are distinguished by different motivations, drivers and processes, however, they describe approaches that often operate together or are in transition. Indeed, scholars note that paradigms often coexist, one does not completely replace the other, but rather tends to superimpose itself on the other system or is in tension with it (Levidow et al., 2013; Coudel et al., 2011). In this respect Hessels and Van Lente (2008) argue that research can benefit from perceiving Mode 1 and Mode 2 archetypes as two ends of a spectrum between which many blends of modes, theories, concepts, methods and roles for research(ers) can co-emerge and coexist. This view is consistent with the observed heterogeneity of scientific work conducted by diverse groups of actors (Star and Griesemer, 1989). It is also apparent in the many ways users are incorporated into scientific research at different points in the research cycle, and in the different creative combinations and the proliferation of approaches that combine various forms of stakeholder participation with cutting-edge scientific research (Neef and Neubert, 2011). Thus translation can take place against a backdrop of inherent complexity in relation to research and practice. In medicine where the term translational research was first used, clarity is still being sought regarding accepted definitions and approaches for the many “translational movements” that have emerged (Burgio, 2010; Shea, 2011). This highlights the need, not only for a more nuanced understanding of translation with respect to the two broad framing models, but also for closer attention to the constituent processes. These needs inform the key questions of this paper (how can interactive approaches be integrated into a science-driven approach to enhance translation? And what are the constituent processes entailed?); they also lead us to envisage a concept of co-translation to explain processes operating in this complex ‘middle ground’ (Fig. 1).

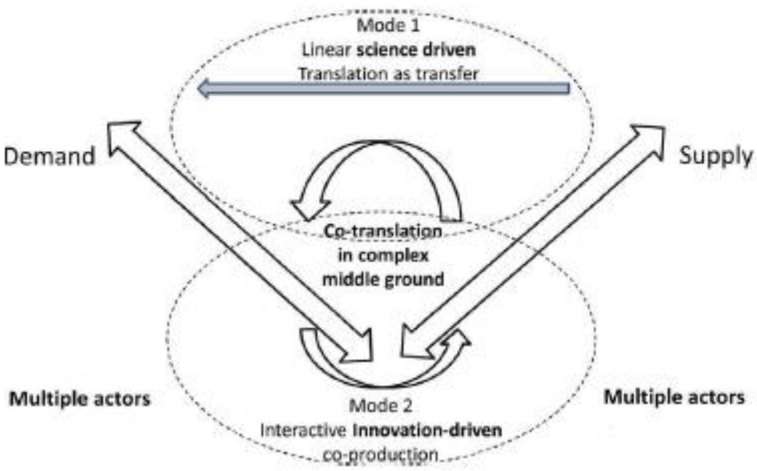

Figure 1 Conceptualisation of co-translation.

With respect to operationalising a more interactive co-translation process, this paper considers how elements of interactive approaches can be incorporated into science-driven approaches to make research-based knowledge more accessible and meaningful to users. This will require applying some fundamental aspects of Mode 2 transdisciplinary research approaches, which are built around feed-back loops between researchers and users, to enhance translation of Mode 1 generated scientific information (Sumberg et al., 2013; Gibbons et al., 1994). In view of the fact that translation processes most likely operate across a spectrum between the two Modes, this calls for a flexible approach (Kristjanson et al., 2009). Iterativity, dialogue and reflection are established research principles in interactive approaches and can be applied using participatory methodologies at different scales with different actors at different levels of intensity (Botha et al., 2014; Dogliotti et al., 2014; Berthet et al., 2016; Roelofsen et al., 2011). According to Baars (2011) such research processes are needed to allow two contrasting views of reality to interact; the scientific development of general knowledge on the one hand and, on the other, the problem solving capacity of experienced practitioners within real life settings. Importantly these approaches can be used to facilitate new communicative relationships and potentially reveal and support constituent translation processes. This analysis informs our methodology as described in the next section, and the analytical framework.

2.3. Constituent translation processes

Whilst the higher level research approaches towards translation and innovation have been considered in the literature, the actual dynamics and constituent knowledge processes (of how potential users identify, define, articulate their research needs and utilise research, or producers or intermediaries translate research outputs for users) have not been widely elaborated.

In exploring the processes entailed in translation, the over-arching concept of matching supply and demand is relevant, particularly with respect to translation of existing bodies of scientific knowledge. This concept has been used to frame analysis of user knowledge needs and how these needs are met at different scales and in different contexts. Typically reconciling the supply of scientific information with user-demand has been problematised in terms of utility and utilisation of scientific information (McNie, 2007).

From the perspective of supply it has been broadly agreed that (diverse) users of knowledge and innovations require knowledge adapted and better translated to their understandings and needs (Leeuwis et al., 2004). One of the major barriers to moving knowledge into practice is that scientists fail to align their communication strategies with the information seeking behaviours and preferences of potential knowledge users (Young et al., 2016). In this respect communication processes and how science information is packaged to the preferences, channels and timescales of particular audiences have become a focus (Bielak et al., 2008). Knowledge translators identify the key messages for different target audiences and shape these in language and knowledge translation products that are easily assimilated and utilised by different audiences. Formats can include decision support tools, manuals, guidelines, factsheets and technical notes. This packaging involves some form of transformation of the content or translative processes in which scientific material has been ‘processed' for consumption by different audiences. This normally involves some purposive translation of ‘languages’, not just transmission of information (Faulkner et al., 2007). Referring to the sociology of translation perspective Holloway (1999, p2025) drawing on Latour (1986), points out that translation is not always a neutral process, defining it “as the dissemination of scientific knowledge formatted for reception by actors using intermediaries which can be written texts or verbal advice incorporating knowledge claims, as well as technical objects”.

From the perspective of demand, scholars concerned with innovation processes have explored the supply-demand relationship by looking at articulation of demands, typically by using some form of diagnostic studies or needs assessments at the start of an innovation process, often from a macro-level structural or institutional perspective (Hall et al., 2006; Klerkx and Leeuwis, 2008a; Röling et al., 2004). Building on this work, others examined how users articulate demand for innovation support at the micro-scale using a learning agenda to capture the dynamic analysis of problems and opportunities (Klerkx and Leeuwis, 2008b; Boon et al., 2011). Kilelu et al. (2014) argued that substantive demand articulation is about concretising unspecified, sometimes latent needs, into clear demands through dialogue between the demand and supply sides of innovation support services. Although, as Kilelu et al. (2014) points out, the demand and supply concept suggests adherence to a linear perspective, demand is not always completely pre-determined leaving the opportunity for supply to be cocreated (see also (Sarewitz and Pielke, 2007). This understands that the balance between supply and demand can be shifted and suggests that with respect to translation processes it can be fluid and two-way.

This paper aims to understand how integrating interactive approaches into a science-driven approach can reveal these constituent processes involved in the context of the VALERIE project. Specifically it describes the development of a methodology that enables stakeholders (as potential users), in three European case studies concerned with arable agriculture[7]7, to identify, formulate and articulate research needs and evaluate existing scientific research outputs for potential solutions to these. In doing this, it allows us to examine how scientific knowledge is transformed as part of this process, and reveal what co-translation looks like as a practice rather than simply a concept.

It is acknowledged that scientific knowledge is only one component of the innovation system and that there are wider systemic challenges to innovation, with social, institutional and political factors affecting both the conduct of agricultural science and the translation of research results into farming practices (Sewell et al., 2014; Hall et al., 2001). It is also recognsed that innovation can happen at different points along the value chain (Vanclay et al., 2013). These aspects are considered in the project, however there is insufficient space to fully report on them here.

[7] Whilst the project is concerned with agriculture and forestry, this paper focuses on analysis of case studies in the former

3. Context and methodology

The premise of the VALERIE project is that many research projects in agriculture and forestry provide excellent scientific results but that outreach and translation of these results into farming and forestry practices is not always effective. The challenge is therefore seen as boosting innovation by facilitating the uptake of formal and empirical knowledge, and its integration into field practices. The project aims to address this by translating research outcomes with a special interest in innovative and applicable approaches into end-user content and format (for farmers, advisers, supply chain actors etc.). It does this by extracting and summarising knowledge from national, international and EU research projects and studies concerning innovations in agriculture and forestry (with a focus on six selected themes[8]). It assembles a document base and provides easy access to it through a smart digital retrieval system (web based) called *ask-Valerie.eu* (Willems et al., 2015). Thus, the document base is derived through a science-driven process and superficially the translation process is understood to involve extraction and summary of research results.

However, central to the project, and to the development of *ask- Valerie.eu*, is an iterative methodology in which the project can collect a wide range of innovation issues, learn how potential users articulate questions for research about these issues, and understand how they screen, filter and test extracted research outputs, as part of the translation process. This methodology and the associated results are the subject of this paper. This approach understands that solutions derived from research need to be utilised and re-built in the field, with the involvement of relevant actors. Case studies (CS) and their stakeholder communities are at the core of this process. Ten CS were selected to represent different regions and production systems across the themes, and are organised around a particular supply chain, sector, or landscape, and so cover different scales and dimensions and incorporate different stakeholder communities. We report on three agricultural CS here (Table 2).

The methodology is underpinned by an iterative or cyclical process based on regular project interaction with stakeholders in CS (Fig. 2). The cycle starts with stakeholders in each CS identifying *innovation issues*[9] and articulating these as issues, research needs or questions in participatory

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[8] The themes are: 1) crop rotations, 2) eco-system and social services, 3) soil management, 4) water management, 5) sustainable integrated supply chain services, 6) recycling and smart use of biomass.

[9] Stakeholders were asked to identify innovation issues, and Thematic Experts solutions, in the understanding that typically farmers take an issue or problem-oriented approach in their day to day activities, and that usable science therefore needs to offer innovation solutions to these. The project criteria for being innovative is that the solution is novel to the user.

meetings. These meetings are facilitated by Case Study Partners, project partners who are extension specialists connected to the CS. Thematic Experts, who are project scientists (who also attend the meetings) then search existing scientific literature for *innovation solutions* to address these issues, and extract, synthesise or summarise the relevant solution-oriented research findings. Stakeholders screen, evaluate and refine these solutions for their innovation potential and feedback to the Thematic Experts, thus completing one cycle. The cycle is repeated and, at each iteration, innovation issues and solutions are reviewed, re-articulated and refined, further information or clarification (by stakeholders and Thematic Experts) is sought and new or modified innovation issues and solutions are generated. A key tool in the process is the Dynamic Research Agenda (DRA) which Case Study Partners use together with stakeholders to monitor, review, revisit and refine the innovation issues and solutions at each meeting. This is modified from the Dynamic Agenda, a reflexive learning-oriented monitoring process (Van Mierlo et al., 2010). The DRA helps to operationalise the process of co-translation allowing articulation of needs and provision of solutions to be jointly mapped in the CS over time.

Table 2 Case Studies: background and meeting methods.

Background, goals, SH characteristics	Participatory method for issue identification & CSP influence
Potato supply chain, Poland	
Supply chain linked to a processor company with a large farm and 60 contract farms. The company invest in research to improve quality and yield **SH:** suppliers of seeds, fertilisers, pesticides, processors and professional farmers already accessing research (12-14 participants at meetings)	Individual participants were asked to list the main issues, this was followed by a plenary discussion about the topics raised and then a process of prioritisation. The CSP steered prioritisation according to: what the project can offer, filtering out systemic constraints and 'well-known' solutions
Innovative Arable Cropping, France	
Farmer group active since 2005, working with an agronomist to test techniques (tillage, legumes, cover crops) to improve soils, reduce weeds. **SH:** mainly farmers, technical services, field advisers, co-operatives, Agricultural Chambers, research institute (6-8 participants at meetings)	Farmers each wrote keywords on a flipchart. Through successive rounds, farmers clarified and explained underlying ideas behind the keywords to the group. With this process the research questions were formulated progressively and collectively CSP tried to steer SH away from previous topics. TE attended meetings
Bread wheat supply chain, Italy	
Quality is a key concern for this supply chain **SH:** Farmers, supply chain players, cooperatives offering storage, millers, input suppliers, retailers and processors (18-20 participants at meetings)	A moderated poster circuit method was used. Participants circulated in groups, filled and reviewed the posters for issues in each step of the chain: production, inputs supply, technical assistance, storage. The broad issues were narrowed down by CSP and TE to issues and research questions concerning production CSP guided SH in selecting issues that could be realistically addressed within the scope of the project. TE attended meetings

SH – stakeholder; CSP – Case Study Partner; TE – Thematic Expert

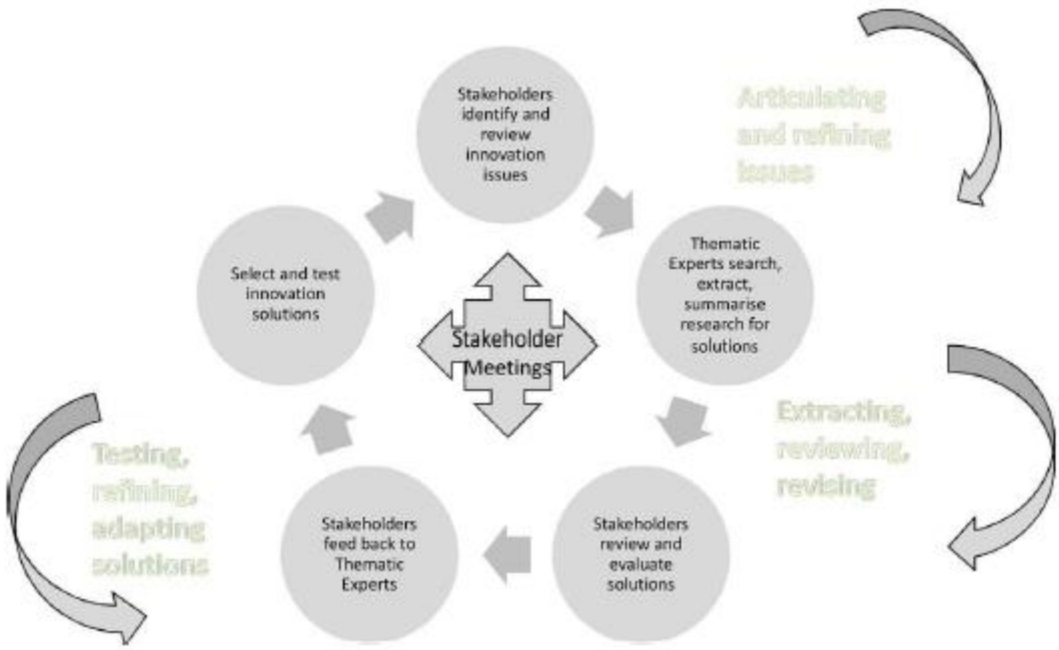

Figure 2 Stakeholder interactive methodology

A minimum of five stakeholder meetings are held in each CS over the project period, however, stakeholder and Case Study Partner interactions take place throughout. As the cycles progress the stakeholders identify trials to apply and test the potential of selected innovation solutions in the local context. These trial results will feedback into the iterative process and provide co-created empirical knowledge to be integrated into *ask-Valerie.eu*.

Case Study Partners select different participatory methods and tools from a project methods toolbox to use in meetings to assist stakeholders in identifying issues and evaluating solutions (Table 2). In the preliminary meeting stakeholders were encouraged to firstly step back from existing interests and identify broad goals and visions so that the scope for innovation was broad. In extracting research, Thematic Experts apply a systemic and organised search for published scientific knowledge using conventional search engines. They also search national repositories and databases, EU sources (CORDIS, EIP) and international projects. Reports, scientific publications, grey literature, technical notes relevant to the CS issues are retrieved and provided to stakeholders, including 100 scientific papers for each CS. The most relevant are used to prepare factsheets of specific innovation solutions for the stakeholders, typically a two page synthesis with a common template (innovation issues, innovation challenges, innovation solution, evidence of benefits, and drawbacks). Stakeholders evaluate these following a structured process common to all CS.

This cycle runs concurrently with development of *ask-Valerie.eu*. As the tool is developed it will replace the Thematic Experts and be used directly by the stakeholders as the search and retrieval system. At this stage of the project the methodology aims to both mimic and inform the tool; the process not only offers insights into how stakeholders formulate and evaluate issues and solutions from research but also offers a proof of concept of the search tool. Furthermore, the factsheet, as well as conveying scientific information directly to stakeholders, is being designed and trialed as a translation format for the main result page for *ask-Valerie.eu*.

Data analysed for this paper are derived from three cycles using meeting reports and DRAs, semi-structured interviews with Case Study Partners, discussion in training (virtual and workshop) and three project meetings. Analysis in each CS is structured around the processes integral to supply and demand, this provides a framework in which to investigate the constituent parts of the translation processes in the 'middle ground', as discussed in Section 2. For convenience these are divided into two sub-sections: *identifying and articulating innovation issues* and, *providing and evaluating innovation solutions*, however in reality the component processes continuously interact.

4. Results

Integrating interactive approaches into an essentially science-driven approach reveals progressive and reciprocal translation processes comprising identification, prioritisation, articulation, searching, retrieval, extraction and synthesis, and evaluation of innovation issues and solutions. Selected results from three CS are analysed here, each supported with detailed DRA.

4.1. Sustainable potato supply chain, Poland

4.1.1. Identifying and articulating innovation issues

In this CS the supply chain deals with potatoes for French fries processing. The stakeholders represent a professional group of producers, processors and input actors dealing with specific supply chain issues who are well provided with, and access and utilise, scientific information with support from the Case Study Partner (Table 2). This CS illustrates how stakeholders identify familiar issues which are progressively reviewed as the interactions are repeated with drilling down into the available research to address pressing specific quality problems, as shown in the DRA (Fig. 3).

In the first meeting nine broad issues were initially collected, mostly concerning crop quality, then analysed by stakeholders in a group discussion with the main priority identified as controlling internal brown spot in potato tubers. This is a prevalent issue and represents a major quality problem in processing of French fries. The preliminary issues focused on known or suspected factors that cause brown spot: Tobacco Rattle Virus (TRV), calcium (Ca) deficiency; and on potential solutions through control with different varieties and with rotation. The Case Study Partners explained the process in his report:

> “the first stage of research questions are very general and open (what could cause poor quality …) but with input from experts (face to face and the fact sheets), questions become more specific”.

This is demonstrated on the DRA which shows that, as meetings progressed and information from research is increasingly made available, the list of stakeholder questions become more refined, although the key issues remained. From the stakeholder perspective, they are not clear whether the issues identified can be addressed with scientific knowledge. According to the Case Study Partner, the stakeholders mixed up innovation issues and gaps in available research outputs. For some issues, identified solutions were already available but apparently not known by some stakeholders, or they could not be answered by scientific knowledge. The Case Study Partner explained:

> “Generally speaking, they talk about problems they encounter, not distinguishing between research needs and other businesses. The question, if it is a research question or not, is also determined by the fact if research has already been done on the topic and if an answer has been found already (without knowledge of the farmer or stakeholders)”

4.1.2. Providing and evaluating innovation solutions

The Thematic Experts synthesised current research understanding of brown spot issues from some 10–15 scientific papers and prepared three illustrated factsheets oriented towards solutions and written in what they said was “an easily understood language and style”. These were supported by other formats- scientific papers and expert presentations (Fig. 3). The stakeholders described the factsheets as valuable, in that they collated information and allowed them to review current understanding. As a farm manager remarked, one factsheet “is better than having technical papers at least 10 pages long”. However, stakeholders said that they did not offer new research findings as solutions for the specific issues raised. The Case Study Partner reported:

> "The factsheets give a good summary of the available knowledge about all aspects of TRV. It became clear to the participants that TRV damage in potato is a very specific phenomena… It is clear that we discuss a complicated problem… we know that there is ongoing research on TRV in potatoes, new or additional information is very welcome."

However, reviewing the 'state of the art' in research (e.g. several TVR strains exist, different nematodes exist as transmitters, only specific species are infected with TVR and cultivars have different susceptibility) prompted revised specific questions from stakeholders.

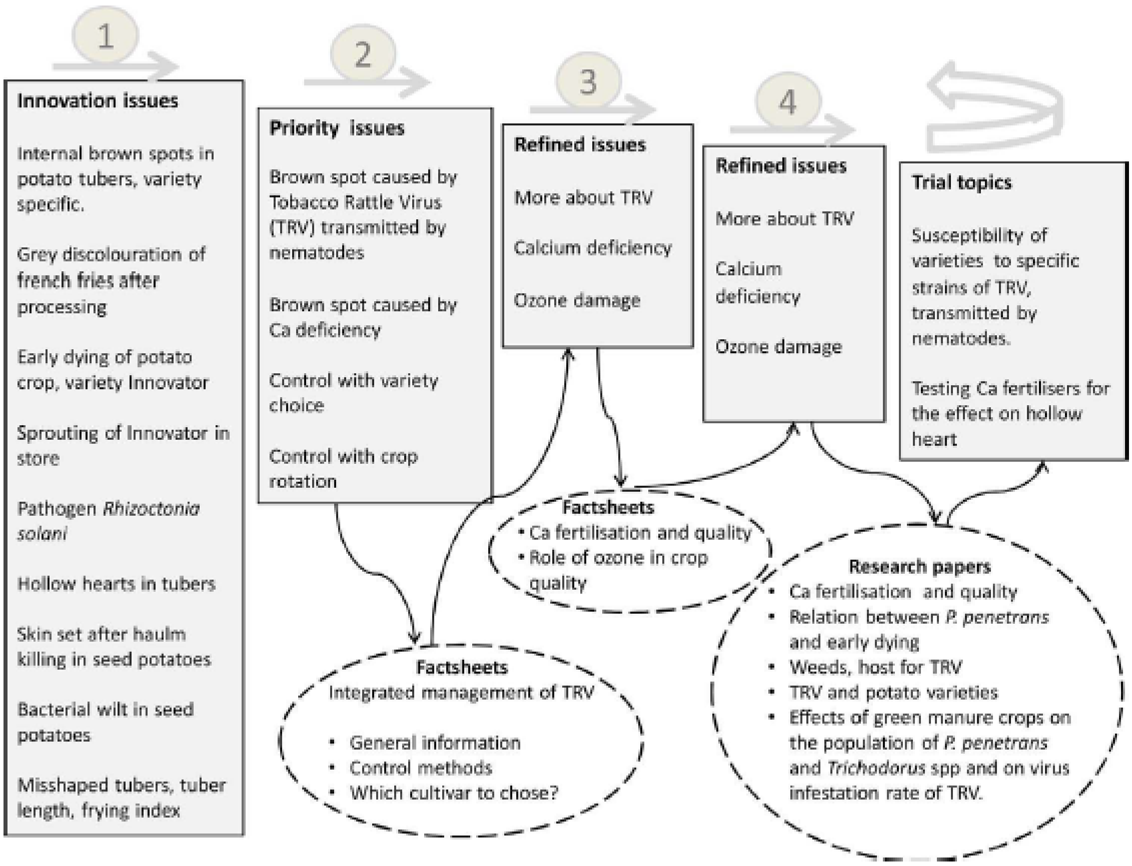

Figure 3 Potato Supply Chain Case Study Dynamic Research Agenda

Despite not providing specific solutions, stakeholder expectations are moderated and they see the potential of the process, as the Case Study Partner explained they are:

> "…a critically positive group of stakeholders, they have very specific questions, related to their business. Stakeholders don't expect a complete and concrete solution. When this is available, fantastic, but also information that can help to find or create a solution is fine."

In Meeting 2, as well as commenting on the factsheets and reiterating their interest in learning more about ongoing research on brown spot and TRV, the original innovation issues list was reviewed and updated, and further issues were identified (the effect of Ca-fertilisation and the possible role of ozone on crop quality) and trial topics were identified as shown in the DRA (Fig. 3). The trial outcomes according to the Case Study Partner can bring the stakeholders to the “next level of utilisation of research outputs”.

From the Thematic Experts’ perspective they found that these professional growers and their technical supporters are already accessing up to date research outputs and it was hard for them to find novel scientific outputs to meet their specialist needs. As the meetings progressed the Thematic Experts reflected on the responses to the preliminary factsheets, searched scientific outputs for solutions to the new issues identified and prepared two further factsheets and five summaries of science papers. However, when presented at the next meeting stakeholders again described them as incomplete and not sufficiently specific for their situation. The Case Study Partner remarked in the meeting report that there are several remaining questions, however it is clear that the detail and complexity of these is advanced beyond the issues first articulated, the report said:

> “There is not a single brilliant solution, as there is interaction between several nematodes, crops and green manure. It’s a puzzle how to find the best way forward, also depending on the crops and crop rotation… we still don’t have the clue to the early dying problem and the question how to deal with a mixed population of P. Penetrans and Trichodus spp in relation to quality problems and yield damage in potatoes”.

The DRA (Fig. 3) proved a useful tool for the Case Study Partner to monitor progress with the stakeholders. Those issues on the original list according to the Case Study Partner will be revisited or are already implicitly answered within the priority questions. Overall the Case Study Partner said that the evaluation and feedback acted to prompt discussion and better elaboration and articulation of issues. However, he felt that there were some limitations with respect to raising expectation of the stakeholders.

4.2. Innovative arable case study, France

4.2.1. Identifying and articulating innovation issues

This CS works with an active farmer group who are testing techniques (tillage, legumes, cover crops, intercropping) to improve soil fertility and reduce weeds. The stakeholders comprise innovative farmers who are knowledgeable and well served by an agronomist and other innovation services providing technical and scientific information. This CS illustrates how stakeholders selected issues already known to them, but were able to progressively construct a set of new specific questions in the first meeting.

In Meeting 1 the Case Study Partner considered it was not necessary to ask the group to identify their wider goals and visions as they have been active together since 2005 and these are well known. With respect to identifying specific innovation issues, the Case Study Partner wanted to avoid the influence of current activities, remarking:

> “We have chosen not to guide nor influence farmers on the research themes by reminding them of their past discussions or field trials. We have, therefore, refrained from mentioning their ‘known' issue related to soil management (tillage and drilling) and soil covers”.

Box 1 Progressive formulation of questions about nitrogen management.

1. Key words /concepts were identified: Nitrogen / behavior of nitrogen / nitrogen cycle in the soil / + carbon / + organic matter / key nutrients cycle in the soil according to different cultural practices (Direct sowing, strip till, cutlery, tillage) or cropping system

1.1 Interim terms: Seeking to break misconceptions on nutrients cycle (e.g. direct sowing increases the OM content of soil; OM can be found concentrated at the surface as mineralisation occurs less easily). "What are the effects of direct sowing, covers, and soil tillage on the nitrogen cycle, its redistribution, and release (and the dynamics of the organic matter and carbon)?"

1.1.1 Final question: "What are the effects of agricultural practices such as direct sowing, cover crops and soil tillage on the nitrogen and organic matter cycles and availability?

Stakeholders formulated innovation issues collectively. The process involved gradual construction of research questions from keywords and issues shared by farmers and produced a refined list of five questions. Box 1 shows the steps taken in developing a specific question about nitrogen management, one of the five questions. The Case Study Partner explained the importance of agreeing on wording as the farmers used many terms to explain the central idea of each question:

> “to ensure mutual understanding between the participants and facilitator, and to link between the words chosen and the realities to which they refer, several iterations were necessary to validate the idea and to define the scope of the question”.

The DRA (Fig. 4) shows how the five issues are progressed with reviews in each meeting, and used to select and formulate the trial protocols, with one selected for particular attention: developing a guide for field assessment of soil and crops.

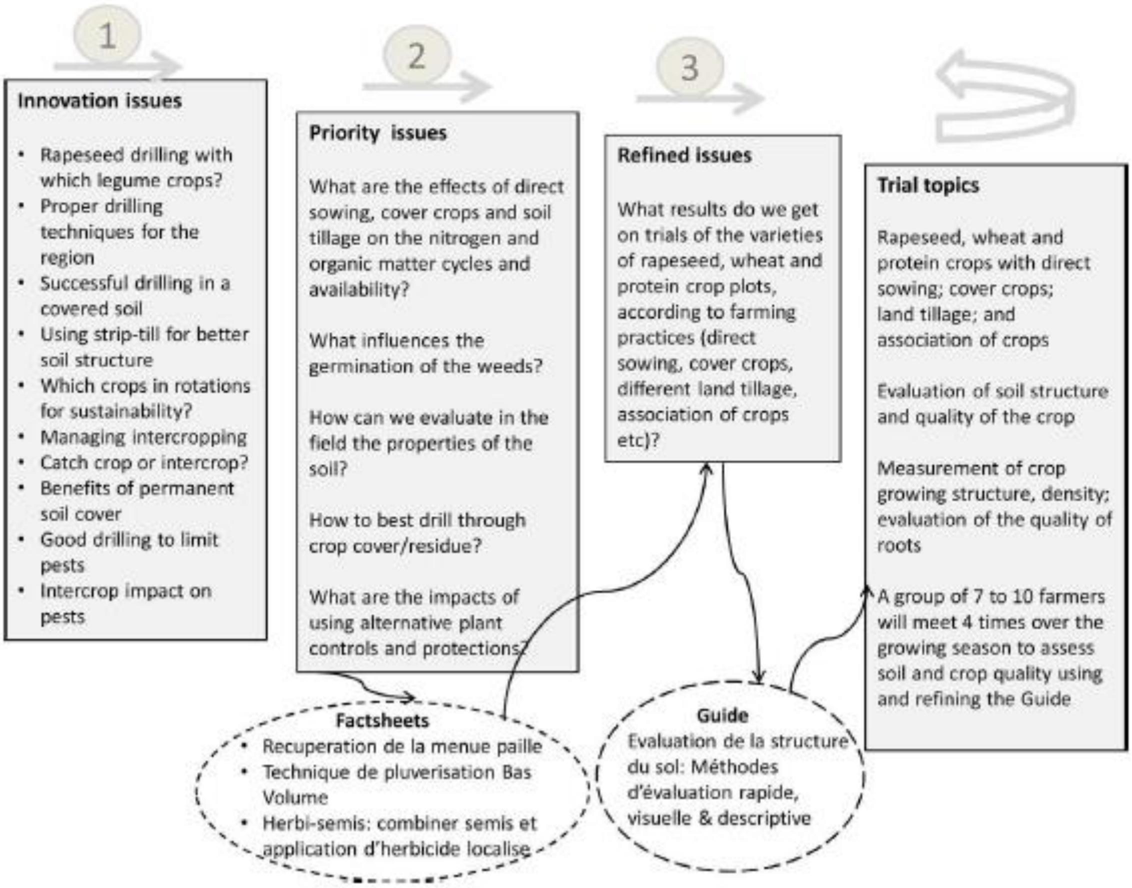

Figure 4 Innovative Arable Case Study Dynamic Research Agenda

4.2.2. Providing and evaluating innovation solutions

When it comes to addressing the specific questions of the stakeholders, despite this process of refining questions, the Thematic Experts remarked that the depth of articulation and refinement of questions was insufficient for them to conduct a thorough search of research saying “farmers asked rather global questions but wish to get specific responses” and Thematic Experts had to ask farmers to provide additional details, specifically to expand on the generic terms used such as ‘weeds’, ‘legumes’ and ‘disease’. Prior to this re-articulation, preliminary factsheets were prepared by Thematic Experts synthesising scientific papers, and providing potential innovation solutions to CS issues. These are two page illustrated formats with scientific information presented as graphs, and costs of techniques detailed. Farmers’ comments primarily concerned the credibility of content. They requested that only verified information is shared and they put great store on robust scientific data. They expressed their preference for a clear and concise description of how to implement the innovation solution. Where trial data are reported these farmers want details of the experimental conditions, so that the operating context of the innovation is explicit and makes clear that “there are no recipes”, rather that trial results are “food for thought.” They also requested evidence of benefits backed up with examples of other farmer experiences, since they believed that this was “more meaningful” than straightforward summaries of scientific information.

The Case Study Partner explained that farmers find it hard to just look at the content, they want to situate the information they receive so that they can judge its relevance to, and validity for, their situation. Thus the usefulness of the factsheet format constructed by synthesising scientific outputs from a number of contexts is questioned. Furthermore, according to the Case Study Partner the farmers are seeking information on the interactions between the techniques offered as solutions, rather than on the techniques themselves, this is something scientific outputs and factsheets cannot impart.

With respect to the solutions proposed, their relevance might not be immediately obvious to the farmers, who, according to the Case Study Partner, “face specific problems, but the answer, perhaps, it’s not very direct, it can be indirect. The problem is specific but the solution can be a combination of dimensions”. The Case Study Partner went on to explain the difficulty the project faced in translating science into formats that have some utility for farmers, highlighting the different attributes that are valued by research and practice:

> “..the challenge for the project therefore is to reconcile their [stakeholder] expectations for contextualised data of practical and validated information with the available [scientific] documents which are characterised by …reports and scientific articles and by their ‘scientific style’ [intended] for an academic audience”.

4.3. Bread wheat supply chain, Italy

4.3.1. Identifying and articulating innovation issues

This CS comprises a broad stakeholder community: farmers, supply chain players, cooperatives offering storage, millers, input suppliers, retailers and processors concerned with producing high quality bread wheat. Producer contracts ensure premium prices but specify conditions for the grain quality.

To reflect the stakeholder community the first meeting explored issues in four areas: Field production; Fertiliser and pesticide supply; Technical assistance; Storage-transformation of wheat (Table 2). This allowed sufficient scope in goals and visions across the whole supply chain to be expressed but generated a long list (17) of issues many of which could not be answered by scientific knowledge (for example, one issue raised was that there are too many varieties on the market). The Case Study Partner remarked "Unfortunately, we noticed that more general issues than research questions came out".

These issues were narrowed down in a process steered by the Case Study Partner and Thematic Experts, to issues and research questions concerning production, since these could be potentially resolved with scientific information. The resultant issues were categorised by the Case Study Partner into three different domains (1. Quick methods for quality assessment of grains; 2. Agricultural practices to save inputs and increase quality; 3. Economical evaluation of the most innovative practices). The DRA (Fig. 5) shows how these remain and are reviewed at each meeting, with a particular focus on quick field testing methods to assess grain quality (to measure grain weight and moisture) to help farmers to decide when to harvest, which was selected as the topic for trialling in the CS.

Stakeholders were aware they needed innovation but prioritised getting a good price for their product. Overall, stakeholders found it hard to identify innovation issues in terms of research as they are already well served with information. The Case Study Partner remarked "It is difficult for stakeholders to identify research gaps because wheat is one of the most important crops and there is plenty of information in the field of wheat research". He went on to report that stakeholders "aren't looking for research per se. they are looking for solutions". When asked to provide research needs the stakeholders had to clarify what was required of them, saying "What type of answer do you want from us?" However this appears to be related more to misunderstanding the purpose of the meeting, as the Case Study Partner argued formulating specific questions is normally not problematic for these stakeholders.

> "if you … take professional farmers, while they are educated in the professional way, so they know their jobs. So, it's not when you go to the doctor and say 'I feel sick', it's not the way. […] When you are a nurse and you go to the doctor, you don't say 'I feel sick', you say, 'I have pain in my elbow, I cannot put pressure on it'. So if you are in the same sector you tend to be specific, so they are not saying 'I have a problem with weed' and then wait for others to understand or unravel what it is."

4.3.2. Providing and evaluating innovation solutions

Thematic Experts summarised and synthesised outputs from several scientific papers to prepare three factsheets (Fig. 5). When these were presented at Meeting 2 stakeholders considered that they did not offer solutions, and in some cases proposed unsuitable approaches (e.g. cover crops, drones), and were not specifically for the bread and biscuit wheat varieties relevant to the stakeholders. The Case Study Partner remarked:

> "From our point of view the first draft of factsheet were not totally responding to the main issue of the case study. If possible, it would be interesting to have other factsheets available … on other themes. Those factsheets should focus on bread or biscuit making wheat, as they are the most common quality typologies grown in this area".

The stakeholders also criticised the factsheet format and content, as the Case Study Partner remarked "what the stakeholders need are factsheets that are really specific, not general or too academic; and format needs to be more practical". This poor matching of issues and solutions might be attributed to absence of existing relevant solution-oriented research, and to some extent the Thematic Experts' limited understanding of the highly specialised nature of wheat production for a bread wheat supply chain, and the economic and practical aspects of these farm operations. However, with respect to the latter, the Thematic Experts' presence at the meetings was described by the Case Study Partner as invaluable, the "best addition" to the meeting due to their interest, suggesting that they fully understood the context of the issues.

Given that a number of issues and questions remained unanswered according to the DRA, the Case Study Partner explained that they "stopped refining the research questions and started looking for answers. Otherwise it is repetitive and no one likes repetition". In the absence of further factsheets from the Thematic Experts, the Case Study Partner themselves prepared factsheets for three selected issues identified as important in Meeting 1 using scientific documents provided by the Thematic Experts (Fig. 5) but drawing on their own resources and understanding of stakeholders needs:

"We went back to analysing the needs and issues of the stakeholders. Among the 100 case study documents, we selected some possible results that could be of the case study interest. When the bibliography was not enough, we enlarged our search field into scientific databases and commercial innovations available on the web, as well as, looking at our physical library. Summaries were short and no longer than one page and we tried to use a simple language, to point out technical and economic aspects of the innovation"

The stakeholders' response to these in the following meeting was more favorable than for the Thematic Experts' factsheets. They assessed them on the basis of utility, they appreciated the focus on prices and availability of the innovation in the selected supply-chain; and the synthetic layout.

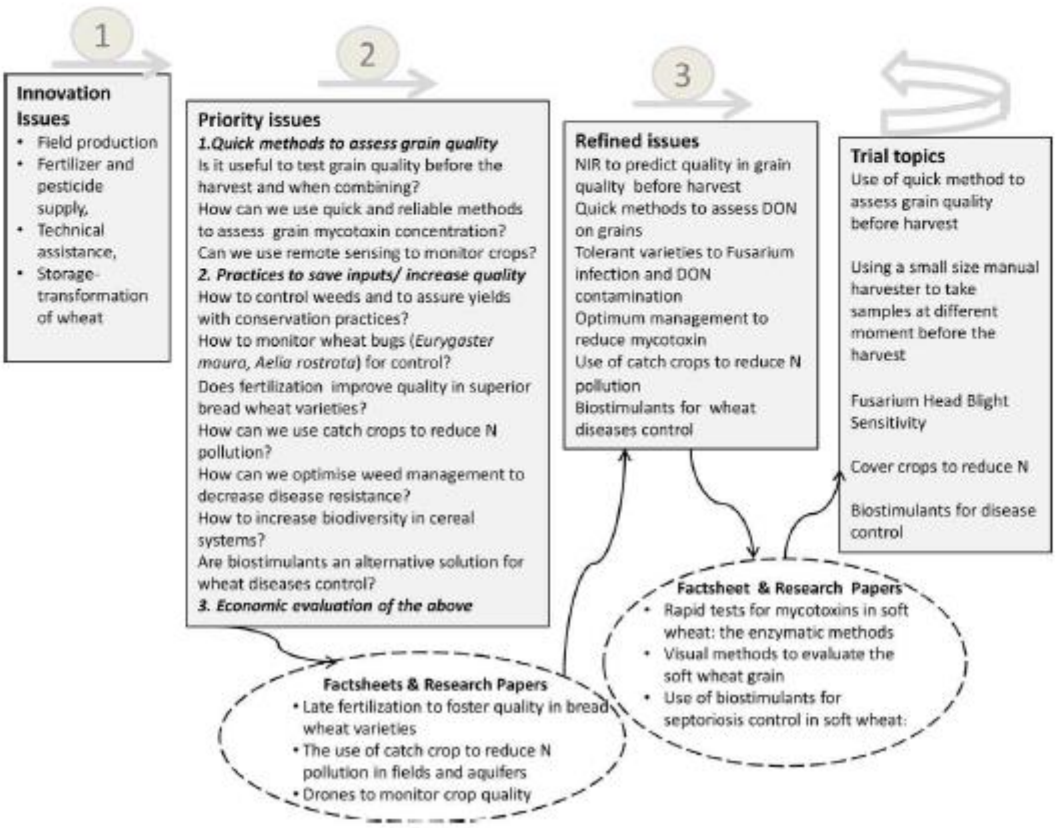

Figure 5 Wheat Supply Chain Case Study Dynamic Research Agenda.

5. Discussion: research translation as co-translation

Analysis to date shows how an interactive approach can support translation of existing bodies of scientific knowledge to different extents, as well as reveal multiple constituent translation processes. This discussion firstly considers the constituent translation processes involved in identifying and articulating issues and in extracting and evaluating solutions, and secondly considers how the iterative methodology enables a communicative co-translation approach to evolve.

5.1. Translation processes

The CS results charting the interplay between innovation issues and solutions reveal a multi-faceted translation process comprising identification, prioritisation, articulation, construction of issues and questions, searching, retrieval, synthesis, interpretation and evaluation. The diverse CS in terms of their social and technical context shape how these processes unfold, specifically the CS goals, the innovation system in which they operate, the composition of the stakeholders, their interests and 'scientific literacy' all have a bearing on the translation processes.

5.1.1. Identifying and articulating issues

Existing activity and innovation support in each CS influences both the process of identification and articulation of innovation issues, and the stakeholders' level of understanding of, and expectations from, scientific outputs. Although encouraged to step back from current interests and initially identify broad goals and visions, stakeholders tended to immediately identify established or current topics. This is not surprising in mature stakeholder communities (Potato Supply Chain and Innovative Arable CS) with established relationships who have previously negotiated and agreed specific concerns and so can quickly agree on relevance boundaries. What is and is not permissible within a stakeholder community, in terms of issue identification, may have been informally established prior to the project. Stakeholders who are diverse and brought together for the purpose of the project (e.g. Wheat Supply Chain CS) require greater discussion and negotiation, as demonstrated by the DRA, before agreeing on boundaries and specific issues to explore; this has also been observed in the other newly established CS in the project. Thus, although there is no single overall issue immediately identified in each CS, the process of identifying and agreeing on an issue was variable depending on CS history.

Thus, although stakeholder demands are not always completely predefined before interaction with others (Kilelu et al., 2014), there is a tendency for some to restrict their issues to known themes. This can limit the opportunity for advancing innovation and restrict the scope of new solutions. Sumberg et al. (2013), in reviewing user involvement in the field of new product development, suggest that 'typical farmers' will more likely identify topics they are familiar with while 'research-minded farmers' might be more enquiring in their issue identification, and arguably evaluation of solutions.

In this study all the CS farmers in the stakeholder communities might be described as research-minded, although they stayed in familiar territory when identifying issues. However, input from formal research allowed the familiar issues to be unpacked and interrogated further with the outcome that newly adjusted questions emerged. Thus, as found elsewhere, dialogue is not only a means of communication, but it is also a means to generate new ideas, negotiate understandings and build knowledge (Sewell et al., 2014).

The specificity of the issue is also determined by the CS background and stakeholder composition. Professional growers in the Potato Supply Chain CS focused down onto quality issues, reflecting the demands of the supply chain they operate in but also previous scientific attention to these problems. They expressed these as highly specific agronomic issues and externalised them as precise research questions. The large range of stakeholders' interests in the Wheat Supply Chain CS alternatively started with wider systemic issues related to markets or other factors. Although this reflects a broader stakeholder community, it also demonstrates the difficulty some stakeholders have in dissociating issues and problems and ways of addressing them. Furthermore, it reveals how stakeholders operate in a complex innovation system and value chain where considerations other than research outputs are more pressing (Hall et al., 2006; Vanclay et al., 2013).

The ability to articulate the innovation issue in terms of concrete and manageable questions or topics for Thematic Experts at an appropriate level of detail was something that varied among stakeholders. In some cases Thematic Experts found that "farmers ask global questions but wish to get specific responses" creating a difficult task for Thematic Experts who need to filter their search to retrieve relevant outputs. Thematic Experts also set their own boundaries with respect to where they search for information, and what they consider is relevant, legitimate and useful. Mismatching of issues and solutions was attributed by some project partners to this poor formulation of issues, as one commented "Sometimes farmers don't ask good questions, they sometimes have the answer in the question". The assumption that stakeholders can turn issues into scientifically valid questions which can be used to seek and test out knowledge is therefore somewhat simplistic. Producers often already have a high degree of experience and complex knowledge which they use for everyday problem identification and solving (Baars, 2011). Asking them to externalise this process and to articulate issues in an explicit way that can be interpreted by researchers is not a straightforward process and in some cases requires sustained dialogue, clarification and a number of iterations. Experience in this project shows that the iterative process needs to be long enough to facilitate such a continuous re-articulation, it is not always realistic to expect stakeholders to identify and specifically articulate their innovation issues in one or two meetings. Articulation develops progressively as topics and questions are revisited, and become more focused at each meeting, steered by new scientific information from the Thematic Experts. As noted in the context of innovation support services, farmers have problems concretising demands, as such, sufficient attention should to be paid to collecting their needs by monitoring the process through continuous capture of information (Kilelu et al., 2014; Ringsing and Leeuwis, 2008). The DRA proved a powerful tool in doing this, allowing issues and solutions to be collectively reviewed at each meeting.

Beyond the specificities of questions, stakeholders sometimes struggle in the process of identification to recognise an issue or problem which might be addressed by a solution derived from research outputs. They identify issues which cannot be resolved by scientific knowledge, or indeed issues that already have a well-known (i.e. not innovative) solution (thus reinforcing the fact that research translation overall is not effective in this CS). This is line with Hoffmann et al. (2007) who suggest that farmers might not know whether the problems they mention can be solved through research. The immediate relevance or application potential of scientific knowledge is not always apparent to practitioners. As noted in the literature on science-policy interface, different actors perceive the usefulness of scientific information differently, they do not uniformly make the same assumptions about what they think is useful and what they know is usable (Lemos and Rood, 2010). In this study, for example, the alignment in assumptions about usefulness between stakeholders themselves and between stakeholders and Thematic Experts is highly variable. Translation appears to work best when the Thematic Experts, Case Study Partners and stakeholders are all comfortable with the scientific environment, as discussed next. Finally the intermediary role of the Case Study Partners in all CS in steering decisions about which issues to select and prioritise was apparent and has been explored separately elsewhere (Ingram et al., 2017).

5.1.2. Providing and evaluating solutions

Stakeholder awareness of, and familiarity with, interpreting and utilising scientific outputs is variable. This is often shaped by their previous engagement with technical support and access to up-to-date specific agronomic information. In some cases Thematic Experts had difficulty in finding relevant solution-oriented research outputs which were new or could meet the high expectations and the specificity required by science-literate stakeholders. The results also revealed the different extent of stakeholder appreciation and respect for the authority and usefulness of scientific outputs. Some (e.g. Potato Supply Chain and Innovative Arable Cropping CSs) demonstrate a level of scientific literacy in that they express interest in the reliability of data and evidence of sources and are able to evaluate the quality of scientific information provided on the basis of the methods used to generate it and its reproducibility. Only in the Potato Supply Chain CS, however, were stakeholders inclined to read or follow up on the scientific papers or references in the factsheets. For other CS stakeholders, although they have sufficient knowledge of scientific terms (e.g. nutrient cycling) to be able to formulate questions, scientific papers or reports are not their everyday currency.

For this reason most of the stakeholders require some form of transformation of scientific information from academic or report style outputs to other formats. In this project this involved a synthesis of scientific knowledge into factsheets for certain issues. From a scientist's perspective a synthesis or summary of scientific documents as written text is the obvious 'unit of translation' as it distills and communicates the key research outcomes in a written, codified format. However, as noted in other contexts the translative processes in which scientific material has been 'processed' for consumption by different audiences is rarely unproblematic, as people will modify knowledge as it passes through (Callon, 1984). It is the Thematic Experts who select particular data to translate, unaware that stakeholder information needs and utilisation are diverse. Although the medium of factsheets is not questioned by stakeholders, the content and format is. Some require specific solutions to issues rather than a synthesis, simplification or generalisation that the factsheets currently tend to deliver, or look for information on interactions between the techniques. While some stakeholders enquire about experimental conditions of the trials summarised, as they want to gauge credibility and interpret the data for their production systems and context, others judge the information provided on the basis of practical utility and look for illustrative examples with farmer testimonials. Although researchers attribute more validity to extracting and synthesising research solutions and messages from a body of work, practitioners look for the detail from single studies, as observed elsewhere (Lavis et al., 2003; Ingram et al., 2016). Overall, as noted by Moser (2010) individual information needs are multi-dimensional, it is too simplistic to assume individuals merely lack information or understanding.

Clearly deconstructing problem solving and knowledge seeking into repeated phases of identification of issues, retrieval and synthesis of solutions and their evaluation in meetings is somewhat artificial (as too is the Thematic Experts' provision of a bespoke search facility) and cannot replicate the dynamic translation processes that go on when stakeholders themselves seek out and utiltise knowledge. Nor can this process account for the multiple facets of stakeholders' own experiential knowledge or what (Baars, 2011) calls 'experiential science' and its interplay with formal science. In this respect we cannot assume that relevant information or solutions can only be found in the scientific domain. However, some important insights have been revealed from the iterative methodology about the multiple elements contributing to the process of translation.

5.2. A co-translation process

Beyond these constituent processes, more fundamentally the utility of the scientific information in providing solutions can be explored and questioned. The assumptions that science can provide such solutions underpins Gibbons et al. (1994) Mode 1 type of knowledge production which considers that problems and their solutions are close to each other in time and space (Lundy et al., 2005). The results here have revealed that the situation is more complex. The assumption that innovation issues can be expressed as research needs or questions and that innovation solutions can be found in scientific knowledge is too simplistic, as in reality the process is far more nuanced. Simple matching does not emerge immediately but requires a dialogue and an understanding to develop between those formulating the problems and solutions, as exemplified by Thematic Expert and stakeholder reciprocal exchanges in the CS.

This project, in integrating interactive and science-driven approaches, is aiming to bring these problems and solutions (and assumptions) closer together in a process that might be conceptualised as co-translation. By incorporating aspects of Mode 2 type research, with its problem-solving epistemology, the methodology fosters the interaction of multiple actors with multi-layered sources of issues and existing solutions to enhance translation. It also allows those affected by the problem to be drawn into the translation process, albeit towards the end. Building the methodology around the principles of iterativity, dialogue and reflection enables issues and solutions to be progressively reviewed, elaborated, clarified, reformulated and distilled. Such repeated purposeful and strategic interaction between knowledge producers and users is seen as key to increasing knowledge usability in a science-policy interface context but is shown here to be equally relevant and important to science-practice translation (Lemos and Morehouse, 2005).

The iterative process facilitates a continuous re-articulation of research needs, while reflection and monitoring (supported by the DRA) reveals that co-translation is a dynamic, reciprocal process of identification, prioritisation, articulation, construction of issues and questions, searching, retrieval, synthesis, interpretation and evaluation and needs to continuously adjust in response to issues and solutions that emerge over time (Fig. 6).

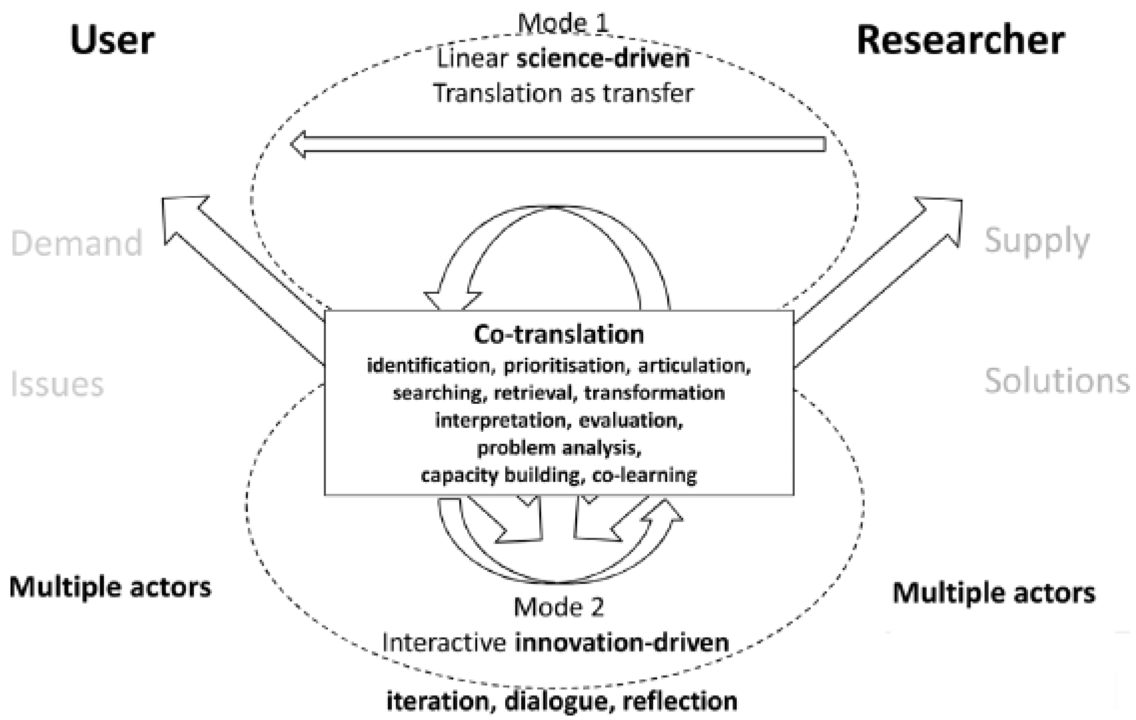

Figure 6 Conceptualisation of co-translation with constituent processes.

Through these processes, co-translation builds stakeholder knowledge but also their capacity to appraise and appreciate research outputs. Even when the search outputs and factsheets did not answer specific issues, they help summarise the state of the art on particular issues, identify gaps, or provide an affirmation that research is missing on certain topics. This corresponds to an understanding of the adoption process as the collection, integration and evaluation of new information to allow better decisions about the innovation by progressively reducing uncertainty (Marra et al., 2003). Thus, user involvement can go far beyond the identification of needs, as noted by (Sumberg and Reece, 2004). Furthermore, repeated cycles supported by the DRA tool, allow co-learning with a more detailed understanding of the problem and context emerging between all actors, as observed in other studies of dynamic learning and articulation demand (Kilelu et al., 2014, Chowa et al., 2013). In all the CS the stakeholders benefited from spending time revisiting innovation issues and thinking about how to better elaborate them. This not only helped them to clarify and negotiate the issues amongst themselves, but also helped the Thematic Experts' task, as it became apparent to the stakeholders that "good answers depend on asking good questions" as one project partner observed. The monitoring and reflection integral to the DRA also led the Case Study Partners, stakeholders and Thematic Experts to develop what one Case Study Partner described as "a different' way" of looking at problem formulation. In these CS there is a process of moving from an unstructured, generic problem to a series of specific issues that contribute to a problem. From this series of specific issues, the CS partner and the stakeholders are constantly trying to identify the critical ones and how to deal with them. In the same way, Thematic Experts start to understand user requirements (and contexts) and how research is evaluated, utilised or adapted; they can also reflect on stakeholder feedback and on their own processes of setting boundaries, interpreting research outputs and factsheet design. Thus, as found elsewhere, dialogue is a key tool to co-construct shared understandings (Sewell et al., 2014). In line with this, scholars commenting on science communication, particularly where there is uncertainty or debate, have referred to the need for a translational domain or translation discourse between scientist and user which allows a conversation to facilitate the decision making process (Faulkner et al., 2007).

Overall, this learning potentially provides a platform for changing participants framing of innovation from linear to interactive and arguably might help researchers shift more towards Mode 2 thinking (Pohl et al., 2010; Gibbons et al., 1994). With continued iteration it may be possible to move more towards a mode of articulation in which issues are deconstructed in conjunction with those of scientific knowledge in order to understand the building blocks and thereby reconstruct them with a common understanding, as described from a transdisciplinary perspective (Ramadier, 2004; Bracken and Oughton, 2006). Although stakeholders are at the very beginning of this process, further iterations will facilitate such coherence.

From the perspective that sees research as providing scientific outputs, and translation as the utilisation of these outputs, then arguably the information provided by the project has not contributed to innovative solutions in the CS, and at best has only provided a starting point for discussion. However, if the research is thought of as going beyond simply providing scientific results, to include structured problem analysis then a process of co-translation, where stakeholders are developing the capacity to explore and test innovative solutions, can be envisaged. This thinking concurs with a wider realisation that research interventions can take many forms, and that the utilisation of scientific information is just one element of a much broader role that research can play in enhancing practitioners' capacity to innovate (Douthwaite et al., 2003).

6. Conclusion

This paper describes experiences in the VALERIE project, which is developing an interactive stakeholder methodology to facilitate translation of existing research outcomes from a wide body of literature. The methodology is evolving, but the results provide useful insights: firstly with respect to how integrating interactive- and science-driven approaches can be operationalised to enhance the translation of scientific knowledge; secondly by revealing the multiple and dynamic processes at play in this translation; and thirdly allowing the conceptualisation of translation to be re-orientated towards co-translation.

Regarding operationalising an integrative approach, the methodology shows how repeated participatory interaction between scientists (in the form of Thematic Experts) and knowledge users (in the form of Case Study Partners and stakeholders), built around feedback, and dialogue can be used to facilitate access, utilisation and understanding of scientific knowledge and so enhance translation. The results show how a collaborative co-translation process can be operationalised in group settings involving end-users, researchers and intermediaries. Although there are recognised problems in replicating collaborative innovation in agricultural research and extension (Klerkx et al., 2017), there are some transferable elements revealed here which would allow this methodology to be implemented beyond this project setting. These include the sustained dialogue and reflection to enable continuous rearticulation and appraisal and joint learning; the use of the DRA which proved a central tool both in facilitating and revealing the dynamic and continuous translation processes; and effective and engaged facilitators who are key intermediaries in operationalising the methodology. Together these can foster an understanding of how farmers and other stakeholders identify issues, ask questions and utilise scientific knowledge, which is of central importance as innovation systems become more farmer-centric (Chowa et al., 2013). Nevertheless it is acknowledged that, whilst stakeholders may be able to identify topics to prioritise or steer agendas, the ability to specify actual questions is less assured. Furthermore, the project methodology cannot replicate the dynamic translation processes that go on when stakeholders themselves seek out and utiltise knowledge from research. Nor can this process account for the multiple facets of stakeholders' own experiential knowledge and its interplay with formal science, or their diverse information needs and existing knowledge networks.

With respect to constituent translation processes, the interplay between innovation issues and solutions that this approach allows, reveals a multi-faceted translation process comprising identification, prioritisation, articulation, searching, retrieval, synthesis, interpretation and evaluation. Such complexity highlights the challenge of reconciling the supply and demand of scientific information, and in particular the simplistic assumption that innovation issues can be easily formulated as research questions which can be answered with solutions from scientific knowledge. However, at a project level the results are being used in development of *ask-Valerie.eu*, where improved understanding about the nature of articulation of knowledge is helping to modify the structure and interface of the search tool. Different views about what constitutes usable knowledge (e.g. various factsheet formats) are also being incorporated into the development of the tool's search result format.

These insights allow us to move beyond an understanding of translation as science- or innovation-driven to envisaging it as a combination of both, where multiple processes interact in a fluid middle-ground, and where the actors involved develop the capacity to jointly analyse innovation issues and solutions and develop a shared ownership of a problem. Thus, as well as offering methodological, operational and empirical contributions, this research advances theoretical understanding of translation, re-orientating the conceptualisation towards co-translation.

From the perspective of the EU, the policy ambitions are to stimulate collaborative translation and in particular to make the large body of existing research-based knowledge accessible and meaningful to potential users. This requires re-thinking how translation is operationalised; as with a shift towards co-innovation approaches and demand- driven agricultural extension, translation requires new mind-sets and skills, and in particular committed and well-resourced intermediaries who can foster multi-actors approaches. Nurturing these will allow scientific research to play a significant role in meeting the many future innovation challenges in agriculture. These observations are equally pertinent to a wider global audience of policy makers, scientists and practitioners who face the same, if not more urgent, imperatives with respect to optimising the outreach and translation of scientific research to support effective local decision making.

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