

Article

Creating a Rainbow for Sustainability: The Case of Sustainable Beef

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Abstract: Sustainability is a complex, multi-dimensional issue that requires contributions from diverse disciplines, perspectives, and actors. Research and innovation are recognised as having the potential to help address some of the trade-offs and synergies associated with sustainability, and interactive innovation in particular offers many advantages. The beef sector has faced significant sustainability challenges in recent times, with criticisms relating to greenhouse gas (GHG) production, biodiversity, water quality, human health, and animal welfare, along with economic challenges to the viability of the sector. Furthermore, the low level of adoption of solutions proposed by research to address these challenges indicates the need for a pan-European multi-actor network to produce actionable and usable information to support European beef farmers. Drawing on practice-based research, the purpose of this exploratory paper was to examine how interactive innovation can be supported in a sector that, to date, has been the focus of limited interactive innovation efforts. It concluded that a “rainbow” of actors and diverse knowledges, along with different types of innovation intermediaries, can enhance the sustainability of the beef sector.



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Keywords: interactive innovation; beef sector; sustainability; multi-actor; innovation broker; innovation intermediary

1. Introduction

While there is a general agreement on the need to transform food systems to become more sustainable, inclusive, and fair [1,2], the means by which this can be achieved is not so clear-cut. It calls for actions at many levels and on many scales, by diverse actors, on an ongoing basis. Barriers related to knowledge, including a lack of shared understanding of the facts [1], gaps in knowledge, a lack of inclusion of knowledge from some sources (e.g., traditional knowledge) [2], the challenges inherent to integrating different sources of knowledge [3,4], and ineffective knowledge transfer and exchange impede progress. Challenges related to sustainability, whereby trade-offs have to be made within and across different elements of sustainability (e.g., economic, social, and environmental) also hinder progress.

By definition, change requires innovation. Furthermore, innovation, through its contribution to the development of technologies and new business models, is recognised as having the potential to help address some of the challenges inherent to sustainability, and to identify opportunities to achieve synergies [5–7]. New knowledge, and new combinations of existing knowledge, drive innovation. Science is accepted as a significant, though not the only, driver of innovation through its role in creating new knowledge, and it is currently in the spotlight for resolving societal challenges [3]. However, transforming good science into good practice is not straightforward. Moreover, a recognition of the systemic, dynamic, and interactive nature of innovation identifies roles and contributions by non-scientific actors in the process. In this thinking, it is recognised that practitioner knowledge is an

important source of innovation, and that technological improvements can be unrelated to basic research [8]. Practitioners can also make other contributions to the innovation process through improving, testing, and evaluating outputs (e.g., processes, materials, or devices) from applied research supporting demonstration and scale-up; and disseminating results and enhancing user acceptance of solutions. Furthermore, it is acknowledged that non-scientific actors—their knowledge, links, and interactions—can also provide essential inputs to scientific research in the form of agenda setting, and specifying and defining problems to be solved [9]. Such problem-oriented, multidisciplinary research provides the foundations for funding calls by many public research funding programmes.

The beef sector, in particular, is one sector that has been the object of significant debate in relation to the need to foster sustainability-oriented innovation [10]. As noted by the OECD [1] (p. 173), “[r]uminant livestock is an important source of protein and livelihoods, but is a significant contributor to environmental problems, including climate change”. The beef sector has faced particular challenges in recent times, with criticisms relating to greenhouse gas (GHG) emissions, water use and quality, biodiversity, human health, and animal welfare, and emotive debates are occurring in various contexts on the role of livestock as part of a sustainable food system [11,12]. Evidence regarding the positive sustainability credentials of beef production and consumption is also widespread, but possibly overlooked in the current context [13]. Pasture-based production systems are generally seen as particularly beneficial, playing an important role in contributing to landscapes, habitats, biodiversity, and soil carbon [14–16]. Various pathways have been identified to improve the sustainability credentials of the sector. For example, in a report for the European Commission, Peyraud and McLeod [7] identify three ways to improve the sustainability of livestock: (a) through efficiency gains; (b) through substitution of high impact inputs with lower impact alternatives; and (c) via a more fundamental redesign of agricultural systems, involving shifts from linear approaches to circular approaches.

Many technical solutions have been identified to address sustainability challenges in the beef sector. However, many of these have not been adopted by farmers. Indeed, a FAO report published in 2013 suggests that significant reductions in sector emissions are within reach through “the wider use of existing best practices and technologies” [17]. An obvious question arises: why have these practices not been adopted? [18] Traditional adoption theory identifies a range of explanatory factors. One element is economic factors, including low margins and dependence on policy supports within the sector, with direct payments via the Common Agricultural Policy (CAP) providing almost 100% of total annual net farm income for the average EU beef farmer (compared to 49% in the dairy sector, for example). Another aspect is socio-economic factors relating to the age of beef farmers and the presence, or absence, of a successor. Finally, structural factors such as limited horizontal or vertical coordination are also important. However, more recent developments in innovation theory pinpoint the innovation process itself as an explanatory factor, arguing that the involvement of end users in the development of solutions is likely to increase acceptance and adoption, not only because of the ownership provided by these practices, but also because the solutions themselves are more localized and appropriate.

Prior to the establishment of the BovINE network, which was the focus of this paper, the European Commission had funded innovation networks to support all the main livestock sectors (sheep, dairy, pigs, and poultry) but not beef. Thus, a network of individuals, groups, and organisations actively involved in the beef industry throughout Europe was developed in order to identify and articulate innovation and technological solutions to address the needs of European beef farmers. This was done through establishing and developing sub-networks across different dimensions, and facilitating cooperation and learning throughout the process. There are very good reasons why there has been very little interactive innovation and multi-actor research in the sector, such as the weak integration mechanisms, whether vertical or horizontal, within the sector, and the lack of trust amongst stakeholders in the chain [19,20]. The purpose of this exploratory paper, therefore, was to examine how interactive innovation can be supported in a sector that, to date, has been

the focus of limited interactive innovation efforts. Drawing on practice-based research, it examined how different streams of knowledge can be combined, shared, and exchanged; how diverse innovation needs can be reconciled; and how ownership can be created for solutions. It had a particular focus on two different types of innovation intermediaries who had a role in integrating knowledge across geographic and thematic domains, and in defining and prioritising the innovation needs of farmers. From a practical perspective, it identified challenges, and critiqued tools and approaches utilised in a real-world context, to produce actionable and usable information in order to support European beef farmers in addressing sustainability challenges.

As recognised by the RIA in Ireland, research approaches involving co-production are necessary to address real-world problems [21]. Moreover, while new knowledge is required from research, it is known that wider use of existing best practices and technologies have significant potential to address many of the challenges facing the sector [7,17]. The purpose of this paper was to examine how these different streams of knowledge can be combined, shared, and exchanged to address the “wicked” problem that is sustainability, by proposing and critiquing tools and approaches utilised in a real-world context. Specifically, it aimed to examine the research and innovation processes undertaken to produce actionable and usable information to support European beef farmers in addressing the sustainability challenges faced by them, within the context of a multi-actor network established specifically to address this purpose. This network, known as BovINE (an EU H2020 funded project) was designed to close the divide between research and innovation by bringing together different actors, integrating the best available knowledge from diverse sources, reconciling different values and preferences, and creating ownership of developed solutions. It addresses multiple stages in the innovation process, from identifying needs, to developing and testing solutions, and disseminating and communicating such results.

There has been little research focusing on how H2020 project actors interact with others to arrange competencies and resources [22,23]. As funding for multi-actor projects grows under the 2021–2027 Horizon Europe programme, it is consequently important to research the underlying operations of such projects [23]. Understanding how innovation brokering is orchestrated offers enlightenment on how such projects integrate different actors to contribute to a more sustainable European beef system. This paper described the formation and operation of the network; identified and commented on tools used along the way to enable the exchange and blending of knowledge from different sources and actors; and identified the roles, challenges, and solutions available to innovation intermediaries in fulfilling their role. It had a particular focus on two different types of innovation intermediaries that had a role in integrating knowledge across geographic and thematic domains.

2. Interactive Innovation: Epistemological, Practical, and Ethical Imperatives

A key element for innovation is a collaborative ecosystem where knowledge, ideas, and experiences flow and are exchanged. [24,25]. This notion, from a social sciences’ perspective, is anchored in perspectives that emerged in Latin America during the 1960s, such as the pedagogical ideas of Freire [26], with contributions of Colombian sociologist Orlando Fals Borda [27], that paved the way for the emergence of participatory action research. These perspectives generated an interest in practice-oriented collaborative research, and a scholarly appreciation of non-academic knowledge. The dialogue between the academic and the non-academic knowledges proved to be an epistemologically rich crossover; it also cross-fertilised ideas for interventions and practice, which were rooted in the daily experiences and needs of (mostly rural) communities. As such, this collaboration was primarily thought of as emancipatory, and linked to ideas of a deep, structural transformation amidst the rural modernisation of Latin America in the 1960s.

This idea of collaborative research and practice as a methodology became increasingly popular in practice and innovation-oriented research in Europe. Partly, this idea responded to the growing awareness that in order to address some of the complex and most pressing

questions of our time, such as climate change or sustainability-oriented development, the knowledge, and the theoretical and methodological tools of any single discipline, were insufficient. Therefore, there was a pressing need for more multi-disciplinary, inter-disciplinary, and trans-disciplinary research in order to combine knowledges and approaches, and thus, produce more robust science. This is an increasing trend in contemporary research [28].

Particularly in agricultural sciences, it is clearer that non-academic systems of knowledges and experiences are critical in responding to some of the challenges in the agri-food sector. Agricultural innovation requires, for instance, mobilisation and engagement with a wide variety of stakeholders, each with different perspectives [29–31]. Despite the fact that integrating different types of knowledge presents its own set of challenges [3,4], this appreciation for non-academic knowledge also responds to the practical realisation that much of the innovation, particularly second order innovation, or innovation that challenges dominant paradigms, happens at a grassroots level, led by motivated farmers and sometimes consumers [25]. Van der Ploeg mentions the gap between farmers' knowledge and that of experts, the latter often being disconnected from day-to-day farming practices [32]. As such, the dialogue between the knowledge held by various stakeholders across the agri-food value chain aims at bridging these gaps, building on those grassroots initiatives, and enabling demand driven innovation.

As defined by the European Commission, the Agricultural Knowledge and Innovation System (AKIS) captured the idea that there is a great deal of wealth, in terms of knowledge, in combining all the various stakeholders in the agricultural sector. Without the radical edge of its Latin American counterparts, AKIS originally grew as part of an interventionist and modernist push to facilitate and coordinate the transfer of knowledge [33]. However, we have moved on since then. The multi-actor approach, incorporating the views and perspectives of various stakeholders in the agri-food sector, was well established in EU Horizon 2020 projects, and the notion of co-innovation was at the core of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) [31]. More recently, EU documents articulated the vision of interactive innovation as a means of 'collaboration between various actors to make best use of complementary types of knowledge (scientific, practical, organisational, etc.) in view of cocreation and diffusion of solutions/opportunities ready to implement in practice' [34]. This concept, instead of adding something new to previous definitions, brought them together in line with multi-actor engagement and complementing knowledges in a collaborative environment.

If there are epistemological and practical benefits to this multi-actor exchange of perspective and knowledge, as described above, there are also important ethical dimensions behind it, which are often articulated as the 'democratisation of knowledge' and/or 'democratisation of innovation'. In using the terms democratisation of knowledge/innovation, we refer to something more than what Von Hippel first described in minimalistic terms [24]. According to this author, the democratisation of innovation is based on the ability of users to innovate according to their own wishes and needs. It is important to also take into account, apart from the knowledge and expertise of the various stakeholders, their concerns in relation to conflicts and power imbalances created in the innovation process [35]. Although we tend to associate good qualities with innovation processes, these may create conflicts of interest on the ground between farmers, and also between the farmers and people living in rural areas [25]. Likewise, the introduction of new technologies can increase social-economic gaps in rural areas and among farmers, for instance, increasing existing inequalities or benefiting only some sectors of rural communities, affecting social cohesion. They can also create new gaps between technology-savvy farmers and those who prefer more traditional methods [35]. Therefore, collaborative innovation is also a way to mitigate these unwelcome (and often unforeseen) side effects and consequences of the innovation process.

The interactive innovation concept is frequently incorporated into EU policy and funding regarding agriculture [36]. Indeed, many projects and programmes are required to implement a multi-actor approach [23,37]. The European Commission perceives the

collaboration of farmers, advisors, academics, policymakers, and other stakeholders as being a key function of multi-actor initiatives. In the case of the beef sector in Europe, it is recognised that interactive innovation interventions enhance the sustainability of the sector because of the opportunities they provides for peer-to-peer learning, and for the integration of best practices and local knowledge with expert knowledge. These opportunities for exchange and learning strengthen the weakest link in the value chain: the weak horizontal integration of the beef producers, which negatively affects their representation channels and undermines their bargaining power in the market. Likewise, the weak vertical integration mechanism, along with other actors in the value chain, negatively affects their bargaining position and deprives them of important sources of collaboration for sustainability-oriented innovation [19,20]. Due to these organisational and integration-related challenges, it is unsurprising that there is little multi-actor research in the beef sector and that interactive innovation and co-innovation remain a challenge. This approach to innovation requires strong and legitimate networks, broad agreements between participants in the horizontal and vertical integration mechanisms, and appropriate funding [38].

In this context, interactive innovation is desirable for many reasons: to integrate knowledges from the ground, from people who have a lived, first-hand experience of the problems and potential solutions; to facilitate the dialogue between different values and perspectives; and to give ownership over solutions to those who actually put them into practice [21]. Moreover, given its multi-actor component, it will also contribute to the horizontal and potentially vertical integration of the beef value chain by increasing interaction between various actors, by adapting solutions to local contexts, and by developing trust between them.

3. Innovation Brokers

Innovation, whether interactive, multi-actor, or otherwise, requires complex interactions at multiple levels; academic studies focused on innovation have routinely highlighted the importance of intermediaries [39–43]. These intermediaries play an important, and often understated, role in interactive innovation. For multi-actor collaboration to be successful, and to reach its latent potential, the necessary actors and stakeholders need strategic assistance. Innovation intermediaries facilitate interaction and network linkages. They are loosely conceptualised as a link between actors when direct interaction is challenging due to high transaction costs (e.g., locating a suitable partner to collaborate with or disincentives for collaboration) or communication problems resulting from differences in culture, interests, language, or capacity to absorb or exchange knowledge [43]. According to Howells [40] (p. 720), the term ‘innovation intermediary’ is an encompassing term that represents ‘an organisation or body that acts as an agent or broker in any aspect of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between; bodies or organisations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations’.

Klerkx denotes that is it often not the case that innovation intermediation is the main objective of an entity [44]. Therefore, there is a necessity to differentiate between innovation intermediaries that act as specialist brokers from actors or organisations who provide some brokerage functions, but not as a core objective. Hence, Winch and Courtney speak about ‘innovation brokers’ as actors who are enablers [45]. They define an innovation broker as ‘an organisation acting as a member of a network of actors [...] that is focused neither on the organisation nor the implementation of innovations [sic.], but on enabling other organisations to innovate’ [45] (p. 751). Innovation brokers are also defined as ‘a type of boundary organisation that specialises in brokering or facilitating innovation processes involving several other parties, but does not itself engage in the innovation process’ [46]. Innovation brokers, therefore, represent a distinct type of intermediary from

those encapsulated by Howells, as their sole purpose is to act as a broker, rather than brokering being a by-product of their activity [45].

Innovation brokers purposefully catalyse innovation by bringing together actors and facilitating their interaction [47]. They broaden the role of agricultural knowledge exchange by creating and facilitating relationships through a multi-actor process [47]. Generally, such brokers span structural holes that are gaps in the social structure between groups of people or organisations [48]. This is brought about by introducing disconnected people, organisations, and networks, or by facilitating new coordination between already connected elements [49].

The role of innovation brokers and intermediaries in supporting and managing relationships between actors has been discussed throughout the literature [45,50–53]. In order to attain credibility and legitimacy, innovation brokers must remain impartial or neutral [54]. Heemskerk et al. identify multiple brokering functions: facilitation, linking and strategic networking, technical backstopping, mediation, advocacy, capacity building, management, documenting learning, and championing [55]. Three basic lines of support provided can be applied in a flexible and iterative manner by intermediaries and brokers [47,56–58]:

- Analysing the context and articulating demand: articulating innovation needs and corresponding demands in terms of technology, knowledge, funding, and policy;
- Composing networks: the facilitation of linkages between relevant actors (scanning, scoping, filtering, and matchmaking of possible cooperative partners); and
- Facilitating interaction: enhancing the alignment and learning of the multi-actor network, which involves facilitating the learning and cooperation in the innovation process.

Actors in AKIS often do not effectively interact in a manner that is constructive for innovation. However, this is often not a result of unwillingness to interact, but due to a lack of capacities, structures, and incentives [59]. Innovation brokers, therefore, are beneficial as they are stimuli who guide the networks into existence, and often hold the network together by taking care of day-to-day network management issues, enhancing trust, and resolving conflict [60–62]. They do so through their access to a variety of tangible and intangible resources needed for innovation [57]. At the system level, innovation brokers create connectedness within the system, and have an animator role in creating new possibilities [40,57]. Through innovation brokering, communication between the multiple actors progresses. Hence, AKIS actors, such as farmers, can conceptualise new possibilities to improve their business, communicate their needs, and share their own practical knowledge and experience, while other actors such as researchers and advisory services can transfer knowledge in a manner that facilitates innovation, and also learn from experiences on the ground [59]. Innovation brokers are consequently perceived as advantageous to the innovation process, by closing system gaps and acting as animators or catalysts [63].

Sustainable agricultural systems require appropriate interventions, adapted to local conditions while simultaneously considering higher system levels (i.e., the farm and its wider environment) [63,64]. Stuiver et al. denote that a transition towards sustainable agriculture requires the engagement of a wide range of stakeholders, allowing for and promoting innovation [64]. Kivimaa et al. outline how the transformation of socio-technical systems towards sustainability is determined by shifts in relations between actor groups, between infrastructures, and between technologies and contexts of application [43]. Considering their function, innovation brokers are potentially key catalysts that accelerate sustainability. They have the capability to be a catalyst for change by encouraging collaborations around niche technologies, ideas, and markets, and by disrupting prevailing norms [43,65]. In regard to sustainability, Deugd et al. underline the importance of discovery and experiential learning [66]. Participatory approaches that abide by principles of inclusiveness and are adopted by brokers can hasten sustainable regime changes [67], by facilitating innovation on the ground with an eye to the aforementioned ethical, knowledge, and practical imperatives.

Actors such as innovation brokers are identifiable based upon the roles they perform. Based on these functions, typologies of intermediaries can be conceptualised [43]. Kivimaa et al. provide a typology of innovation intermediaries, while also identifying their areas of focus [43] (Table 1).

Table 1. Typologies of innovation intermediaries implemented in the BovINE project [43].

Type	Description	Objective
Systematic broker	Intermediating on system level between multiple actors	Creating a space for new and diverse activities
Grassroots intermediary	Exists at a local scale. Intermediating between local entities	Works bottom-up to develop novel ideas
Process intermediary	Mediates action in projects	Supports project-based priorities set by other actors

4. Methodology

4.1. Overview of BovINE

Responding to the call for more multi-actor type projects in Europe to incorporate the perspectives of various stakeholders in order to co-develop initiatives [31], the BovINE project was established. Its principal aim was to tackle the urgent sustainability challenges faced by beef producers, by bringing together a range of actors to collaboratively develop practical innovations that could be implemented on European beef farms. It addressed these challenges by focusing attention on four key thematic areas: socio-economic resilience, animal health and welfare, production efficiency and meat quality, and environmental sustainability. To do this, four sub-networks, one for each thematic area, and nine national/regional subnetworks, representing nine EU member states (Belgium, Estonia, Germany, France, Ireland, Italy, Poland, Portugal, and Spain) were established. Each member state was represented by both an academic and a beef farmer representative body, in order to enable the capture of knowledge from both research and practice. Through the establishment of this pan-European framework, a transnational approach was applied to access and disseminate knowledge across the four thematic areas. Each thematic subnetwork was driven by a thematic working group, led by an academic partner and involving EU beef producer associations, researchers, and advisors. This transnational network was subsequently managed by a project management team that ensured the coordination and interconnection of all activities.

The BovINE project takes the form of a ‘systematic intermediary’ (Table 1), as the project links various constituents of continental, domestic, and regional AKIS actors. Similar to other brokers, systematic intermediaries enable actors to articulate their knowledge, resource, input, policy, funding, and technology needs, which is also known as demand articulation [44,57]. They differ from other typologies as they enable desired systematic change by brokering networks at the sectoral level; they do so by overseeing the process and consolidating the objectives of the various actors and stakeholders involved [59]. While the project acts as a systematic broker, it also establishes a number of innovation intermediaries, i.e., actors who broker innovation but for whom brokering is not their core objective. For instance, regional networks were founded, and acted as grassroots intermediaries. Meanwhile, thematic working groups are classified as process intermediaries. Brokering across multiple levels of facilitates reciprocal support actions between key actors that further the innovation process [22]. This is particularly pertinent in the beef sector, as its rate of innovation is lower than that of other agricultural sectors, such as dairy and tillage. Europe has an array of beef system typologies and supply chains that vary according to location, climate, and societal demands [10]. Some systems are efficient and sustainable, while others are comparatively lacking. An obscure mosaic of production systems endures and significantly affects innovation adoption [23]. Systematic innovation brokering can be used as a catalyst for innovation to overcome some of the fundamental challenges

associated with the beef sector. Studies concerning systematic brokering are evident in platforms such as EIP-Operational Groups [23].

4.2. Innovation Framework

Flyvbjerg [68] asserts that expertise beyond simple rules based knowledge, such as innovation brokering and facilitation of multi-actor processes, is generated from knowledge and experience of cases. A case study methodology was consequently adopted to demonstrate the value of innovation brokers in the context of the BovINE project [69,70]. The main focus of the study was not on the project itself but on a particular phenomenon [71]; namely, innovation brokers. Case study methodology is defined as an intensive, detailed, and in-depth study, examination, or investigation of a single unit. [72]. Indeed, case studies are context-specific accounts, from which generalisable learnings relevant to other contexts are identified [68,73]. Stake's approach for selecting cases was followed in that "the first criterion should be to maximise what we can learn" [74]. The objective of the case study was therefore met by means of a qualitative approach involving observations of brokering conducted during the project. Information regarding the case study was provided by the BovINE project coordinator and project manager. It drew on observation, information documented in BovINE deliverables, and internal operational guidelines, minutes of meetings, and evaluations of events, etc. All the empirical data was gathered, analysed, and structured according to how brokering was implemented in the project. This formed the basis of the comparative analysis. BovINE's use of innovation brokers was an example of how they can be utilised effectively in a multi-actor setting. Therefore, the methodology followed an information-oriented approach in that the study sought to maximise the utility of information from a single case [68].

H2020 projects such as BovINE are conceptualised as collaborative affiliations between actors pursuing innovation. The project acts as a systematic broker primarily responsible for engagement and management of an innovation network. Dhanaraj and Parkhe denote "network orchestration" as the intentional activities initiated by an orchestrator of an innovation network such as BovINE [75]. The framework of the research presented in this paper followed the principles depicted by Dhanaraj and Parkhe in that it focused on the orchestration processes in the BovINE project. They establish three primary orchestration processes necessary for managing innovation networks; managing knowledge mobility; managing innovation appropriability; and managing network stability [75]. Innovation network management consequently adheres to the management functions of an innovation broker. Batterink et al. state that in the context of brokering, innovation orchestration is the action of enabling an environment that stimulates knowledge exchange (knowledge mobility), facilitating an egalitarian transfer of the strengths and weaknesses between actors (innovation appropriability) that enables the functions of the actors involved (network stability), as well as demand articulation [76]. Furthermore, successful multi-actor participation is conceptualised as an iterative development that moves beyond one-way communication towards consultation, collaboration, and ultimately empowerment [21]. With respect to research focused on sustainability, this co-production of knowledge and innovation is defined as "collaborative processes involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future" [77] (p. 2). It involves assembling a collaborative team of academic and non-academic actors, a collaborative definition of objectives, joint knowledge production, and the integration of results into action [21,78,79]. Hence, the subsequent section depicts how the EU-funded BovINE network, as an example of collaborative research practice, orchestrated innovation. It addresses the establishment of subgroups of networks, the key actors involved, demand articulation, innovation process management, communication and dissemination, and evaluation. It pays particular attention to the key innovation brokers employed within the network and their role in collecting, producing, and exchanging knowledge through multi-actor networks.

5. Case Study Application

5.1. Establishment of Sub-Networks

The BovINE project recognised two main loci for the production and exchange of knowledge. On the one hand, there were geographically defined units in which various stakeholders engaged on a periodic basis, creating the space for the flow of knowledge and for collaboration on a very practical level. On the other hand, there were thematically defined groups where particular stakeholders from various contexts could also produce and exchange knowledge (high system levels). Among these two loci, we identified the greatest potential for meaningful exchange and collaboration for sustainability-oriented innovation in relation to the beef sector.

Sub-networks were established on a geographic basis, consisting of a group of local/regional farming practitioners, and innovation and business actors concerned with beef production. They were labelled as ‘regional networks’ (RNs). Nine RNs were created in nine countries; Ireland, Italy, France, Spain, Poland, Portugal, Belgium, Germany, and Estonia. The establishment and coordination of each regional network was the responsibility of the regional network manager (RNM). In addition to this, thematic networks were established, known as thematic working groups (TWGs), each with an appointed TWG leader (TWGL). The TWGs operated across geographic boundaries and were defined according to the four thematic aspects of the project. The overall BovINE innovation process framework illustrating these structures, and indicating points of contact, is depicted in Figure 1.

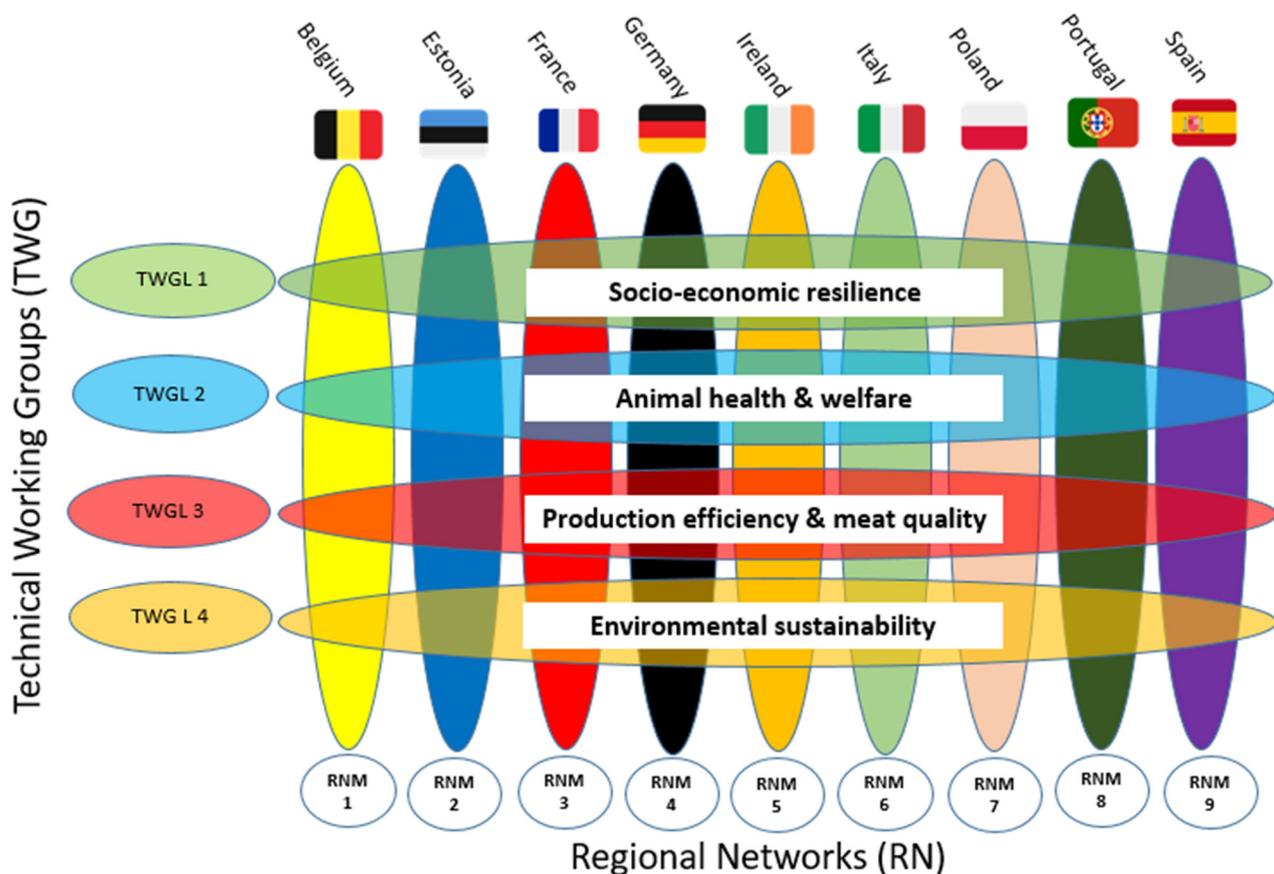


Figure 1. The BovINE innovation process framework: An illustration of the thematic and regional networks.

It was envisaged that the person appointed to the position of RNM possessed knowledge and experience in dealing with the main actors involved in the bovine knowledge innovation system (BKIS) for their region, i.e., beef farmers, researchers, advisors, agricultural professionals, and input suppliers. As they were responsible for connecting existing

and newly established networks of stakeholders related to the four thematic areas, they required competencies in communication and facilitation, as well as strong organizational skills. Within BovINE, they acted as the primary contact point for each of the RNs throughout the project. The RNMs were selected and appointed from practice partners/farmer representative bodies from each region. Research orientated partners also offered support to the practice partners in network development and management as necessary. To connect the RNs to each other, and thereby enable the exchange of ideas and knowledge between RNMs, a regional network managers group was established in year 2. This group also played a significant role in developing the capacity of each RNM to act as an innovation intermediary, by facilitating discussions around regional differences in terms of priority needs, and encouraged each RN to have greater input on any innovations collected. It also enabled the RNMs to take further ownership of the BovINE innovation framework, and as a result established a greater trust in the innovation process.

Four independent TWGs—one for each thematic area—were established and led by representatives from agricultural research institutions/universities. The formation of such groups was essential to ensuring a multi-actor approach underpinned all activities related to innovation generation and knowledge exchange by incorporating a wide range of knowledge and expertise in the group.

Both innovation entities (RNMs and TWGLs) functioned as ‘innovation intermediaries’ through their dual roles as ‘peer network brokers’ and ‘innovation consultants’. Thus, they had a number of key responsibilities such as facilitation, linking and strategic networking, documenting learning, and championing their regional networks. Although the RNMs may have previously carried out a number of the functions of an innovation intermediary, such as acting as a mediator, helping to find advice and/or funding, or suggesting collaborations, the TWGL were new to the role. In this regard, the TWGLs were trained to act as enablers for interactive innovation.

5.2. Implementation of Innovation Framework

Both sets of innovation intermediaries (RNMs and TWGLs) were expected to interact extensively throughout the course of the project to implement the innovation process framework. Thus, several key stages were identified for close interaction. The points of interaction between the RNs and the TWGs in facilitating and developing demand-driven innovation within the BovINE project are depicted in Figure 2 below. The following sections elaborate on how each process was implemented in more detail. It focuses on the role of the RNMs and TWGLs as important innovation intermediaries within the systemic innovation framework that is the BovINE network, and on the activities of the BovINE coordinator as a systemic broker.

5.3. Identification of Key Actors

The first task for each RNM was to utilise their extensive knowledge of the beef industry in their region to identify all potential actors within the BKIS. An initial network of actors was identified and was continuously extended throughout the lifetime of the project, as and when further actors became involved in BovINE. This approach allowed for the integration of any new initiatives in beef sustainability that arose throughout the lifetime of BovINE (e.g., newly formed producer groups, establishment of operational groups, (inter)nationally funded projects, etc.). In the establishment of transnational thematic working groups, actors from the RNs were encouraged to participate in order to integrate practitioner knowledge with that of ‘experts’. Although this process was not reciprocated in the formation of the RN, knowledge formed in the TWG was channelled back to regional networks through the RNMs.

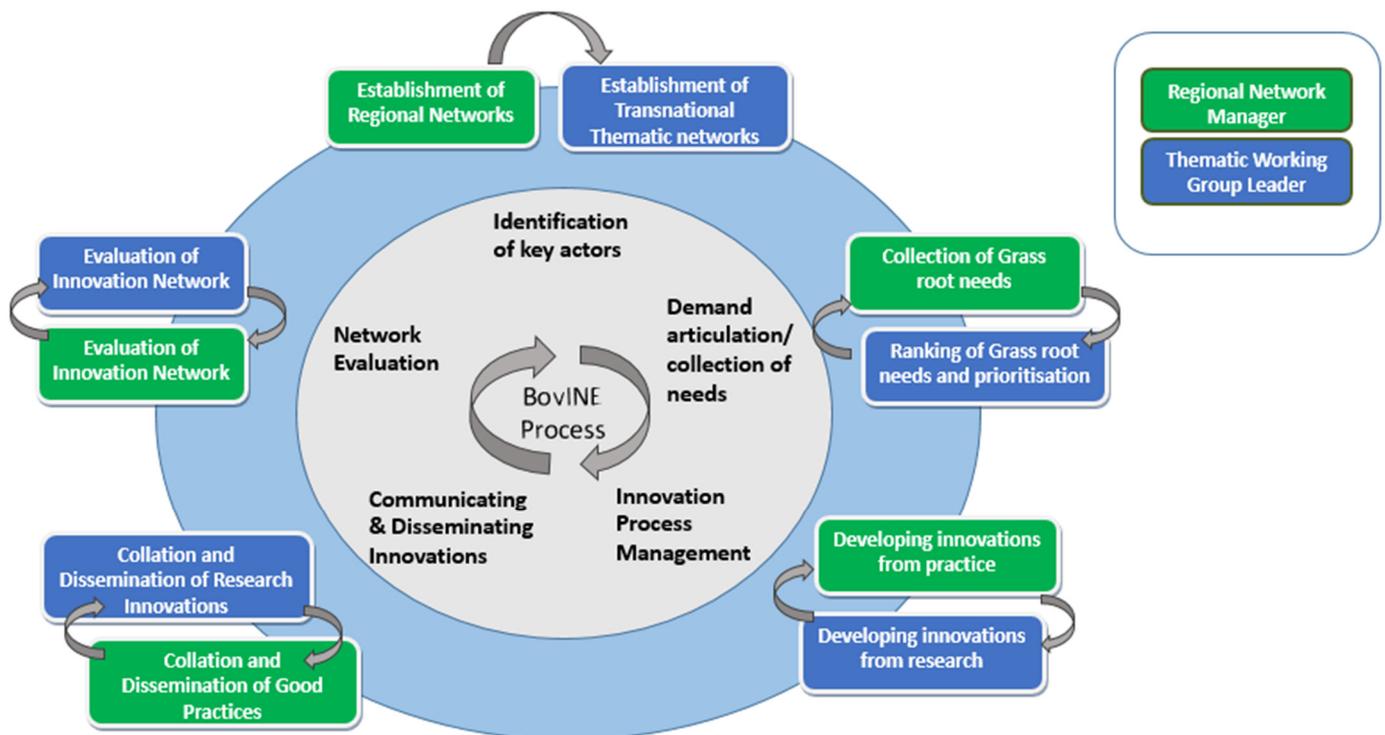


Figure 2. The BovINE innovation process, and the role of the innovation intermediaries therein.

Table 1 below provides an indication of the types of actors included in each regional network. The RNs were required to comprise of a minimum of 25 actors spread across all categories. However, in most instances, this number was far exceeded as the project progressed, with most RNs having in excess of 30 actors in attendance at BovINE annual national/regional meetings. For example, the Irish BovINE meeting held in 2021 had 100 people in attendance.

To support the RNM in developing and facilitating interaction in their network, partners within each member state represented within BovINE developed a regional level multi-actor map. Maps included detail in relation to each actor's involvement within the beef industry (i.e., their main activities/objectives), the type of actor they represented (see Table 2), in addition to their relationship and relevance to other key actors within that region. The maps remained interactive to enable partners to input and profile the most recent information about new actors and initiatives established within their region. Figure 3 is an illustration of one network map produced by the French RNM. It shows the diverse interests of different actors across each of the four sustainability themes addressed by BovINE, and was used by the RNM at different stages in the BovINE process. The partners depicted in green have interests across all thematic areas, and thus, provide potential opportunities for integrating knowledge. The partners particularly associated with one of the thematic areas are useful sources of solutions and/or potentially represent key targets for dissemination purposes.

Table 2. Types of actors included in BovINE regional networks.

Farmers
Veterinarians
Agricultural merchants/suppliers
Agricultural cooperatives
Beef processors
Producer groups/organisations
Breed associations
Agricultural advisory and education service providers
Farmer representative bodies
Semi-state bodies/organisations

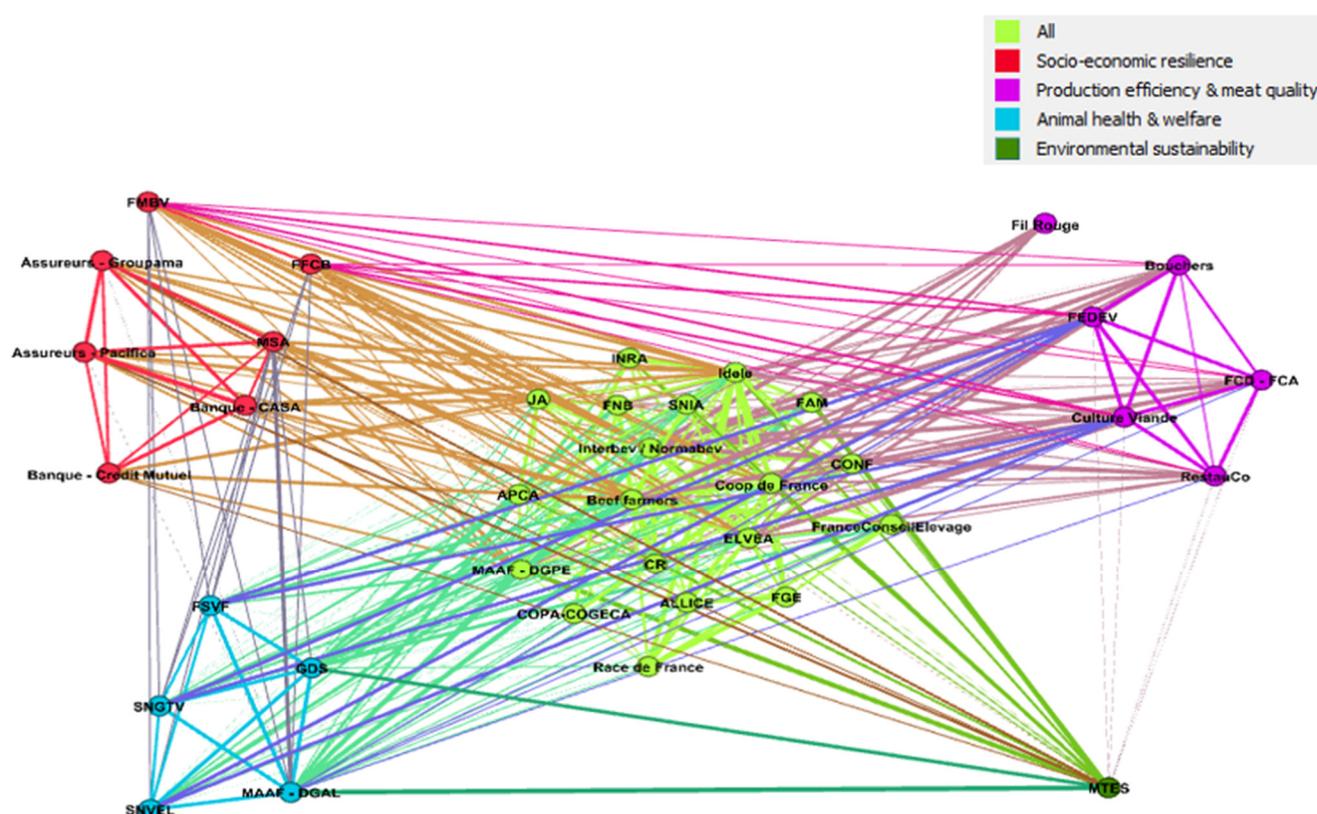


Figure 3. BovINE multi-actor map developed for the French BovINE network by innovation intermediary (colour indicates relevance of actor to BovINE thematic area, lines indicate relationships between actors).

5.4. Demand Articulation/Collection of Needs

Central to the BovINE process was the identification of the current ‘grassroot needs’ for beef farmers in each region. Thus, to facilitate this, a participatory networking approach known as ‘hot topics’ was applied by the RNMs during national multi-actor workshops held in each of the nine regions on an annual basis. Actors identified in the multi-actor network were also identified to these workshops, with local publicity undertaken in advance of the meetings indicating that there was an open invitation to all those involved in the beef sector to attend. Priority topics identified by participating actors in each workshop (Table 2) were selected and categorised according to each of the BovINE themes. The RNMs, along with workshop facilitators, were responsible for managing an open discussion with workshop

participants to select the themes/topics that gave the greatest representation of the needs of the beef farmers in that region. The needs identified from the exercise formed the basis of a ‘needs register’, related to each of the four thematic areas.

In order to cluster the needs from each region into more manageable themes/topics for the project to address as a whole, needs listed on the register were prioritised using a ranking process leveraging the thematic expertise of each TWG. The TWGs were asked to review and validate the needs related to their particular thematic area based on (a) the probability of finding potential solutions, and (b) their novelty relative to those identified in previous years (relevant after year 1 of the BovINE innovation process). Ranking was based on innovative character, holistic nature, impact and exploitability, and probability of success. In this way both sets of innovation intermediaries collaborated to articulate needs, implementing a stringent process in facilitating linkages across different types of knowledge, and ensuring the democratisation of the needs identified. A strong voice was given to farmers across the nine EU member states to articulate their needs. Table 3 presents the priority topics that resulted from this process in year 2.

Table 3. BovINE Year 2 priority topics, clustered from grassroot needs of nine regional beef networks across Europe.

Thematic Area	Priority Topic
Socioeconomic Resilience	– Initiatives to improve beef image
	– Examining economically efficient housing systems
Animal health and welfare	– Simple tools to measure animal health and welfare
	– Indicators of good health and welfare in beef cattle
Production efficiency and meat quality	– Reducing the effect of stress on meat quality
	– Optimising the number of calves per cow per year
Environmental sustainability	– Environmental reward schemes for beef farmers
	– Methods to increase carbon sequestration on beef farms

The demand articulation process involved all partners within the multi-actor BovINE network to ensure that practitioners, as well as researchers/scientists, had a say in the prioritisation. All partners were given equal representation within the process, which resulted in approximately equal weighting between practitioners and academic/experts.

5.5. Innovation Process Management

A systematic approach was applied by both innovation intermediaries to identify solutions to address the priority topics selected, using two parallel processes (Figure 4):

- (1) The TWGs undertook a review of solutions developed by research but not yet applied at farm level on a widespread basis. Solutions were sourced from both published academic literature and grey literature and were termed research innovations (RIs).
- (2) The RNs identified solutions from on-farm innovations (good practices) that had already been implemented by members of a regional network. As representatives of each region, the RNMs were required to collect information through the following mediums:
 - At existing BKIS events such as conferences, open days, workshops, and farm walks, etc.;
 - At the national BovINE multi-actor event held within their region;
 - Through the deployment of online surveys directed at specific groups of network actors; and
 - Through the regional farming media engaged with the project.

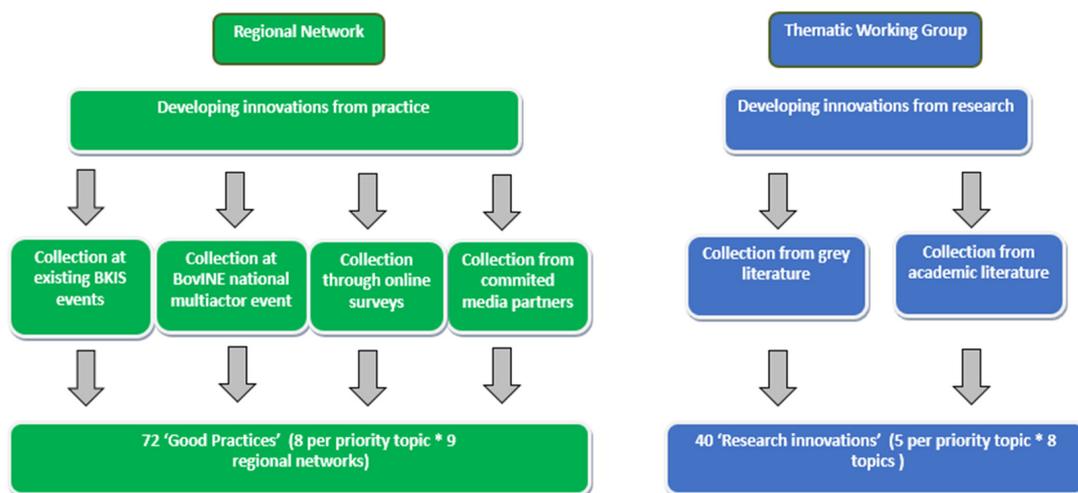


Figure 4. BovINE process for generating innovations.

In total, each of the nine RNMs collected eight ‘good practices’ each year (one per priority topic) resulting in 72 on-farm solutions for dissemination throughout the BovINE consortium. The TWGLs subsequently developed ten RIs per year, (five per priority topic) resulting in a total of 40 solutions for sharing with members of the BovINE network. In order to evaluate the feasibility of the proposed RIs in practice on-farm, a two-step approach was applied with innovations assessed based on the knowledge of both the RN and the expertise and knowledge of the TWG on a specific thematic area. Firstly, through the implementation of on-farm demonstrations, the RN evaluated the merits of a given RI on beef cattle farms in their respective country/region, accounting for the combined impact on all four thematic areas. Secondly, where it was not possible to evaluate the feasibility of certain research innovations in practice due to practical or project time constraints (e.g., innovations to optimise the number of calves per cow per year), the knowledge of those within each TWG was leveraged to identify benefits and potential obstacles of implementation.

As cost is often identified as a barrier to adoption, a standard BovINE methodology was developed to implement a cost–benefit analysis of validated innovations. Drawing on the combined knowledge of members of each RN and TWG, the BovINE cost–benefit analysis approach evaluated changes to technical efficiency indicators, prices, and input costs due to the proposed innovation practices. In the event that it was not possible to gather sufficient data to undertake a cost–benefit analysis of a validated practice, the opinion of experts within each TWG was sought to provide reasonable estimates of the expected impact.

5.6. Communicating and Disseminating Innovations

A key aim of the BovINE project was to contribute to the sharing of easily accessible practice-oriented knowledge for the beef sector, through the co-creation, conservation, and dissemination of a wide range of material, including practice abstracts and other audio—visual material such as webinars, animations, and farmer videos. Based on the innovations selected, each RNM and TWGL was responsible for compiling practice abstracts for presentation at national and transnational workshops, and on the project’s publicly accessible knowledge repository, the ‘BovINE Knowledge Hub’ (BKH), while 64 of these abstracts were also made available to the EIP-Agri Service Point. These abstracts were created in such a way as to combine expert and practitioner knowledge to address the particular grassroot needs identified by each RN. Therefore, only those research innovations that had been feasibility tested on beef farms through demonstration were documented. To further support the distribution of the knowledge generated, the project’s communication and dissemination partner ensured the dissemination of the themes and practice abstracts

to all stakeholders and intermediaries across European geographies and languages. Audio-visual materials were produced in English, with subtitles available in the eight languages of the network in order to address language barriers.

Linkages were also created with several related projects and initiatives at both a national and a transnational level by leveraging the connections generated by the RNM and TWGL to further foster ongoing knowledge exchange and innovation activities between the various structures of the BovINE Innovation Framework (Figure 1). The commitment of umbrella organisations of beef farmer organisations, innovation intermediaries/advisors, and actors across the beef supply chain was sought to support in the multiplication of knowledge/innovations, and to broaden the scope of the project beyond the European member states represented within the consortium.

6. Evaluation of Innovation Network

In order to evaluate the effectiveness of the networking process at both a national and transnational level, short questionnaires were developed, and a survey conducted with participants at the biannual project meetings. Furthermore, in order to evaluate various aspects of the interactive innovation process, a suite of impact assessment tools, outlined in the practitioner handbook developed as part of the EU-funded LIAISON project (<https://liaison2020.eu/>; accessed on 7 February 2022), were implemented by both the RNMs and TWGLs at various stages throughout the project. Specific activities such as the collection of grassroot needs, and the further prioritisation of these needs into ‘hot topics’ across the European beef sector, were evaluated by conducting semi-structured interviews with key members of both groups and relaying this information back to the consortium as a whole. Outcomes from these interviews indicated that for the online meetings, the use of a digital whiteboard software enabled the process to be more interactive. However, the capacity to use this was dependent on the skillset of the actors involved.

Further to this, to understand the experiences and impacts of the BovINE project on actors who were actively involved in each RN e.g., farmers, researchers, advisors, etc., an evaluation tool for multi-actor networks known as impact stories was applied [80]. To implement this evaluation tool, each RNM undertook semi-structured interviews with members of their RN to capture how they felt the project had impacted them. Table 4 below outlines the various tools employed at various points throughout the BovINE process.

Table 4. List of processes and tools employed in the BovINE project.

Process	Sub-Process	Tools Employed
Identification of key actors	Establishment of regional networks	Multi-actor maps
	Establishment of transnational thematic networks	Parallel sessions at project conferences, thematic webinars
Demand articulation/collection of needs	Grassroot needs collection	Annual stakeholder event, ‘hot topics’ tool
	Prioritisation of grassroot needs	‘Hot topics’ tool
Innovation process management	Developing innovations from practice	Farm visits, farmer surveys, virtual whiteboard software
	Developing innovations from research	Grey and academic literature review, online ranking tools
Dissemination and Communication	Collation and dissemination of innovations	Practice abstracts, online repository
Network evaluation	Evaluation of innovation intermediary	Self-evaluation questionnaires
	Evaluation of project impact	Impact stories

Gender aspects were given specific consideration in BovINE activities with training provided to all partners during the kick-off meeting. BovINE events were also evaluated in terms of gender participation, and discussion took place within the TWGs and RNs on the potential impact of gender on the use and adoption of identified GPs and RIs. Despite

these processes, it was recognised that there is an (unconscious) gender bias in the sector, tied in with the predominantly male ownership of farms across Europe.

7. Discussion

In agricultural innovation research there is a tendency to concentrate attention on macro-level innovation systems such as the AKIS [22]. Conversely, the micro-level, which encompasses innovation entities such as H2020 research projects, receives comparatively less consideration [23]. Increasingly, it is recognised that an understanding of the elemental mechanisms of how multi-actor H2020 projects operate is critical [23]. An appreciation of how such projects assimilate diverse types of knowledge and reach consensus is insightful. Feo et al. denote that in many H2020 thematic networks, some actors are not adequately involved, and the projects outcomes are consequently not fully adopted [36]. Furthermore, international projects often lack a methodological approach to integrate socio-cultural differences [31,81]. The BovINE project seeks to rectify such issues by explicitly involving diverse actors and stakeholders. Klerkx et al. emphasise that multi-actor approaches should conscientiously foster learning environments that advance adaptation to local conditions and that are able to link to a wider network [81]. The BovINE case study presents a framework for implementing a systematic innovation brokerage role, and for orchestrating and advancing innovation across a number of geographically and thematically defined sub-networks across Europe.

The BovINE project is a large-scale multi-actor network that was established to address the sustainability challenges of the beef sector in Europe. Reflecting limited interactive innovation in the sector to date, it acted as a systemic innovation broker, creating structures to enable the exchange of knowledge amongst diverse actors, at both regional and transnational levels, across diverse themes relating to sustainability. Two different types of innovation intermediaries had key roles in establishing, animating, and facilitating these structures, the regional network managers and thematic working group leaders. Although the success of the approaches and processes implemented within multi-actor projects is somewhat case-dependent, and as noted by [28] (p. 1102) “there can be no structured step-by-step or ‘best practice’ guide to conducting integrated research”, reflection on the BovINE approach to interactive innovation may provide insights for others seeking to implement a similar process [28] (p. 1102). As highlighted by Macken-Walsh, while the multi-actor process is recognised as a valuable approach, it can also result in unintended outcomes and paradoxes [73].

7.1. Forming the Multi-Actor Network

The European beef innovation network was established to identify solutions to farmers’ grassroot needs. A key founding principle was a recognition of the value of knowledge from different sources—practitioners and scientific experts—to provide solutions to these needs, and the need to involve farmers in the development of solutions as a strategy to increase their relevance to, and thus likelihood of adoption by, farmers as end users. Through involving all relevant actors in the development process, BovINE fulfils the definition of the contemporary multi-actor approach [82]. However, in order to maximise the full potential of those participating in a multi-actor model such as this, innovation brokers/intermediaries are needed to facilitate interaction, exchange knowledge, and produce acceptable innovations [39–43]. The roles for different types of innovation intermediaries in establishing the network, and in facilitating knowledge exchange at different stages in the innovation process, is described above and illustrated in Figure 2. The TWGLs were selected for their depth of knowledge within a specific thematic area, along with the breadth of their international academic networks. In contrast, the RNMs were selected for the depth of their national networks (farmers and other actors within the beef sector), and the breadth of their knowledge across thematic areas. These different roles required different skillsets; thus, the selection of the innovation intermediary was undertaken to ensure complementary sets of skills and knowledge. By including such a diverse skillset in

the selection process, innovation intermediaries were considered equipped to undertake the various roles expected of them [55]. However, it also should be noted that neither the RNMs nor TWGLs were employed as specialist innovation intermediaries within their parent organisations; rather they provided some brokerage functions. Thus, it was important that the project management team initially acted as an innovation broker, enabling connections between the RNMs and TWGLs, and supporting them in establishing their respective networks.

Sustainability is holistic, complex, and inherently transdisciplinary [28]. The fact that the RNMs worked across thematic areas identifying GPs, and TWGLs from different disciplinary areas worked across geographic boundaries identifying RIs should in theory enable transdisciplinary innovation. Notwithstanding the fact that multi-actor work must transcend boundaries between actors to create new knowledge [28], differences in knowledge, beliefs, interests, priorities, languages, cultures, and capacities amongst different actors [73] could make this difficult to achieve. Thus, the project management team organised specific meetings to facilitate this interaction and to enhance alignment and learning within the network. When it became clear that the RNMs had different levels of involvement in the BovINE process, the need to facilitate peer-to-peer knowledge exchange between the RNMs became evident. This resulted in the establishment of a RNMs group. As prior to the project, the RNMs were accustomed to undertaking limited brokerage functions, it was difficult for them to fully understand and to relate their role in BovINE to their existing responsibilities within their parent organisation. The establishment of a RNMs group helped them to exchange knowledge and experiences in relation to their brokerage functions, with evidence that some RNMs took leadership roles in supporting other RNMs during various stages in the BovINE process.

While relationships between the RNMs and TWGLs were very cooperative and collegial, the TWG was the focal point where knowledge was assimilated from experts and practitioners. This resulted in a somewhat hierarchical structure, whereby the TWGLs were seen as the ultimate adjudicators of which RIs and GPs should be disseminated widely. This resulted in the TWGLs having a high level of responsibility for the quality of material produced from the network as a whole. In an attempt to reduce this burden, and to give greater ownership to the RNMs for the solutions they gathered, responsibility for uploading content to the BKH was given to the RNMs in year 2. This resulted in the RNMs becoming more engaged with the BovINE innovation process, encouraged greater ownership of the final resolutions presented, and improved the quality of content uploaded to the BKH.

The RNMs also had a particular responsibility to bring the solutions identified within BovINE back to actors in their regional networks. While it was expected that the RNMs had extensive links across thematic areas at a regional level, this was not always the case due to the breadth of areas covered. In some cases, it was difficult for the RNMs to have direct interaction with local actors across all thematic areas. The development of a social network map (see Figure 1) for each region, which identified actors and key nodes for each geographic area, helped to reduce the effort ('search costs') associated with such activity. Each regional map contained critical information regarding the primary beef actors from each region. The TWGLs and RNMs used these to identify organisational and individual contacts that they wanted to both connect with BovINE via the national network at meetings, and to access the project's online knowledge repository, the BovINE Knowledge Hub.

While the two different innovation intermediaries within BovINE interacted at various stages of the innovation process, there was a need for an overarching systemic innovation broker to coordinate the process, ensure alignment and learning within the network, identify and reflect on potential sources of bias or the potential for a lack of inclusivity, and to ensure the democratisation of knowledge. In this respect, the project established a technical committee to oversee such issues, and to steer and facilitate the knowledge exchange process between the two groups. At an early stage in the project, it was evident that both innovation intermediaries were operating their respective networks in isolation

of each other. Therefore, in order to initiate greater exchange of knowledge between the two entities, the technical committee organised several exchange meetings between both in years 2 and 3. Although the initial meetings acted to build trust and open communication channels, they ultimately streamlined the BovINE process.

7.2. Facilitating Interaction and Generating Innovation

The BovINE network was established to address the sustainability challenges of the European beef sector. Peer-to-peer knowledge exchange is recognised as valuable for sustainability, and often takes place within communities in the context of alternative production models [3]. Multi-actor networks, e.g., in the form of local EIP-Agri operational groups, were also recognised as having a role in bringing knowledge together to address local sustainability problems. Likewise, knowledge from scientific research can contribute to the “new knowledge base, with new content” deemed necessary by Šūmane and colleagues to support a transition towards more sustainable agriculture [4] (p. 232). These authors also call for “new forms of knowledge and new processes for learning”, suggesting that current knowledge capture and exchange mechanisms within the sector are not fit for purpose. Indeed, research conducted in Malawi indicates that external ‘expert’ knowledge provided to farmers is strongly focused on increasing productivity and incomes, and thus, imbalanced in terms of sustainability objectives [83]. In contrast, these researchers found that farmers’ knowledge “integrates the diverse and long-term concerns of the local community—food security, social activities related to food, local economic conditions and sustainable soil management”(p. 233). Therefore, informal, local, practitioner-based knowledge and formal scientific knowledge need to be combined in order for agriculture to become more sustainable. A mechanism is clearly required to integrate both sources of knowledge, across all dimensions of sustainability. The BovINE network provides a framework for achieving this for the European beef sector; it combines knowledges from both knowledge streams and across the three pillars of sustainability in order to achieve this (Figure 1).

In order to ensure a responsiveness to farmers’ needs within the multi-actor exchange model, the process employed in the project focused intently on collaborative exchange to develop innovative solutions. In this respect, needs were selected and prioritised in a democratic fashion. In line with Von Hippel [24], beginning at the initial stages of grassroots needs development, a ranking process was undertaken by diverse actors across regions on the needs collected by the RNMs from farmers at national and regional events, to ensure that the priority topics chosen were likely to benefit farmers across Europe. As noted by Nicholas et al., the applicability of innovations across a wide geographical area, and in a wide range of systems, provides an argument to support investment in research and innovation [84].

It is arguable whether or not more weighting could have been given to the practitioner perspective in this ranking exercise. A risk with such an approach, however, is that certain region-specific needs might not be addressed (i.e., they would not receive sufficient “votes”). Another issue, identified by Macken-Walsh, relates to responsible research and innovation (RRI), whereby co-creating interventions that are challenging (rather than popular) to society may be required [73]. Ranking, with selection of the most favoured topics, is unlikely to achieve this. Thus, while multi-actor work often seeks consensus, developing solutions to sustainability challenges faced by the beef sector at European scale can militate against identifying locally appropriate solutions, and against solutions that may be challenging rather than popular. This risk is somewhat mitigated in BovINE by the planned production of a needs register, wherein all needs identified by farmers at regional meetings are recorded and available for further review by academics and policy makers.

Multi-actor work should provide opportunities to leverage and creatively combine differences [73]. Thus, early on in the process, both innovation intermediaries identified a need to provide a space for creative tensions in order to tease out the nuances of a given solution. In this regard, the forum of national/regional meetings was useful to gain insights into farmer perspectives across Europe. Furthermore, it is recognised that

many technologies are capital intensive, with academic literature citing concerns that some technologies are less suitable for small-scale farmers/operators [12]. In an effort to ensure that innovations developed within BovINE had widespread application, demonstrations of research innovations were undertaken in a range of contexts. In addition, by collecting the specific needs of a wide range of farmers in terms of size, systems, and capacities, all solutions found directly addressed the concerns of multiple operators.

Notwithstanding these efforts, following Macken-Walsh [80,85], it was recognised that BovINE consists of a limited number of partners from a limited number of European member states, and thus, it is questionable as to whether it functions as an effective and legitimate representative function of the wider sector. Given the increased public scrutiny of the livestock sector, and recommendations in the context of RRI to include actors in order to better align both the process and its outcomes with the values, needs, and expectations of society, it is arguable as to whether representation of the sector is even sufficient.

An important consideration in the articulation of user needs is the requirement for vigilance regarding elements of bias in the collection process. As one would expect, upon the formation of each multi-actor network, there was an initial tendency for innovation intermediaries to involve a large portion of farmers who were more receptive to change and more visible in their rural communities. This, however, could be a source of bias, as specific regional voices may have been weighted towards needs arising from dominant systems of production in a given region, rather than the needs of the minority farmers seeking to develop alternative production systems (on power imbalances and technological innovation, see also Hackfort [86]). To mitigate against this, BovINE established a set of central principles to be enacted by all innovation intermediaries in the formation of their networks, which sought to ensure a diversity of production systems and socioeconomic circumstances to be included.

Another significant hurdle in the interactive innovation process was the translation of innovations from one context to another. Although one of the strengths of utilising a multi-actor network to develop interactive innovation is the inclusion of a diversity of actors, this in itself can lead to difficulties in delivering innovations through a medium best understood by all end users. To this extent, BovINE focused on developing audio-visual content from demonstration/pilot farmers to communicate a given message in a format best understood, irrespective of language. Training was provided for all partners so that each innovation intermediary focused not only on composing their network and facilitating interaction, but also on acting as a conduit to relevant knowledge by supplying it in a user-friendly manner. Furthermore, the production of webinars and professional animations around several GRNs provided a mechanism whereby the RNMs and TWGLs worked creatively together to appropriately translate and articulate different knowledges for end users.

7.3. Learnings from the Formation of Thematic Networks

Multi-actor projects such as BovINE are dynamic social entities made up of diverse members that are supported to function as best as they can [87]. In order for multi-actor groups to be successful, they need membership and organisation; social and emotional dynamics; trust and security; solidarity; and facilitation and learning drivers [67]. Perhaps most crucial for innovation brokering is facilitation that fosters participation. Ensuring the successful adoption of an innovation requires taking into consideration the culture, power, institutions, and policies, as well as the actors themselves. Participatory approaches can help achieve this. Therefore, it is imperative that innovation brokers abide by the seven key principles of participation: all individuals have the right to participate; hear unheard voices; seek local knowledge and diversity; reverse learning; use diverse methods; experts should allow space for others to participate; and attitudinal and behavioural change [67].

Interestingly, the shift from face-to-face events to online platforms, and the availability of online digital tools such as virtual whiteboards, was observed by BovINE partners to enable more introverted actors to become involved and take ownership of the innovations

developed. However, it is also important that the process pays special attention to those farmers who may not participate in online platforms due to their socio-demographic circumstances.

8. Conclusions

Innovation is widely regarded as having a significant role in supporting the development of a sustainable agricultural system. In order to develop innovations with real potential, several key considerations must be applied. Firstly, combining knowledge from multiple sources/actors ensures that innovations are developed that encompass knowledge from a range of disciplines and sources. Secondly, including the voice of both the scientific expert and the practitioner is important if developed innovations are to be practice ready, acceptable for potential users, and achieve the most impact. For sustainable innovation, developed innovations need to be adapted to local conditions, whilst also considering a wider systemic context.

In line with this, it is in keeping with responsible research and innovation (RRI) to ensure that knowledge is generated in an inclusive fashion, so that differences in contexts and power imbalances are considered. This helps to ensure that innovations are not exclusive to certain types of farms, e.g., large-scale, capital intensive, or specialised operations; or benefit only certain types of farmers (male, wealthier, etc.) at the expense of others. The role of innovation intermediaries is key to the success of the interactive innovation process, by acting as a facilitator of linkages, collaboration, and the exchange of knowledge.

Social science-based methods and principles underpin many of the practices associated with interactive innovation. However, as illustrated within BovINE, practitioners (RNM) and non-social science academics (TWGL) are well suited to undertaking facilitation and innovation brokering roles. The provision of tailored training enables non-social scientists to embed key social science concepts in practice and to successfully operationalise interactive innovation. Of particular importance is the development of the capacity of these innovation intermediaries to implement both a multi-actor approach and a participatory research methodology in defining a networks' needs, and in co-designing solutions to address these.

The BovINE project addresses sustainability in a bottom-up way, focusing on grassroots needs as identified by farmers, and proposing solutions that farmers, individually or with other farmers or stakeholders in the supply chain, can adopt. While some identified solutions that were more holistic or systemic in nature, they did not generally address policy making issues. This provides a point for reflection: given that scientific knowledge is more prominent in policy making environments that shape agriculture [88], and the need to integrate different knowledges to address sustainability, how can informal practitioner-based knowledge be better integrated into the policy-making domain?

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