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Perspectives

Improving interdisciplinary collaboration in bio-economic modelling for agricultural systems

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ABSTRACT

Interest in models that integrate biophysical and economic components of agri-environmental systems has increased, largely in recognition of the multiple services provided by agri-environmental systems and reflecting the complexity of 'multi-functional' agriculture. We discuss the challenges of bio-economic modelling projects where biophysical and social-science research is integrated. Specific interdisciplinary challenges arise from, for example, differences in language and system understanding between disciplines, limited rewards for interdisciplinary research in the current academic merit system, and the time demands of interdisciplinary projects. Drawing on the authors' collective experiences in developing and applying bio-economic models, we discuss ways to overcome these challenges. Important lessons for future integrated modelling projects are to invest enough time at the start of the project to align research expectations, recognising the central role of communication, and training research 'integrators' who can facilitate collaboration within interdisciplinary teams.

1. Introduction

An important feature of agricultural production systems is the interdependence of environmental, biological and socio-economic resources. Consequently, applied agricultural systems research will need to properly consider the relationships between the quality and quantity of natural resources — including soils, water, habitat quality, plant and animal physiology, and farm production costs and profits (e.g. Hasler et al., 2003; Huber et al., 2013). Addressing complex agri-environmental issues calls for interdisciplinary bio-economic research that recognises the complexity of agricultural systems, including their joint roles in food production, delivering ecosystem services, and contribution to rural economies. There is a growing interest in interdisciplinary bio-economic modelling, to provide information to policy makers and to help improve management decisions (Brouwer and Van Ittersum, 2010: 1).

There are several examples of projects that aimed to involve researchers from multiple disciplines. For example, interdisciplinary studies from the Rural Economy and Land Use (RELU) programme (Lowe and Phillipson, 2006) included non-market valuation (Armsworth et al., 2012; Bateman et al., 2006), land use modelling (Arnoult et al., 2010) and food choice (Tiffin et al., 2006). Another example of an interdisciplinary project was the Economics and Welfare of Extensive Sheep (EWES) programme (DEFRA, 2009). This project integrated measures of animal welfare into a bio-economic model that also included husbandry and socio-economic elements for extensively managed sheep flocks (Goddard, 2011; Stott et al., 2012). The EU funded SEAMLESS,[1] SENSOR,[2] and LUPIS[3] projects integrated biophysical, economic and social systems through research consortia that involved teams of researchers from different countries and a variety of disciplinary backgrounds (Brouwer and Van Ittersum, 2010; Ewert et al., 2009; Helming et al., 2008; van Ittersum et al., 2008; Reidsma et al., 2011). The examples mentioned above necessarily involved interdisciplinary project teams, often working with stakeholders.

While the benefits of cross-disciplinary integration are widely acknowledged (Huber et al., 2013; Wam, 2010), it brings with it several

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[1] Systems for Environmental and Agricultural Modelling; Linking European Science and Society.
[2] Tools for Environmental, Social and Economic Effects of Multifunctional Land Use in European Regions.
[3] Land Use and Sustainable Development in Developing Countries.

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important challenges. Rossini and Porter (1979) already noted that interdisciplinary research is often unsuccessful, and stressed the need for strategies that can successfully integrate knowledge from diverse disciplinary backgrounds. More than three decades later, Bruce et al. (2004) reviewed interdisciplinary projects that were carried out under the European Union Fifth Framework Directive. The authors found that "disappointingly few projects are clearly interdisciplinary, particularly in terms of crossing the boundary between natural and social sciences". These observations raise questions about the barriers to integration, and the best ways to conduct interdisciplinary research (Huber et al., 2013).

Rotmans and van Asselt (1996) noted some important challenges in interdisciplinary projects, such as the frequent lack of credibility in disciplinary science, the lack of common protocols and study approaches, and difficulties in balancing social, economic, and environmental considerations; these issues still remain (Beder, 2011). Differences in methodological approaches can also present a barrier to bio-economic research. For example, biophysical scientists typically rely on logical positivism, while economists often rely on principles of valuation and tradable commodities which may not yet be widely accepted by ecologists (Wam, 2010).

A large number of bio-economic models has been developed for different farming systems and agro-ecological conditions (e.g. Janssen and van Ittersum, 2007; Kragt et al., 2012). Such models may link biophysical and economic models, but their individual components are typically developed from a single-disciplinary perspective (e.g. economics or agronomy) (Kragt, 2012). Bio-economic models tend to be limited in their level of integration, and often involve limited genuinely interdisciplinary teamwork (Hasler et al., 2003). There have been increasing calls for bio-economic models that focus more on integrating knowledge at conceptual as well as technical implementation levels (Flichman et al., 2011). This paper seeks to discuss how integrative bio-economic models can be developed in multi-disciplinary teams. We are motivated by the increasing collaboration between agronomists, economists, sociologists, and researchers from bio-physical science backgrounds in agro-environmental modelling projects. While research exists on interdisciplinary research (see, for example, Bammer, 2012; Brown et al., 2015; Kragt et al., 2013; van Rijnsoever and Hessels, 2011), there is limited focus on the integration of agricultural sciences and socio-economic research. Drawing on our collective experiences in applied agricultural economics, we will focus specifically on improving the success of bio-economic modelling projects that integrate natural sciences and economics in agricultural systems.

In the next section, we will discuss the main challenges related to working across economic and biophysical domains. In Section 3, we offer reflections on approaches that can help to overcome the identified challenges. The final section discusses the implications for research and training, specifically considering agricultural economics.

2. Challenges to interdisciplinary research projects

Literature discussing how to conduct interdisciplinary research in agricultural systems is relatively scarce. This section therefore draws from the wider literature on integrated research, and on the authors' experiences, to examine some of the key challenges that may be encountered in interdisciplinary research projects. The section is structured around six main issues: expectations, communication, data, resources, expertise and recognition. In Section 2, we explain these issues, followed by potential solutions in Section 3.

2.1. Diverging expectations about the research objectives and model boundaries

Bio-economic modelling that integrates economics with agricultural science, environmental science, ecology, epidemiology, or other sciences will bring together a range of participants. Such multi-disciplinary research teams bring specific management challenges that can pose major barriers to successful collaboration (Moxey and White, 1998). As with any research project, the expectations of team members may vary about what the research is going to address, the breadth and depth of the studies, and the methods of assessment. This can pose problems in interdisciplinary projects if each discipline has a different set of objectives and procedures. Expectations management is therefore an important component of working in teams, and is particularly challenging when working with multiple disciplinary expectations.

To effectively and successfully develop interdisciplinary bio-economic models, team members need to reach agreement about the goals of the model, its scope, its scale, the research questions it will answer, etc. Without discussing team expectations and agreeing on the project objectives, there is a danger that individual researchers (a) embark on a collaborative project that does not align with their own objectives; or (b) pursue questions and conduct research that does not contribute to the joint goals for the bio-economic model. We have seen these issues reflected in the tendency for multi-disciplinary research projects to organise and manage work packages along disciplinary lines. In such cases, it is easy for work progress to become misaligned between work packages, even when overall objectives were initially agreed upon. Consequently, the overall project objectives may not be achieved, increasing the risk that team members will compensate by focusing on their individual disciplinary objectives (e.g. single-discipline publications).

An important distinction between many single- and multi-disciplinary studies and integrated research is the generally problem-oriented approach taken in bio-economic modelling. Bio-economic models are often developed to answer real-world questions. These policy-relevant questions will provide the context for the analysis, and often guide the research procedures. In integrated research, contrary to most discipline-based and curiosity-driven inquiry, problems designate methods and scope, not the reverse (Brewer, 1999). Researchers embarking on an interdisciplinary project need to be aware of this difference when setting expectations about project outcomes.

2.2. Difficulties in communication between disciplines

Many authors have noted the difficulties in communicating science across disciplines (e.g. Brown et al., 2015; Kragt et al., 2011), and this remains a challenge in bio-economic modelling projects. Communication difficulties can arise for various reasons. Firstly, disciplines have their own specific jargon – which may not be understood by other disciplines. Disciplinary jargon complicates discussion between team members of different disciplines, particularly at early project stages when team members are still unfamiliar with each other. Improving communication does not necessarily mean that participants need to agree upon "a common language" (Tress et al., 2007). Overcoming language difficulties is a matter of reducing the use of jargon, and agreeing on a common *understanding* of terminology from the outset.

Each discipline's way of thinking and communicating is shaped by different assumptions about the world, captured in part by disciplinary epistemology and ontologies[4] (Wam, 2010). Both of these tend to be bound by disciplinary norms. This means that disciplines have different ways to define and express knowledge – which may not be valued by other disciplines.

Norgaard (1992) noted that each discipline has its own 'cultural' belief system: a largely unstated, unquestioned system of beliefs held in common. This means that disciplinary 'beliefs' may not always be fully compatible, which will present barriers to communication and effective collaboration. In an interdisciplinary modelling project, researchers

[4] Epistemology deals with our beliefs about knowledge: what we can know, how we can know it, as well as our values and aims; ontologies relate to the kind of things that exist; our world views and assumptions about the nature of things (Grix, 2002). In Artificial Intelligence, ontologies refer to a set of concepts that are specified in some way to create an agreed-upon vocabulary for exchanging information.