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Review

On the development and use of farm models for policy impact assessment in the European Union – A review

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ABSTRACT

Farm models are potentially relevant tools for policy impact assessment. Governments and international organizations use impact assessment (IA) as an ex-ante policy process and procedure to evaluate impacts of policy options as part of the introduction of new policies. IA is increasingly used. This paper reviews both the use of farm models in such policy IAs in the European Commission, and the development and use of farm models for policy IA by the scientific community over the past decade. A systematic review was performed, based on 202 studies from the period 2007–2015 and results were discussed in a science-policy workshop. Based on the literature review and the workshop, this paper describes progress in the development of farm models, challenges in their use in policy processes and a research and cooperation agenda. We conclude that main issues for a research agenda include: 1) better understanding of farmer decision-making and effects of the social milieu, with increased focus on the interactions between farmers and other actors, the link to the value chain, and farm structural change; 2) thorough and consistent model evaluation and model comparison, with increased attention for model sensitivity and uncertainty, and 3) the organization of a network of farm modellers. In addition, the agenda for science-policy cooperation emphasizes the need for: 4) synthesizing research evidence into systematic reviews as an institutional element in the existing science-policy-interfaces for agricultural systems, 5) improved and timely data collection, allowing to assess heterogeneity in farm objectives, management and indicators, and 6) stronger science-policy interaction, moving from a research-driven to a user-driven approach.

1. Introduction

Agricultural systems models are in theory relevant tools to evaluate different policy options in in so-called impact assessments (IA) (e.g., Antle et al., 2017; Van Ittersum et al., 2008). IA is an ex-ante policy process and procedure to evaluate impacts of policy options across a range of impact areas as part of the introduction (or not) of new policies. IA is increasingly used by governments and international organizations, and in many cases specialised support units and platforms exist. In 2003, the European Commission (EC) established the instrument of ex-ante policy IA to promote better regulation and to improve the quality and transparency of regulation (COM, 2002). IAs aim to, among others, support sustainable development by assessing the likely intended and unintended economic, social and environmental impacts of policy options and increase the evidence base underlying policy proposals in a systematic way. The results of IAs enable policy-makers to take better informed decisions. Also at national level IAs are being performed for new policies (e.g., Hertin et al., 2009), while international organizations frequently use IA as well (Vuorinen et al., 2014).

Currently, developments in the policy and science domain are to some extent occurring in parallel (Adelle et al., 2012). At the policy side agricultural and environmental challenges (e.g., climate change, environmental degradation, biodiversity loss, rural population decline) have resulted in responses and strategies in terms of climate-smart agriculture, bio-based and circular economy, resource efficiency and socially acceptable farming (e.g. EC, 2016a). These responses and strategies are also reflected in the UN Sustainable Development Goals (UNDP, 2016) and the Societal Challenges as formulated by the European Union (EC, 2016b). At the science side, research made numerous efforts to respond to these challenges with integrated research, covering the economic, environmental and social dimensions of sustainable development (e.g. Helming et al., 2011; Schneider et al., 2011; Van Ittersum et al., 2008; van Vuuren et al., 2015). For example, in the SEAMLESS project an integrated assessment framework for the agricultural sector was developed that connected different disciplines (agronomy, economics, and environmental science) and spatial scales (field, farm, region, market) (Van Ittersum et al., 2008). Although the development of many scientific tools is funded by the EU (Podhora

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et al., 2013), few have been used in policy making (Adelle et al., 2012). As there is a challenge both in production and use of knowledge, it is timely to evaluate both the production and use of knowledge with respect to IA of agricultural systems. Jordan and Turnpenny (2015) investigated the actors, capacities, venues and effects of tools of policy formulation from the policy analysis perspective, and showed that many links have been established, and studying the use of these tools adds to our collective understanding of politics. In this study we focus on a specific type of tools, and take an agricultural systems perspective.

Recently, large research networks have been established to improve agricultural modelling and application (AgMIP, Rosenzweig et al., 2013; MACSUR, www.macsur.eu; GYGA, www.yieldgap.org). These networks engage in multi-model ensembles, model intercomparisons and improvements and model applications to address societal questions. However, to date there has been a focus on crop or regional level, while the farm level, as a key decision-making level, is receiving less attention. As impacts of policies are likely to differ per farm (type), using models that distinguish impacts for different farm types is important to provide reliable assessments. Farms differ in specialization, size, intensity and orientation, influencing their resources, constraints and objectives, and consequently in decision-making and economic, environmental and social impacts of scenarios and policies (e.g., Cortignani and Dono, 2015; Reidsma et al., 2015b; Viaggi et al., 2010a). While crop and regional level models provide useful insights on policy impacts, it is equally important to better understand the sustainability and resilience of different farming systems. For the EC, improving farm modelling for policy impact assessment is a major aim (Langrell et al., 2013; Louhichi et al., 2015).

The aim of this article is 1) to assess the use of models, and specifically farm models, in policy IA, 2) to identify progress in farm modelling, and 3) challenges in science-policy interaction with farm models, leading to 4) a research agenda for further developing farm models, and 5) a cooperation agenda to improve the use of evidence in policy making processes such as IA. We developed a general framework for reflection to formulate future needs for research and cooperation in the field of IA of agricultural systems (Fig. 1), with specific focus on farm models. Issues dominating policy agendas are an incentive for scientific development of models to address these issues. Scientific developments need to be synthesized, in order to provide good input for evidence use by policy makers. If evidence is used, this can lead to new issues reaching the political agenda, and the cycle continues.

As a first step, we assessed evidence use by policy-makers, by making an inventory of IA reports by the EC in the policy area 'Agriculture and Rural Development'. Next, scientific development was assessed based on a systematic review of scientific literature. This review follows the one by Janssen and Van Ittersum (2007). We focused on farm models applied in the European Union (EU), to limit the scope and allow comparative analysis. Third, a science-policy workshop was organized to discuss findings regarding evidence use and scientific development, to synthesize progress and challenges and to develop a research and cooperation agenda.

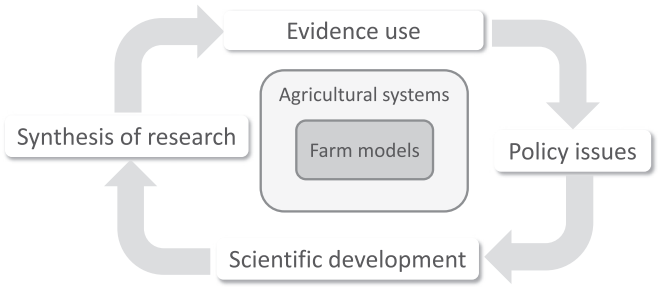

Fig. 1. General framework for reflection to formulate a research and cooperation agenda in the field of impact assessment of agricultural systems, and farm models specifically.

2. Material and methods

2.1. Evidence use in IA reports at EU level

The reported model use in EU IAs from 2003 to 2014 was assessed. All 805 IA reports in 21 policy areas on EU level were examined (EC, 2015). The focus here is on the 24 IA reports in the policy area 'Agriculture and Rural Development' (see Supplementary material 1). We investigated whether models were used, whether specifications of these models could be found, and whether references to scientific studies were made to support the IA.

2.2. Scientific development: systematic review

To evaluate scientific development, a systematic review was performed to assess the use of farm models for policy impact assessment in the European Union. We considered all journal articles, conference papers and book chapters indexed in Scopus (www.scopus.com), from 2007 to 2015, based on specific keywords. First, we selected articles using the keywords 'farm', 'model' AND 'policy' in their title, abstract and/or keywords. From these, all articles with a case study outside the European Union were excluded. In addition, we checked whether farm models were used; all articles that did not use farm models were also excluded. Many empirical analyses using farm level data are available, but these were not considered for this review. As with these keywords not all relevant articles were found, we also used the keywords 'agriculture', 'model', 'policy' AND 'Europe'. All found articles that used a farm model for policy assessment were also included, if these did not overlap with the other search results. We selected articles from 2007 to 2015, to follow up on the review by Janssen and Van Ittersum (2007). Even with these restrictions, a total of 202 articles were included in our database (see Supplementary Material 2). Of these, 18 were reviews, which were omitted from most analyses. Hence, in most analyses, 184 articles were included.

As a first step to synthesize research (Fig. 1), the countries, sectors and policies for which models were applied were assessed (Section 3.2.1). To evaluate progress in farm modelling, the review by Janssen and Van Ittersum (2007) was used as a basis. They reviewed bio-economic farm models (BEFMs) based on Mathematical Programming (MP); we extended their review and also included other types of farm models. Based on their review, Janssen and Van Ittersum (2007) proposed a research agenda including four issues for which progress was evaluated and which we also use in the present review: 1) better understanding and modelling of farmer decision making and possible effects of the social milieu (Section 3.2.2); 2) development of a thorough and consistent procedure for model evaluation (Section 3.2.3); 3) inclusion of several economic and environmental aspects of farming including multifunctionality (Section 3.2.4) and 4) development of a generic, modular and easily transferable BEFM (Section 3.2.5). Janssen and Van Ittersum (2007) also formulated four good practices: description of the 1) end use of the model, 2) agricultural activities, 3) model constraints and 4) model evaluation. As a description of activities and constraints is required for model evaluation, progress on these is included in Section 3.2.3. The intended end use is related to the required stakeholder interaction, and as we are specifically interested in science-policy interaction, this is evaluated in Section 3.2.6.

For each issue evaluated, we counted the number of studies that addressed this issue (e.g., whether social indicators were included) based on the 184 model studies. For the type of policies (Fig. 4) the 18 reviews were also included. Progress and challenges as identified by the 18 reviews were also summarized if relevant.

2.3. Science-policy workshop

On February 17, 2016, a workshop was held in Brussels to formulate future needs for research on IA of agricultural systems, based on a joint