

Participatory modelling in ecological economics: applications, best practices and future challenges

Submitted as Oral presentation in the Topic:

Special Session 7.3. Advancing participatory modelling approaches for sustainability transitions

Summary

Integrative modelling approaches support the development of long-term solutions for the transition to a sustainable society, promoting a holistic understanding of the interrelationships between biophysical, social and economic systems. In recent years, several participatory modelling applications to ecological economics issues have been developed, using a diversity of methods and tools for stakeholder engagement and knowledge integration. This paper aims to explore advances in participatory modelling and bring to the fore the role of system dynamics, as well as other integrative and multi-method modelling approaches, in supporting sustainability transitions. The paper provides a theoretical background to the special session “7.3. Advancing participatory modelling approaches for sustainability transitions” and includes a systematic review of recent methodological innovations, as well as recommendations for future applications related to the conference themes. An extended discussion will be promoted on best practices, challenges and research opportunities for advancing the science and empirical developments in participatory modelling platforms.

Extended Abstract (600-1200 words)

Exploring long-term solutions for the transition to a sustainable society requires the development and implementation of integrative modelling approaches that facilitate a systemic understanding of the complex interactions between biophysical, social and economic systems (Kelly et al., 2013). System dynamics modelling, for example, has been used for a long time in ecological economics studies, providing a synthesis framework in problem-solving processes (Farley et al. 2005) and a powerful tool for scenario-based analysis. Moreover, with stakeholder engagement becoming widespread and indispensable to assessment and modelling efforts (Voinov and Bousquet, 2010), participatory system dynamics applications to ecological economics issues have been increasingly promoted (e.g. Van den Belt, 2004; Antunes et al., 2006; Beall and Zeoli, 2008; Sedlacko et al. 2014; Videira et al. 2009). Participation in the modelling process brings several advantages, namely promoting learning and co-production of knowledge, preventing policy implementation failures and ameliorating conflicts between actors implicated in environmental and sustainability decisions (Costanza and Ruth, 1998; Blackstock et al. 2007; Jones et al., 2009). This growing body of literature addresses a suite of participatory modelling platforms and emerging application areas (e.g. sustainable consumption and economic growth, socio-ecological systems and resilience, degrowth pathways) wherein stakeholders are involved to varying degrees in the modelling process (Antunes et al., 2014; Stave, 2010).

Within this context, this paper aims to explore recent advances in participatory modelling and bring to the fore the role of system dynamics, as well as other integrative and multi-method modelling approaches, in supporting sustainability transitions. We discuss the theoretical underpinnings and provide a state-of-the-art in emergent participatory modelling applications in ecological economics, thus establishing a comprehensive background for the special session “7.3. Advancing participatory modelling approaches for sustainability transitions”.

The paper addresses the following research questions: *What is participatory system dynamics modelling and how has it evolved in recent years, particularly with respect to ecological economics applications? Which features of participatory modelling approaches develop our capability of understanding the interactions between economic, social, and natural systems? Which are the main challenges and opportunities for advancing participatory modelling approaches supporting sustainability transitions?* To address these questions we first look into participatory modelling

applications developed in the past decade to provide a systematic account of methods, addressed themes and best practice principles. Subsequently, we adopt a forward-looking stance, identifying the critical challenges and opportunities for advancing the field.

Participatory modelling aims at involving stakeholders in the conceptualization, specification and synthesis of knowledge and experience into a useful model, for the purpose of addressing complexity of socio-ecological problems. Among the several modelling methods possibly included under the “participatory modelling” umbrella, we focus on the system dynamics approach. Environmental and sustainability issues are characterized by high complexity, long-term impacts with unequal social, ecological, economic consequences and political controversies, irreducible uncertainties and incommensurable values (Hage et al. 2010). All of these features are compatible with the system dynamics modelling method, which is particularly fit for studying ecological economics issues. For example, Boulanger and Bréchet (2005) compared 6 modelling approaches supporting policy-making and assessment in sustainable development (i.e. Macro-econometric, computable general equilibrium, optimization, system dynamics, Bayesian networks and agent-based models), concluding that system dynamics ranks well against the majority of the proposed methodological criteria to address the features of sustainability problems. Such criteria include deploying a transdisciplinary approach, applying uncertainty management procedures, adopting a long-term view, adapting to local-global perspectives and accommodating plural perspectives and stakeholder participation. The latter is critical for promoting a systematic dialogue between science, society and policy (Hage et al. 2010), in alignment with a post-normal science view (Funtowicz and Ravetz 1993). Methods that facilitate joint knowledge production and mutual learning of science and society are thus necessary for social learning and transition to sustainable societies (Kates et al. 2001). Hence, participatory modelling offers one of such platforms for structured deliberation, involving stakeholder groups in problem conceptualization and sustainability assessment of public and private policies.

To bring about a systematic account of applications to ecological economics issues, we surveyed the literature using Scopus database. We found an increasing trend in the suite of participatory modelling applications under different “banners” (e.g. participatory modelling, mediated modelling, group model building), particularly from 2005 onwards. We also looked more specifically into the system dynamics modelling studies published in the *Ecological Economics* journal, critically reviewing both sets of articles. We develop an interpretative framework to structure the discussion of our findings, which is built around four dimensions that characterize integrative modelling efforts (Jakeman et al. 2006; Parker et al. 2002): i) nature of the issues modelled; ii) participation in model building and use; iii) scales of analysis, and iv) integration of modelling methods and other tools in multi-method approaches.

The empirical dynamic modelling studies reviewed show a wide diversity and coverage of ecological economics concepts and sustainability issues, such as: *ecological macroeconomics and degrowth* (e.g. Victor, 2007, 2012; Videira et al. 2014), *sustainable consumption* (Sedlacko et al. 2014), *biodiversity conservation instruments* (Arquitt and Johnstone, 2008; Beall and Zeoli, 2008), *global energy modelling* (Dale et al. 2012), *ecological footprint accounting* (Jin et al. 2009), *common pool resources* (Castillo and Saysel, 2005), *agricultural sustainability* (Shi and Gill, 2005), *river basin management* (Videira et al., 2009), *fisheries management* (BenDor et al., 2009) and *waste management policy instruments* (Ulli-Beer et al., 2007). Authors justify the use of a system dynamics approach to model these themes due to the complexity and dynamic nature of the underlying issues. The standout features of the method, which are recurrently mentioned, include the provision of a transdisciplinary scientific language, an explicit recognition of non-linear relationships and feedback loop processes typical of ecological-economic systems, adoption of a long-term perspective supporting analysis of model-based scenarios and policy evaluation, consideration of time delays and acceptance of plural metrics (monetary and non-monetary) in the same model. System dynamics modelling *with stakeholders* brings yet additional advantages by placing the modelling exercise within a collaborative learning environment, expanding problem views, building consensus and extending multi-stakeholder dialogues on system complexities. We take stock of these participatory modelling case studies to advance principles and best practices, along a continuum of modes of application that serve different purposes for stakeholder involvement in model construction and use – from collaborative learning

platforms, to participatory systems mapping, to participatory system dynamics modelling (Antunes et al. 2014).

Departing from the findings outlined above, the paper concludes by discussing a set of future challenges and recommendations for advancing participatory modelling platforms. Opportunities for further research include the development of capacities for conducting such processes. Hence, additional studies are needed for bringing insights into calibration of procedures, overcoming time limitations of voluntary stakeholder participation and developing facilitators/modellers skills (Dionnet et al. 2013). Another pressing issue, which has been somewhat overlooked in past experiences, concerns the need to further explore the values informing participatory modelling and developing appropriate communication of modelling results to decision-makers (Voinov et al. 2014). Finally, we discuss and illustrate the potential for combining participatory modelling with other methods and tools in multi-method approaches. This is a critical challenge, which is addressed by investigating the appropriate conditions for integrating participatory system dynamics modelling with other modelling approaches (e.g. agent-based modelling, geographical information systems, input-output analysis) and ecological economics methods (e.g. resource accounting tools, sustainability indicators, multi-criteria evaluation).

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