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Opportunities for knowledge co-production across the energy-food-water nexus: Making interdisciplinary approaches work for better climate decision making

Candice Howarth[a,*], Irene Monasterolo[b,c]

[a] University of Surrey, Guildford, GU2 7XH, United Kingdom
[b] Frederick S. Pardee Center for the Study of the Longer-Range Future, Boston University, Boston MA02215, USA
[c] Vienna University of Economics and Business (WU), Welthandelsplatz 1/D5, 1020 Vienna, Austria

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ABSTRACT

The relationship between the energy-food-water nexus and the climate is non-linear, multi-sectoral and time sensitive, incorporating aspects of complexity and risk in climate related decision-making. Current methods of analysis were not built to represent such a complex system and are insufficiently equipped to capture and understand positive and negative externalities generated by the interactions among different stakeholders involved in the energy-food-water nexus. Potential amplification effects, time delays and path dependency of climate policies are also inadequately represented. This paper seeks to explore how knowledge co-production can help identify opportunities for building more effective, sustainable, inclusive and legitimate decision making processes on climate change. This would enable more resilient responses to climate risks impacting the nexus while increasing transparency, communication and trust among key actors. We do so by proposing the operationalization of an interdisciplinary approach of analysis applying the novel methodology developed in Howarth and Monasterolo (2016). Through a bottom-up, participative approach, we present results of five themed workshops organized in the UK (focusing on: shocks and hazards, infrastructure, local economy, governance and governments, finance and insurance) featuring 78 stakeholders from academia, government and industry. We present participant's perceptions of opportunities that can emerge from climate and weather shocks across the energy-food-water nexus. We explore opportunities offered by the development and deployment of a transdisciplinary approach of analysis within the nexus boundaries and we analyse their implications. Our analysis contributes to the current debate on how to shape global and local responses to climate change by reflecting on lessons learnt and best practice from cross-stakeholder and cross-sectorial engagement. In so doing, it helps inform a new generation of complex systems models to analyse climate change impact on the food-water-energy nexus

1. Introduction: exploring complexity in the nexus

Understanding the impacts of climate change on socio-economic development, international decision-making and financial markets stability is challenging. An important challenge for the academic community, practitioners and policy-makers is understanding how the cost of climate change impacts and climate policies affect socio-demographic and economic development – and how feedbacks in this complex system affect outcomes. There is increasing recognition by academics and policy makers that the relationship between human-environmental systems and the climate are interconnected (Jacobs and Mazzucato, 2016; Fagerberg et al., 2016). In this complex system where cross-sector feedback loops, time delays at the macro-economic level (Hake et al., 2016; Stacey, 1992), and heterogeneous short-term thinking agents at the micro-economic level, influence non-linearity and policy uncertainty (Mercure et al., 2016; Rezai and Stagl, 2016). A key challenge is understanding the sources of uncertainties in our knowledge of these interactions, how they manifest themselves (e.g. parameters' values, model structure, behavioral responses, or knowledge of fundamental processes) and how they affect model scenarios. Such uncertainties are inherent in the dynamics of the complex networks that shape climate change and our responses. Uncertainty of climate impacts on sectors within the nexus such as food production and food security at different geographical levels (Burke et al., 2011;

* Corresponding author.
E-mail address: Candice.howarth@surrey.ac.uk (C. Howarth).

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Asseng et al., 2013; Rosenzweig et al., 2014) and scales (Garcia and You, 2016) has recently being analysed in the literature (Gillingham et al., 2015; Weitzman, 2011; Nordhaus, 2011; Knutti and Sedláček, 2013). Yet how to tackle the sources of climate uncertainty may result in increased risk and may affect different sectors across the energy-food-water nexus and development dimensions (social, economic, environmental, political) remains unclear. Indeed, sector based and integrated assessment models which usually represent Computable General Equilibrium (CGE) economies, endowed with a carbon/GHGs cycle of different complexity, are mostly used for climate policy analysis but have well-known limitations for modeling the dynamics of a complex system. Recently, the limits of these models have been highlighted by an increasing number of scholars (Pindyck, 2013; Farmer et al., 2015; Ackerman et al., 2009; Stanton et al., 2009) and include: substantial model-to-model variability; difficulty in estimating growth parameters; difficulty in representing a range of behavioral responses within individual sectors to different kinds of climatic and/or economic stresses; underestimation of the negative externalities of carbon and, in turn, its social cost. The issue of time lag also requires further exploration, particularly between the impositions of a stress and how sectors, agents and markets respond, which potentially constitute a major source of uncertainty. Simple considerations of dynamics therefore suggest that time lags in complex dynamic systems have the potential to be destabilizing.

The climate policy and research agenda continues to explore the interdependencies that exist among multiple sectors (Zimmerman et al., 2016) particularly where competing demands require strategic and careful management (Sharmina et al., 2016). Assessments of the science of the impact of anthropogenic climate change on ecosystems and human societies (IPCC, 2014) demonstrate that these will be mixed and evolve in nature, affecting commodities and limited resources that are fundamental for current and future generations. However, it remains unclear how the introduction of climate policies (e.g. global carbon tax, or phasing out fossil fuel subsidies) could impact the multiple actors that span the food-energy-water nexus. Indeed, climate policy has been identified as a potential source of carbon stranded assets − i.e., assets that are at risk of losing much of their value as a result of un-burnable reserves (Caldecott and McDaniels, 2014; Leaton, 2012) for companies who own them and investors who owns shares in such companies. Risk transmission from climate policies to the real economy, and to some extent to the financial sector, for example, is becoming an increasing area of focus in this regard (Battiston et al., 2016; Dietz et al., 2016; European Systemic Risk Board, 2016).

Nexus resources are fundamental for societal development, however they are limited and are being depleted at a rate faster than ecosystems can cope with (WWF, 2014; Rezai and Stagl, 2016). The concept of the nexus entails a holistic view of the world that surrounds society and interactions with a complex system of feedback loops, different sectors and natural resources (Hamiche et al., 2016; Fang and Chen, 2016). In this sense, it can be seen as the epicentre, or meeting point of a series of (often complex) components, which come together to represent something that is more than the sum of its parts. As a result, debates on the nexus often centre on: (i) what it is that is 'connected'; (ii) the exact nature of those connections; and (iii) boundary issues, i.e. if everything is linked in some way, then when and where do we draw the line? In addition to consisting of a network of relationships between energy, water and food systems and the complexities that characterise them, the nexus requires an understanding of 'soft' factors which are difficult to measure but are nonetheless key in delivering and supporting decision-making (Howarth and Monasterolo, 2016). These factors include, but are not limited to human values and perceptions, natural and technical processes related to systems considered, and the role of time in the interactions among different sectors (past and future).

The interactions across the energy-food-water nexus raise questions about traditional sectorial-based and focused systems that evolve and relate to one another. In order to work effectively on nexus issues, existing and new concepts that fundamentally exist within the nexus need to be explored. There have been attempts to disentangle the complexity of the food-water-energy nexus moving through case studies at the regional and local levels, to identify useful lessons. One such example is the case of Hindu Kush Himalayan ecosystem services in South Asia, which demonstrated that in order to sustain resilience of resources and food, water, and energy security in the region, cross-sectoral integration was needed, along with regional integration between upstream and downstream players, critical for ensuring food, water, and energy security (Rasul, 2014). Another example, is the context of sustainable consumption of food, water and energy, a practices approach would explore the social organisation of cooking, which, as an activity, consumes food, water and energy, and can complement more traditional approaches in sociology or psychology. Similarly exploring the full impacts of a complete food chain through life cycle thinking (Azapagic, 2015) could increase understanding of the diverse mechanisms that could be used to reduce the impact of this sector on exacerbating nexus shocks such as climate change (Jeswani et al., 2015).

There is growing recognition of the relevance of nexus thinking and approaches to increase understanding of its characteristics and intricate interactions that would enable decision makers to better address sustainability challenges. However whilst this term is growing in use to capture the importance of integration of approaches and stakeholders in solutions to sustainability and resource challenges, Cairns and Krzywoszynska (2016) urge caution about the risk of 'turning nexus into a "matter of fact" where it remain a 'matter of concern" (164). Yet, a comprehensive framework of analysis based on robust methods of analysis which fully captures the complex dimensions of the nexus and related decision making processes (Mowles, 2014), is missing. Specifically, more knowledge is needed on (i) how nexus stakeholders − from across academia, policy, business, finance and insurance sectors − perceive the impacts of climate change on their activities within the nexus, (ii) the direction and intensity of their network of relations within the nexus and (iii) the potential effect of other nexus actors on their climate decision making strategies. Indeed, this information is fundamental to inform the current debate on how to shape the broad context on international, national and local responses to climate change. Further analysis is needed to explore and understand how heterogeneous nexus actors will react to alternative climate mitigation and adaptation policies, either supporting or blocking their implementation according to their perceived gains and losses, and consequently the impact of their behaviour on the nexus.

Understanding the sources of shocks and potential impacts on and responses by the nexus require integrated and transdisciplinary systems thinking, adopting innovative approaches to the analysis of coupled human-environmental systems to develop effective solutions and decision making processes (Howarth and Monasterolo, 2016). An innovative approach to analyse the nexus is required involving a spectrum of qualitative and quantitative methodologies, traditionally used for sector-specific analyses in different research fields (e.g. natural sciences, social sciences, mathematics and physics), to be applied in innovative ways to complement and add value to each other's results. By building on Howarth and Monasterolo (2016), we develop such an approach that acknowledges the limitations of siloed and single-sector approaches and draws on the rich expertise of stakeholders that work and interact in the nexus. Most importantly, such an approach will need to provide decision-makers with transparent and accessible results that enable them to gain a deeper understanding of the characteristics of the nexus and how, in the aftermath of a shock, these develop a higher degree of complexity, non-linearity and uncertainty.

2. Methods

The methodology for knowledge co-production and development applied in this paper consists of a further development of the