Environmental Science and Policy 83 (2018) 46–53

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Emergence of new knowledge for climate change adaptation

Marta Olazabal[a,*], Aline Chiabai[a], Sébastien Foudi[a], Marc B. Neumann[a,b]

[a] Basque Centre for Climate Change, BC3, 48940 Leioa, Spain
[b] IKERBASQUE, Basque Foundation for Science, 48013 Bilbao, Spain

ARTICLE INFO

Keywords:
Climate change adaptation
Knowledge co-production
Systems approach
Fuzzy cognitive mapping
Decision-making

ABSTRACT

Decision-making for climate change adaptation requires an integrated and cross-sectoral approach to adequately capture the complexity of interconnected systems. More meaningful decisions can be taken in an arena where different agents provide knowledge of specific domains. This paper uses a semi-quantitative method based on cognitive mapping to demonstrate how new knowledge emerges when combining knowledge from diverse agents. For the case of heatwaves in the city of Madrid (Spain) we elicit knowledge about climatic impacts across urban sectors and potential adaptation options. Knowledge is elicited in individual interviews and then aggregated using fuzzy cognitive maps. We observe that the individual maps vary considerably in size and structure and find evidence of diverse and even contradictory perceptions. There is no "super-stakeholder", who theoretically could provide full knowledge about mechanisms operating in this urban system: the maximum percentage of the final aggregated map explained by a single individual is 26% in terms of concepts and 13% in terms of connections. We illustrate how the emergence of new knowledge can be sustained by combining scientific and policy expertise. Our approach supports knowledge co-production and allows to account for the interconnectedness of urban sectors under climatic impacts in view of formulating more robust adaptation strategies.

1. Introduction

Knowledge co-production, understood as a collaborative process in which shared and usable knowledge (van Kerkhoff and Lebel, 2015) is produced out of a pool of diverse knowledge sources and types is fundamental for decision making in socio-ecological contexts and for the transition to global sustainability (Clark et al., 2016; van Kerkhoff and Lebel, 2015). Transdisciplinary approaches have been considered highly useful for addressing complexity, uncertainty and controversy (Serrao-Neumann et al., 2015). Although such approaches are not easy to implement (Hegger et al., 2012; Thompson et al., 2017) they have been found useful for integrating different knowledge domains for policy-making (McPhearson et al., 2016). Particularly in relation to climate change adaptation, methods that allow for collective learning are essential (Armitage et al., 2011; Borquez et al., 2017; Huitema et al., 2016; Lemos and Morehouse, 2005; Serrao-Neumann et al., 2015) to make systems more resilient, legitimate and effective (Howarth and Monasterolo, 2017; Huitema et al., 2016). Scholars have understood knowledge co-production about climate issues in a variety of ways (Bremer and Meisch, 2017); we use the concept here in the context of social learning, referring to a collaborative process in which scientists and all stakeholders including institutions jointly define a problem and its potential solutions by building system knowledge.

In this paper we particularly aim to show how knowledge can be co-produced through novel methodological approaches that help to analyse information in an integrated way. We present and apply a methodological approach that can facilitate and support knowledge co-production. Specifically, we show how to collect and combine different perspectives, to analyse pooled knowledge from different groups and to identify cross-sectoral synergies and interactions in view of supporting complex decision-making processes, such as those related to climate change adaptation. Through a case study in an urban context, we find evidence that combining diverse knowledge sources can support the emergence of new knowledge, which is expected to lead to a better understanding of climate change impacts and thus, to an improved basis for adaptation decision-making.

As climate change affects multiple sectors at multiple levels (Adger et al., 2005), effective adaptation planning requires taking into account diverse individual and collective perspectives (Bremer and Meisch, 2017; Collins and Ison, 2009; Grothmann and Patt, 2005) but also take into account potential barriers and mismatches that may arise (Wamsler, 2017). The ability to generate and use knowledge is one of

* Corresponding author at: Basque Centre for Climate Change, BC3, Edificio sede, Planta 1, Parque Científico UPV/EHU, Barrio Sarriena s/n, 48940 Leioa, Bizkaia, Spain.
E-mail addresses: marta.olazabal@bc3research.org (M. Olazabal), aline.chiabai@bc3research.org (A. Chiabai), sebastien.foudi@bc3research.org (S. Foudi), marc.neumann@bc3research.org (M.B. Neumann).

https://doi.org/10.1016/j.envsci.2018.01.017
Received 4 October 2017; Received in revised form 3 January 2018; Accepted 25 January 2018

the most important indicators of adaptive capacity (Williams et al., 2015), as rich and diverse knowledge is expected to improve the robustness of decisions. Eliciting knowledge that is scattered and disaggregated among diverse stakeholders is, however, a difficult task (Aylett, 2014). In some instances, knowledge is in the hands of groups or individuals with vested interests who are not inclined to share it. In others, they might simply not be aware of its value and therefore not perceive a need to share it. However, the use and combination of knowledge from many diverse sources is fundamental for effective adaptation decision-making, especially when data on the functioning and performance of a system is scarce or uncertain (Armitage et al., 2011; Mehryar et al., 2017; Olazabal and Reckien, 2015; Reckien, 2014).

The task of integrating different sources of knowledge is challenging. In the last decade, many scientists have emphasised the value of systems approaches for meeting the challenges of sustainable development and global environmental change and, in particular, climate change adaptation (Bai et al., 2016a,b; da Silva et al., 2012; Fiksel, 2006; Kelly, 1998). By 'systems approach' we mean characterising a system through a model that describes its central elements and how they are related to one another. The model can be built individually or collaboratively. Fig. 1 compares individual and combined perspectives, similar to the parable of the blind men and the elephant. In this parable (Shah, 1993), each man perceives one part of "the truth" by touching just one part of the animal, but the men are only able to "see" the reality when they combine their knowledge. Individual perspectives are valuable as the experiential knowledge of individuals can capture many details of specific parts of a system; combined perspectives, on the other hand, offer an integrated view, capable of better capturing the complexity of an entire system.

Eliciting and combining knowledge through a systems approach helps to understand how a system's elements may interact. A systems approach for adaptation knowledge co-production is valuable to i) achieve a comprehensive understanding of how a complex system works, ii) discover cross-sectoral interactions and potential unintended impacts of adaptation decisions affecting infrastructures, services, resources and population, and iii) help identify the most efficient or effective ways of achieving certain adaptation goals. In this study, we address the first two of these; the third is beyond the scope of this work.

In this paper, we present quantifiable evidence of the value of a systems approach for knowledge co-production in climate change adaptation decision-making. Through a case study on heatwaves in an urban context, we show how using a procedure where knowledge from diverse social, institutional and scientific agents is brought together can support a broader understanding of climate change impacts and helps to build more robust system descriptions. In particular we study heatwave impacts in the city of Madrid (Spain) and potential adaptation options. For this, we use fuzzy cognitive mapping (FCM) (Jetter and Kok, 2014; Kosko, 1986; Özesmi and Özesmi, 2004; Papageorgiou, 2013) as a participatory, semi-quantitative expert-based approach useful for knowledge co-production. We collect individual perspectives (maps) on how a system performs under heatwaves in order to develop a combined map. We illustrate the potential value of the approach for knowledge co-production that can ultimately serve decision making for adaptation.

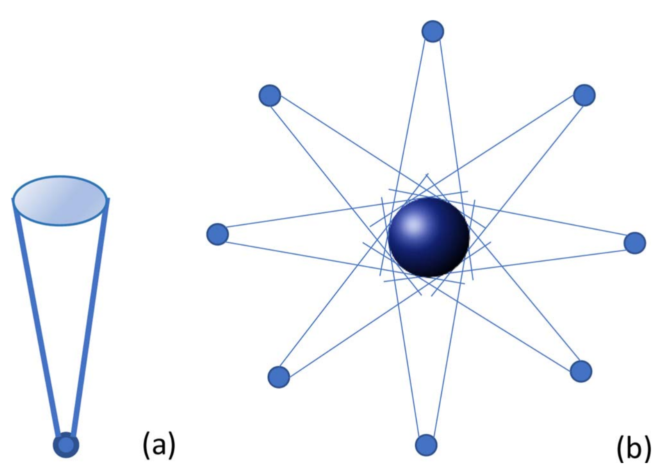

Fig. 1. Individual vs. combined perspectives. (a) Individual lens: contemplates knowledge from a single view point; (b) Multiple lenses: by combining different viewpoints an integrated, cross-sectoral and interdisciplinary perspective is obtained.

2. Methods and case study

In this paper, we conduct individual interviews with stakeholders in the city of Madrid to obtain cognitive maps. We compare these individual maps and then aggregate them. By analysing the aggregated map, we show how new knowledge emerges.

2.1. Fuzzy cognitive mapping (FCM)

FCM is a participatory, semi-quantitative method that allows the integration of views from different participants and construction of an aggregated model that can then be used to analyse scenarios (Jetter and Kok, 2014; Kosko, 1986; Özesmi and Özesmi, 2004). Participants develop maps consisting of concepts and weighted, directed connections. These causal maps reflect their experience, knowledge or perceptions about the system (see e.g. Gray et al., 2015; Olazabal and Pascual, 2016; Reckien, 2014). The mapping serves as a tool to collect disperse information and aggregate it into a model, which can then be used to identify interdependencies between concepts, including unexpected trade-offs and synergies. FCM can be applied at various stages of a decision-making cycle (Vogel et al., 2007). The methodological features involved in FCM make it a useful tool for knowledge co-production in systems characterised by complexity, uncertainty and scarcity of data (Mehryar et al., 2017; Olazabal and Reckien, 2015; Reckien, 2014).

A systems approach such as FCM, applied to climate change adaptation, allows to identify cascading effects and interactions across sectors that otherwise would be difficult to identify and analyse. This is what we refer to as new system knowledge and describe it as fragments of new understanding of the structure and behaviour of a system. When this new knowledge is obtained through the aggregation of individually elicited knowledge, it assists to overcome ignorance, misconceptions and biases of individual views (Kosko, 1992; Özesmi and Özesmi, 2004) and is therefore expected to be useful in adaptation decision-making processes.

2.2. Madrid heatwave case study

2.2.1. Objective

The case study that deals with the analysis of impacts and adaptation options in the context of heatwaves in the city of Madrid. To assess indirect impacts and design more robust adaptation measures, individual participants should cover different disciplines or sectors. We identify different knowledge sources and collect stakeholders' perspectives on how different urban sectors (such as health, water, energy….) can be affected. These perspectives are then aggregated into a model and it is demonstrated how new knowledge emerges under scenario analysis.

2.2.2. Selecting stakeholders and knowledge domains

Stakeholders interviewed are experts from different fields and sectors that are directly or indirectly affected by heatwaves (health, climate change, urban planning and design, green infrastructures, …). By responding the two questions "What are the impacts of heatwaves in the city of Madrid?" and "What are the potential adaptation measures?", participants were asked to describe the phenomena through a cognitive