ELSEVIER

Technology in Society 29 (2007) 388–406

Technology In Society

www.elsevier.com/locate/techsoc

Sustainable governance of emerging technologies—Critical constellations in the agent network of nanotechnology

Arnim Wiek*, Stefan Zemp, Michael Siegrist, Alexander I. Walter

Institute for Environmental Decisions, Natural and Social Science Interface, ETH Zurich, CHN, 8092 Zurich, Switzerland

Abstract

Emerging technologies, such as nanotechnology, feature considerable uncertainty regarding benefits that can be realized and unwanted side effects that ought to be avoided. Sustainable governance of emerging technologies addresses this issue from an integrated societal perspective that proposes collaboration among agents from science, business, government, and the public during the process of technological innovation and diffusion. In this paper, we present agent network analysis as a method to identify critical constellations in the agent network against the normative background of sustainable governance. Results from a transdisciplinary study on the agent network of nanotechnology in Switzerland reveal, among others, missing key agents, non-fulfillment of required functions, non-availability of required knowledge, and deviations between self- and cross-perception. The study contributes to methodological discussions on the formation of agent networks in science, technology, and public policy studies.

Keywords: Nanotechnology; Agent network; Sustainable governance; Cross-perception analysis; Transdisciplinary research; Emerging technologies

1. Introduction

Emerging technologies, such as nanotechnology, are currently associated with high economic expectations and major opportunities for public welfare [1,2]. Since toxicological studies have indicated potential risks for health and the environment when nanotechnology is involved [3–9], critical voices call for precautionary regulation and sustainable governance of nanotechnology, which requires efforts from various societal agents [1,10–12]. Expert tools, such as life-cycle analysis and risk assessment, which were designed to support precautionary and sustainable technological development, have recently been applied to nanotechnological materials and applications [9,13,14].

Sustainable governance of emerging technologies requires more than expert-driven risk management, however. Even if the risks of an emerging technology such as nanotechnology are technically manageable, guarded public perceptions may persist, very likely interfering with societal acceptance of nanotechnological

*Corresponding author. University of British Columbia, Institute of Resources, Environment and Sustainability, 2202 Main Hall (Room 446) Vancouver, Canada V6T 1Z4. Tel.: +1 604 822 9376.
E-mail address: awiek@ires.ubc.ca (A. Wiek).

0160-791X/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.techsoc.2007.08.010

innovations [15,16]. Thus, technology governance strives for collaboration among agents from science, business, government, and the public during the process of technological innovation and diffusion [1,17–22]. The concept of *sustainable governance* extends this approach by balancing economic with environmental and social interests in a long-term perspective [21]. It includes negotiation and coordination of perceptions, values, functions/roles, and resources of the agents involved according to an operationalized, normative framework of sustainable development [21,23–25]. Sustainable governance seems to be of increasing importance in nanotechnology, where technological innovation and diffusion are currently driven by economic expectations that tend to overrule societal concerns, and collaborative undertakings are still at the premature stage [1,26–28].

A crucial prerequisite for sustainable governance of emerging technologies is reliable information about the network of agents that are involved in or affected by technological innovation and diffusion [21,29–31]. Such information completes an analytical perspective of technology development and provides important insights for strategy building and implementation of sustainable governance [12,21,32].

There is a broad spectrum of analytical approaches that deal with properties of agents and social networks, such as centrality, cohesion, density and the like, while applying qualitative and quantitative methods in a variety of research fields. The majority of these approaches can be perceived—from a methodological perspective—as variants of general multi-agent network analysis, including, among others, social network analysis [33,34], actor-network theory [35,36], dynamic actor network analysis [37], structural agent analysis [32], and approaches such as principle-agent theory [38], all of which are relevant in the context of science and technology policy [39].

In this article, we present an empirical study on the agent network of nanotechnology in Switzerland: a case study of sustainable governance of an emerging technology in Europe. The study considers methodological proposals of agent network analysis [32,37,40,41], sharing established analytical parameters and tools with social network analysis. The approach features two particularities: constructivism and transdisciplinarity. The study focuses on cognitive and discursive representations of the agent network under investigation [42] taken from structured interviews with a broad spectrum of agents. Apart from network properties, special attention is paid to so-called "cross-perceptions," which uncover deviations between self- and social perception [41]. Analysis of cross-perceptions is the entry point for the transdisciplinary research process—a collective, consensus-oriented, strategic effort that integrates knowledge from multiple perspectives by following the principles of mutual learning and joint research among agents from different societal fields [43–48]. Our study is conducted in accord with these features not only to produce a reliable analysis but also to disseminate the available knowledge among the agents involved, thus providing a basis for strengthening the agents' network [49,50].

Conducted in the context of sustainable governance, the study deals with the available knowledge, the functions/roles, and the interactions of the network's agents from a *status quo* perspective—as is done by the majority of social network analyses. In addition, the study identifies deficits and improvement potential for the network, which are determined against the concept of sustainable development of emerging technologies [31,51].

The study addresses three research questions:

1. Which key agents are active in the development of nanotechnology in Switzerland, and how is their network constituted?
2. What are the key agents' functions/roles and knowledge for promoting sustainable governance of emerging technologies?
3. Which of the identified agents' functions/roles is presently realized, what knowledge is available, and what is the improvement potential for sustainable governance of nanotechnology in Switzerland?

In answering these questions, our study provides insights into critical constellations and indications for effective sustainable governance of emerging technologies that resemble the case of nanotechnology in Switzerland. Since Switzerland spends the world's fourth-highest per-capita amount of public funding for nanotechnology [52], the results of this case study can be transferred to some extent to other countries that are engaged in developing this emerging technology.