Climate Science and Policy Research

Conceptual and Methodological Challenges

Edited by: Eva Lövbrand, Björn-Ola Linnér and Madelene Ostwald

Centrum för klimatpolitisk forskning
Centre for Climate Science and Policy Research

Rapport/Report 09:03

The Centre for Climate Science and Policy Research Report Series

The reports in the Centre for Climate Science and Policy Series have been peer-reviewed by at least two senior researchers before publication.

This publication can be quoted as: Lövbrand, E., Linnér, B-O and Ostwald, M. (eds.) (2009). *Climate Science and Policy Research. Conceptual and Methodological Challenges*, CSPR Report N:o 09:03, Centre for Climate Science and Policy Research, Norrköping, Sweden.

The report is available at: www.cspr.se/publications

About the authors

The authors of this report are all affiliated with the Centre for Climate Science and Policy Research. For individual author biographies, please visit the CSPR webpage at: www.cspr.se

Centre for Climate Science and Policy Research

The Centre for Climate Science and Policy Research is a joint venture between Linköping University and the Swedish Meteorological and Hydrological Institute. We conduct interdisciplinary research on the consequences of climate change as well as measures to mitigate emissions of greenhouse gases and ways to adapt society to a changing climate. Producing effective climate strategies presupposes that the climate issue is studied in its context with other measures for sustainable development, therefore the Centre also undertakes research on related environmental and resource issues. Our research spans international and global as well as Swedish conditions.

For more information on our research and other publications please visit www.cspr.se

Postal Address

Linköping University
Centre for Climate Science
and Policy Research
The Tema Institute
SE-601 74 Norrköping
Sweden

Telephone + 46 (0)11 36 33 47
Telefax +46 (0)11 36 32 92

E-mail: cspr@tema.liu.se

Centrum för klimatpolitisk forskning

ISSN 1654-9112
ISBN 978-91-7393-579-1

Table of Contents

Editorial

The scope of climate change research has grown immensely over the last decade. Beyond the extensive efforts to map and understand how the various components of the climate system interact and respond to human forcing, academics from a range of fields are today deeply involved in the social and political struggle to develop effective and legitimate climate change policies. While initially focused on the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, we have in recent years seen a growing academic interest in local, national, regional and trans-national climate change mitigation and adaptation efforts. In a time when decision makers have linked such efforts to other policy areas such as energy security, finance, land use, and social development, new academic fields have also become involved in the study of climate change. Hence, climate change research is increasingly conducted at the interface between the natural and social sciences, engineering and the humanities. This development spurs self-reflection in the research community. The Intergovernmental Panel on Climate Change (IPCC), with the mandate to assess the latest research for decision-makers, is currently working and deliberating on how to design the next round of assessment in the light of a widen agenda of climate change policy. It is at this dynamic interface that we find the expanding field of *climate science and policy research*.

Climate science and policy research is by no means a stable academic field. Rather, it is by virtue a broad, diverse and hybrid enquiry that includes a range of epistemological, theoretical and methodological orientations. While much of the research under this umbrella has developed in parallel to (and often in direct response to) climate change policy, the field also includes a wide set of scholarly efforts to challenge and problematise the ideas and discourses underpinning such policies. This scholarly diversity may question climate science and policy research as a meaningful academic label. And indeed, as indicated by the various contributions to this report, the interpretations of what this field is all about vary considerably. However, despite this variety, we argue that the different academic contributions to this field converge around the quest to interpret, understand, problematise and, at times, solve the challenges facing society under a changing climate. Some of this scholarly work has, directly or indirectly, sought to inform climate change policy. In other cases climate change has emerged as a vantage point for advancing the academic understanding of how links between nature and society, science and policy, development and environment, North and South are constituted and sustained.

In this report we draw attention to a set of conceptual and methodological challenges that we think arise from this broad scholarly enquiry. In the first chapter, Simonsson examines the importance of scale in climate change research. In order to effectively inform policy, she suggests that the academic study of climate change needs to adjust to the geographies of climate change policy-making. However, since science may not be able to deliver climate information at the spatial resolution asked by decision-makers, Simonsson also calls for greater scholarly awareness of the scalar challenges in climate science for policy. In the second chapter, Ostwald and Kuchler trace the conceptual genealogy of climate science and policy research. Starting in the historic development of the climate sciences, they end up in a much more complex and inter-disciplinary research landscape. Ostwald and Kuchler ask how researchers in the field of climate science and policy research can relate to this complexity.

In the third chapter, Glaas, Friman, Wilks and Hjerpe situate climate science and policy research in the scholarly debate on Mode 1 and Mode 2 science. Following a long-standing debate on the role of science in climate policy making, they ask whether this field of enquiry gains its legitimacy from autonomous basic research produced in sites distinctly demarcated from the world of policy (Mode 1), or from knowledge produced in the context of application (Mode 2). While it may be challenging for scholars of climate science and policy to engage in both modes of knowledge production at the same time, the authors point at examples where the distinction between Mode 1 and Mode 2 breaks down into a new research domain which they label as Mode 1.5. A similar discussion is raised by Hansson and Wibeck in chapter four. While climate science and policy research can be interpreted as an academic field in its own right, its close links to action can also result in a difficult balancing act for researchers. Drawing upon examples from public acceptance studies, Hansson and Wibeck highlight problems that arise when climate researchers advance a normative agenda and hereby influence the people they study. Finally, in chapter five, Jonsson, Lövbrand and Andersson offer examples of research produced in direct collaboration with affected stakeholders. While such ‘participatory research’ often is said to increase the legitimacy and problem-solving capacity of climate science and policy research, the authors discuss how and when that promise holds true.

The conceptual and methodological challenges discussed in this report are the result of a seminar series held at the Centre for Climate Science and Policy Research (CSPR) at Linköping University from autumn 2007 to spring 2008. As such the chapters reflect an ongoing debate and internal self-reflection at a centre that still is young and under development. Since its establishment in 2004, the CSPR has grown steadily and today functions as an interdisciplinary platform for more than 20 senior and junior researchers active in the field of climate science and policy research. In this report we do not set out to give a comprehensive picture of the challenges facing researchers at the CSPR, nor scholars in the broader field of climate science and policy research. Neither is it a statement of what CSPR is, but rather a bouquet of thoughts around our own research. By sharing our reflections with a broader scholarship, we do, however, hope that this report will contribute to the ongoing debate on the scope, direction and function of this expanding and dynamic academic field.

Eva Lövbrand, Björn-Ola Linnér and Madelene Ostwald

1. The understanding and use of scale in climate change research and policy

Louise Simonsson

Introduction

How can a scientific assessment of global environmental change designed to influence local decision-making best be structured? How should authority and responsibility to manage global environmental problems be allocated among different levels of government? How should the costs and burden of global environmental problems be shared between nations, sectors and people? These questions share the implicit or explicit recognition that global environmental change is a cross-scale phenomenon that requires assessment at and integration across scales in order to inform policy- and decision-making most effectively (Cash and Moser 2000). Nevertheless, scale is far from a straightforward concept. It has been theorized, discussed and questioned by several academic disciplines, but probably most so in geography. After many decades of research in geography and related fields, the debate is ongoing and there is still no canonical theory of scale.

At a seminar held at Centre for Climate Science and Policy Research (CSPR) during spring 2008, there was a consensus among the participants that scale indeed matters in climate science and policy research, and that we need to relate to the term in various ways. However, the understanding of the concept differs. The different interpretations might be a reflection of the various academic backgrounds present at the CSPR, or of the demands and nature of the various research projects conducted at the CSPR, or perhaps a combination of the two. This paper focuses on the concept and use of scale in climate science and policy research, especially within the vulnerability and adaptation field, one of the core research themes at CSPR. It starts with a brief overview of the main theoretical perspectives on the concept, and how these perspectives link to the work and intellectual debate at CSPR. The paper concludes with a discussion on the future scalar challenges for CSPR research, and climate science and policy research at large[1].

Does scale really matter?

At the CSPR and in the climate change research community at large, several actors struggle with problems that follow from the persistent scale discordance, identified by Cash and Moser (2000). Firstly the case of 'environmental externalities' raises important scalar challenges (Holland et al. 1996). If an "environmental problem is exported beyond certain jurisdictional boundaries to neighboring jurisdictions which have no or little influence over the source of the problem", how can the responsibility for corrective actions be identified and allocated? Besides trans-boundary environmental problems such as acid rain, the scalar challenge of environmental externalities today involves problems of more global kind such as climate change, where the atmosphere acts as a global common.[2] Whereas trans-boundary pollution problems have been successfully managed through regional agreements such as the Convention on Long Range Transboundary Air Pollution in Europe, the global reach of the climate challenge has resulted in more complex and contested political arrangements.

Secondly, scale is relevant and crucial to discuss when science informs policy and management. The scale of scientific analysis and assessment, and the scale for which scientific information is needed, may not necessarily be the same. Thus, explanations and predictions of climate change impacts may be less useful for regional and local decision-makers, if scientists are unable to predict impacts at local scales.

Theoretical perspectives on scale

Geographical scale can be defined as the spatial dimensions of a process, an observation, or a decision (Wilbanks 2007; Capistrano et al. 2003). Pragmatically scale is often used to denote the spatial extent and resolution, as well as the detail, in which processes can be studied. However the temporal aspects of scale also need to be recognized. Space-time scaling predicts the behavior of systems within a range of matched spatial and temporal scales. Phenomena

[1] Although the theory of 'panarchy' (see e.g. Gunderson and Holling 2001) is not discussed here it is also relevant for many of the research fields at CSPR. One of the essential features of the panarchy is that it turns hierarchies into dynamic structures and is explored primarily in systems theory and global governance.

[2] See the classic `tragedy of the commons' (Hardin, 1968), where the idea has been discussed and developed in the common-pool resources literature.

studied over long temporal scales, and at small spatial scales, often have low predictability because they are complicated and have a strong random element. Conversely, systems examined over large spatial scales and short periods often have high apparent predictability simply by virtue of experiencing little change over the time in question. Scale can also, and sometimes simultaneously, imply a level of organization or a functional unit (Ahl and Allen 1996). However, there is disagreement on the precise extent or definition of any scale (e.g., where are the boundaries of something 'local'?), and there is rarely perfect congruence of, for example, a spatial and a functional unit identified at the same scale (Sayer 1991).

The many aspects of scale can easily be confusing. Part of the confusion is due to, and evidence of, how scale is socially defined and particular to certain political, scientific, legal, or cultural lenses. People impose a definition of scale for a particular issue and for particular purposes. As such, scale can be understood as a heuristic concept employed by scientists and managers to organize their understanding of the world and the relationships and interactions therein (Cash and Moser 2000). Nevertheless, realist perspectives on scale provide a firm foundation for most global environmental change research in general, and climate science and policy research in particular.

Realism and constructivism in scales

Manson (2008) has developed a useful epistemological scale continuum that runs from realism, via hierarchical scale concepts, to constructionism (see Fig 1). He argues that most research perspectives in the field of global environmental change research share the ontological premise that a real world exists out there. However, the various perspectives differ dramatically in their epistemological orientations, i.e. the extent to which they believe that science can accurately represent this complex reality. *Realist scale* assumes that observers can access the objective reality, and therefore supports measurement, modeling and explanation. As such, realism functions as the starting point for efforts to identify relationships between scales, to collect data or to build theory. Realist scale concepts are often related to terms such as resolution that can be described in, for example, grid cells or individuals in a population. Even though not all climate scientists necessarily interpret scale in this sense, or even agree with it, they all have to relate to it since most of the basis (and assumptions) of climate change clearly use this meaning.

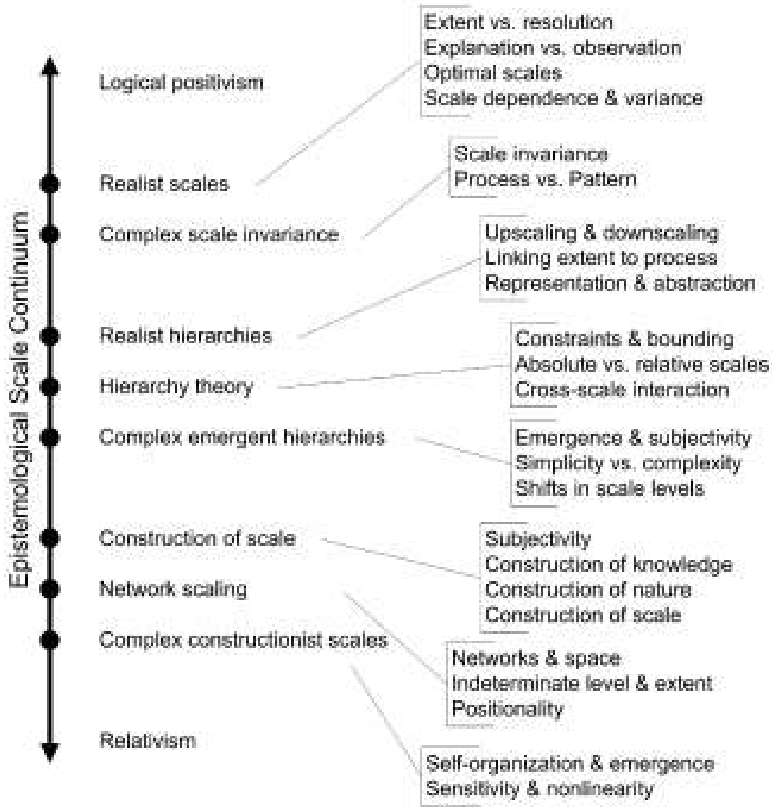

Figure 1. The epistemological scale continuum (Manson 2001)

Within the realist spectrum of Manson's continuum, research design requires that we decide on the *scale of observation* (the importance of data and the role of the observer), *the scale of explanation* (the scale at which to understand a system or process), and *operational scales* (describes the use of e.g. global climate models). These distinctions are important since they often differ. Models can employ a household explanatory scale, but be calibrated at observational scales defined by census tracts or pixels in satellite imagery. Studies of the vulnerability to climate change are, for example, often meaningless beyond scales defined by individuals, households, institutions, or nations. Thus the study of vulnerability processes at explanatory scales, need to fit with resolution. Since vulnerability is comprised by multiple factors, assessments are usually performed at a local scale but with external and internal dimensions (i.e. driving forces for local vulnerability can be identified at other scales and contribute to the explanation). Vulnerability assessments at national scales can be criticized for being too simplistic and unable to identify driving forces, which many believe is the very purpose of vulnerability assessments. Nevertheless, such national vulnerability assessments can still be of great political importance since they form the basis for decisions whether countries are eligible for UNFCCC funding.

At the other end of Manson's continuum we find the notion that scales do not really exist, in and of themselves, except as convenient mental devices for ordering the world. Hence, scales are socially produced (Smith 1990). The ontological dimension of this *constructivist* understanding of scale is rarely applied in climate science and policy research. Although many constructivists are engaged in the study of climate change, few would argue that climate change *only* is a social construction that has no basis in measurable and detectable elements in a real world. Nevertheless, on an epistemological level, many constructivist scholars have highlighted how discourses and norms contribute to the scalar interpretation and political ordering of climate change (see, for instance, Pettenger 2007). The global scale is the peak of scales, and the power to proclaim the globality of any event is the power to put the world on alert. In this globalist discourse, the global is presented as the scale from which there is no escape, the place at which there exists no option of disengagement. Arguments over who should reduce greenhouse gas emissions that contribute to climate change also have a scalar dimension that affects the allocation of responsibility (c.f. the discussion on historical responsibility).

Networks need to be mentioned in this context since they also relate to climate change activities. How are networks of social actors constituted at different scales, and what does this allow them to do or not do with regard to social praxis? A given project can simultaneously be local, regional, or global in terms of linkages to other phenomena. Networks in this sense challenge the notion of a fixed or objective scale. Some would even argue that the implications of networks are multiscalar to the point where scale as a concept loses relevance (Leitner et al 2002).

Cross-scale interaction

One means of identifying and understanding cross-scale interaction is by using the idea of hierarchies. Realist hierarchies are relevant for several challenges facing climate science and policy research at large, as well as at the CSPR. These challenges involve, for example, downscaling and upscaling (e.g. climate impact modeling), linking spatial impacts to the policy process (e.g. vulnerability and adaptation studies and institutional analysis), and representation and abstraction (e.g. stakeholder analysis). Socio-economic, political or administrative units (municipality-city-county-nation), or ecological boundaries (tree-stand-forest-ecosystem), often inform the analysis of climate change. Hierarchies highlight the importance of identifying relationships between these various geographical units.

Social systems tend to organize formal roles and responsibilities (functional and organizational) hierarchically, which in turn sets the scene for several processes related to climate change vulnerability, adaptation and mitigation. It is, however, a well-known problem that fixed scalar levels does not work for all types of processes (this applies not only to political institutions but also to landscape elements), which brings us back to the importance of research design and flexibility. The observer needs to choose a system of aggregation. Each level is characterized by the behavior of its components, and is bounded by constraints at other levels. In order to identify appropriate scale levels therefore requires scholars to knowingly move across levels, rather than dogmatically staying in one. Hierarchy theory thus adds another entry point to the analysis of cross-scale interaction in complex human-environment systems such as the climate system (Holling 1995).

Vulnerability assessments often show that smaller scales have a lower probability of threat (e.g. to severe weather events due to climate change), but are less resilience if the threat were to be realized. Larger scales, by contrast, have a higher probability of threat somewhere within them but more resilience in coping with the threat, as they generally have access to a wider range of resources for damage response and cost-sharing (Eriksen and O'Brien 2007). Also, paradoxically, resource availability is predominately top-down, while innovativeness and problem focus are predominately bottom-up. As a consequence, there have been calls for co-management structures that cross scales in order to promote sustainable development (Wilbanks 2007). One example of scale issues for sustainability is climate change adaptation. If, as Adger et al (2005) argue, adaptation to climate change is an issue relevant at local, national and international levels, the spatial scale over which the dimensions of adaptation and reduction of vulnerability can be implemented varies. Understanding adaptation therefore requires consideration not only of different scales of human action, but also of the institutional social construction of appropriate scales.

Although the actions individuals undertake to adapt to threats such as climate change can be said to be autonomous, they are often constrained by institutional circumstances such as regulatory structures, property rights and social norms associated with rules in use (Adger et al 2005). Many adaptation responses are thus determined at a local scale, but depend on structures and resources at global and national scales. The scales of appropriate adaptation measures also extend to lower elements of the political and jurisdictional scale. Municipalities, cities, firms and markets are all adapting within the bounds of available technologies, regulatory systems and perceptions and knowledge of future climate risks (e.g. Naess et al. 2005). A public sector agency may, for example, ignore the environmental or developmental effects of an action because they can be externalized in the decision-making process. They become ‘‘somebody else’s problem’’, at another level or scale. Or individuals may argue that my actions do not matter when the problem is at such a “large scale”.

Translation of results and understandings across scales

Not all localities are shaped by every change at a larger scale, and not every large-scale system is affected by change in every locality. Establishing scale invariance requires a good deal of evidence and robust explanations. As multiple processes can lead to identical patterns, and many different patterns can result from a single process, it is not enough to match typical patterns across multiple scales in a system and assume that the resulting processes are invariant (Manson 2008). However, equating small-scale with local, or large-scale with global, can also mask features in complex systems marked by sensitivity and cross-scale interactions.

Scientists are trained in critically analyzing observations at different resolutions. Such analyses become more important the larger the system is, or the longer the time scale is. For example, climatologists and geologists normally use a longer, or larger, time scale than most other academic disciplines. If we are to assess whether anthropogenic climate change is occurring, we cannot simply look at a global mean temperatures from pre-cambrium to 2009 A.D. fitted into an A4 sheet. From such analyses it would be very hard to detect changes that have occurred since industrialization. However, a higher resolution of the later part of the curve needs to be placed in the context of climate changes and variations during a long period of time (a large time scale). The choice of temporal, and spatial, scale for validation and comparison of data is also part of the reason for the sometimes infected debate on the causes of observed changes in the global climate. Is the cause anthropogenic, or are we merely witnessing a natural variation? At CSPR we do not conduct climatological research, but in the frequent interaction with various stakeholders we are often faced with the question and asked for ‘proof’ that climate change does not equal natural variability.

At the CSPR many research projects use case studies as their main methodology. Choosing the right scale for investigation, and then adding several other study objects at various scales, is then necessary if patterns and processes are to be verified. Otherwise explanations run the risk of incorrectly creating findings that may be artifacts of an incomplete analysis. Although there are methods and tools for analyzing multi-scale environmental processes, they may neglect that social aspects (e.g. vulnerability) are a dynamic outcome of both environmental and social processes occurring at multiple scales. Therefore, when vulnerability maps are produced to identify problematic regions, we should be attentive to analyze the adaptive capacity of such regions at different scales (e.g. household, municipality, county, country) (Metzger et al 2005).

Future challenges of scale in climate science and policy research

In this paper we have found that there are distinct differences in the scalar concept used in the various scientific disciplines and sub-disciplines involved in the study of global environmental change in general, and climate change in particular. Hence, the epistemological scale continuum makes it risky to assume that a given scale perspective is automatically applicable to any research question. As suggested by Manson (2008, p 785); "(i)n addition to focusing on how to choose the best scalar combination of observation and explanation for a given problem, researchers should actively consider the range of scale perspectives, not matter how seemingly inapplicable". There are consequently several broad questions regarding scale that we as climate science and policy scholars need to ask ourselves when designing, interpreting and communicating our studies and results:

- Why do we (and the research funder) focus on a certain scale as opposed to another?
- To what extent do existing data, scenarios and scientific approaches influence or limit the scale of our research?
- To what extent do existing data, scenarios and scientific approaches influence or limit the scale of practical action and implementation?
- At what scale and resolution do we visualize and communicate our results? How are our results framed and represented through language, figures and images?

To reach a proper understanding of driving forces and their behavior in complex systems such as the climate system, it is impossible to adopt a single research methodology (Bouma 1998). In interdisciplinary research fields such as climate science and policy research, several methods are often used and calibrated for specific scales. A central finding from the scalar overview in this paper is that methods should be designed so that information and understandings are complementary to different scales, and/or in different phases of the research process (Verburg and Veldkamp 2001). Thus, scholars in the field of climate science and policy research face the challenge of matching scales of biogeophysical systems with scales used in climate policy, while at the same time accounting for cross-scale dynamics (Cash and Moser 2000). This challenge is exemplified by the knowledge demands from stakeholder in this field.

Many participatory studies at CSPR show that stakeholders often call for scale-specific knowledge and information of high certainty in order to successfully manage the effects of climate change. Science, public institutions and practitioners therefore need to deal with scale specific knowledge demands (e.g. down-scaled studies that increase local understanding, capacity and action). However, scholars of climate science and policy research also need to be attentive to situations when scale-specific requests from stakeholders indeed represent a genuine lack of knowledge and understanding, and situations when decision-makers refer to a lack of knowledge in order to postpone action. In the field of climate change, efforts to link science to the policy process have primarily been organized around scientific assessments such as those produced by the Intergovernmental Panel on Climate Change (IPCC). This linear science for policy model typically assumes that policy-relevant scientific information produced for the purpose of the UN-led negotiations on climate change, also will be assimilated and used at lower scales (e.g. by municipalities) (Kingdon 1995). One fundamental problem with this approach is that it ignores the interactions between actors located at different scales. Hence, in order to be useful to policy, scholars of climate science and policy research have to be considerate to the scalar dimension of societal knowledge demands.

Conclusion

The overview of the scale concept offered in this paper suggests that scale indeed matters in climate science and policy research. Although far from all scholars in this field are (or can be) actively engaged in the ongoing conceptual discussion on scale, it is important to recognize that decisions about research design, analysis, use and communication all have a scalar dimension. To operate in the dynamic and interdisciplinary field of climate science and policy research is challenging in many ways. However, in order to offer constructive and viable input to the political debate on future climate change mitigation and adaptation options, we as scholars do not only have to respond to knowledge demands from societal actors. We also have to be better attuned the conceptual challenges and limitations generated by our respective academic disciplines, at all scales.

References

Adger, W. N., Arnell N. W. and Tompkins. E. L. (2005), 'Successful adaptation to climate change across scales', *Global Environmental Change* **15**, 77–86

Ahl, V. and Allen, T.F.H. (1996), *Hierarchy Theory: A Vision, Vocabulary, and Epistemology.* Columbia University Press, New York.

Bouma, J. (1998), 'Introduction' in Stoorvogel, J.J., Bouma, J, and Bowen WT (eds.), *Proceedings of an International Workshop on Information Technology as Tool to Assess Land Use Options in Space and Time*, Wageningen: Quantitiative Approaches in Systems Analysis 16.

Capistrano D. et al (2003), 'Dealing with Scale', in *Conceptual Framework: Millennium Ecosystem Assessment,* Kuala Lumpur: Island Press, pp. 107-126.

Cash, D.W. and Moser, S.C. (2000), 'Linking global and local scales: designing dynamic assessment and management processes', *Global Environmental Change* **10**, 109-120.

Easterling, W.E. (1997), 'Why regional studies are needed in the development of full-scale integrated assessment modeling of global climate change processes', *Global Environmental Change* **7**, 337–356.

Eriksen S. and O'Brien K. (2007), 'Vulnerability, poverty and the need for sustainable adaptation measures', *Climate Policy* **7**(4), 337-352.

Gunderson L.H. and Holling, C.S. (2001), *Panarchy: Understanding Transformations in Systems of Humans and Nature*, Island Press.

Hardin, G. (1968), 'The tragedy of the commons', *Science* **162**, 1243-1248.

Holling, C.S. (1995), 'Sustainability: the Cross-Scale Dimension' in Murasinghe, M., Shearer, W. (eds.), *DeWining and Measuring Sustainability*, Washington DC: The World Bank, pp. 65–75.

Kingdon, J.W. (1995), *Agendas, Alternatives, and Public Policies*, New York: Longman.

Leitner, H., Pavlik, C. and Sheppard, E. (2002), 'Networks, Governance and the Politics of Scale: Interurban Networks and the European Union', in Herod, A., Wright, M.W. (eds.), *Geographies of Power. Placing Scale*, Malden: Blackwell, pp. 274–303.

Manson, S. (2001), 'Simplifying complexity: a review of complexity theory', *Geoforum* **32** (3), 405–414.

Manson, S. (2008), 'Does scale exist? An epistemological scale continuum for complex human–environment systems', *Geoforum* **39**, 776–788

Metzger, M. J., Leemans, R. and Schröter D. (2005), 'A multidisciplinary multi-scale framework for assessing vulnerabilities to global change', *International Journal of Applied Earth Observation and Geoinformation* **7**, 253–267

Naess L.O., Bang, G., Eriksen, S. and Vevatne, J. (2005), 'Institutional adaptation to climate change: Flood responses at the municipal level in Norway', *Global Environmental Change* **15**(2), 125-138.

Ostrom, E. (1998), 'Scales, Polycentricity, and Incentives: Designing Complexity to Govern Complexity' in Guruswamy, L.D. and McNeely, J.A. (eds), *Protection of biodiversity: Converging Strategies*, Durham, USA: Duke University Press.

Pettenger, M. (ed.) (2007), *The Social Construction of Climate Change.* Ashgate Publishers.

Sayer , A. (1991), 'Behind the locality debate: deconstructing geography's dualisms', *Environment and Planning A* **23**(2), 283-308.

Verburg P.H. and Veldkamp A. (2001), 'The role of spatially explicit models in land-use change research: a case study for cropping patterns in China', *Agriculture, Ecosystems and Environment* **85**, 177-190.

Wilbanks, T.J. (2007), 'Scale and sustainability'. *Climate Policy* **7**, 278-287.

2. Climate science and policy research coming into being. Examples from the international politics of bioenergy and the case of avoided deforestation

Madelene Ostwald and Magdalena Kuchler

Introduction

After five years of existence, the Centre for Climate Science and Policy Research (CSPR) at Linköping University has literally gone from an infant phase to a hungry teenager with big feet and long arms, fed by the abundant and constantly growing flow of climate change research of different brands and accompanied policy demands. In this paper we will sketch out our view of this development with some crude descriptions of findings and processes that have had impact on the evolution of this continuously expanding scientific area. To tie our interpretation of the broad and diverse field of climate science to the younger field of climate policy research, we will in this chapter draw upon two concrete examples of ongoing *climate science and policy research* found at the CSPR.

From climate science to climate science and policy research

The Earth is surrounded by an envelope of air that acts based on physical processes giving wind, precipitation and pressures in different patterns. The understanding of these processes and patterns has traditionally been the scope of climatology or *climate science*. The primary data used in this scientific field is mainly observational data obtained over many years (Henderson-Sellers and Robinson 1986). Hence, the behaviour of the climate system in the past is used to understand the processes controlling the present climate. The climate has varied greatly over the past million years; something paleo-climatologists study through proxy records indicated in succession of cold and warm (inter- glacial) periods or from information in sediments. The difference between the variability of the climate over a short time span (say a few decades) and over long time periods (spanning thousands of years) may be hard to distinguish for non-experts. Several parameters affect the climate such as air pressure patterns, chemical composition and pools storing greenhouse gases (GHG). The GHGs in the atmosphere control the radiation that escapes to space and that is needed to balance the incoming solar radiation. When altering the GHG concentrations in the atmosphere, the amount of radiative energy in the climate system is thus modified resulting in changes in pressure systems, precipitation patterns and temperature.

In the later part of the 20th century, several climate scientists reported observed changes in our present climate such as sea level rise (e.g. Etkins and Epstein 1982) or increased temperatures (e.g Bolin 1977). One of the most exposed datasets is probably the "Hockey Stick" trajectory (Figure 1) presented by Mann and colleagues in 1999 (Mann et al. 1999). As indicated in Figure 1, the "Hockey Stick" showed a comparatively stable Northern Hemisphere mean temperature over the last 900 years, with a sudden increase around the year 1900. This change was defined generally as global change, or more specifically as global *climate change*. Global assessments indicated that there was an increase in global mean temperatures of 0.6ºC over the last hundred years (Meadows et al. 1972).

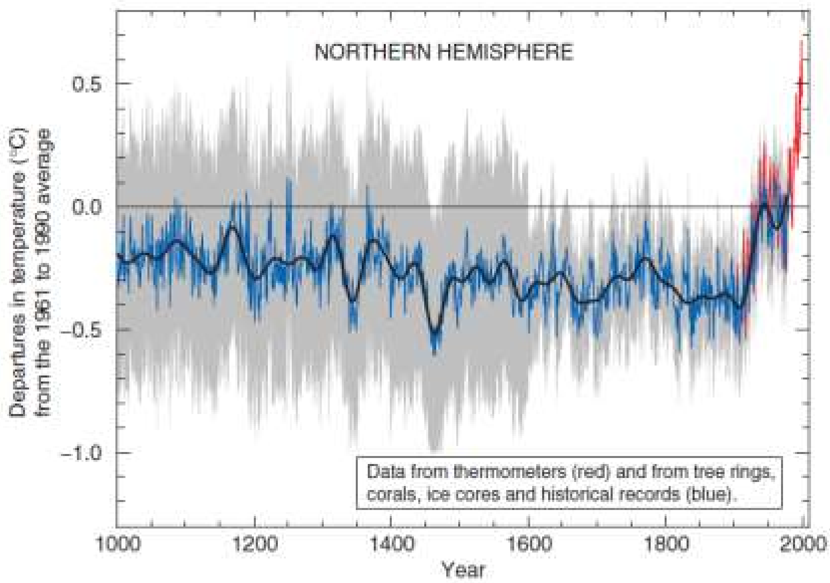

Figure 1: The 'Hockey Stick' describing the temperature and it uncertainties in the Northern Hemisphere over the last 1000 years. The temperature record has been reconstructed from proxy data. Source: IPCC (2001).

Parallel to the observations of global *climate change*, work was carried out to understand the impact of atmospheric carbon dioxide (CO_2) concentrations on the climate system. Charles David Keeling, who was a trained chemist and oceanographer, started to measure the atmospheric concentration of CO_2 from a sight at Mauna Loa in Hawaii in 1958[3]. Again the

[3] CO_2 is measured as the concentration of CO_2 molecules in a volume of air, expressed as parts per million (ppm or ppmv).

idea was to gain access to data that could explain processes in the present climate system. From a climate science point of view, Keeling's work turns out to be the most precise and continuous measurements of atmospheric CO_2 (Neftel et al. 1985), documenting a steady increase of CO_2 concentrations (Figure 2). The level of CO_2 started at 315 ppm in 1958 and reached 378 ppm in 2005. Following Keeling's work, the US National Oceanic and Atmospheric Administration (NOAA) reported a further increase to 386 ppm in April 2009 (NOAA 2009).

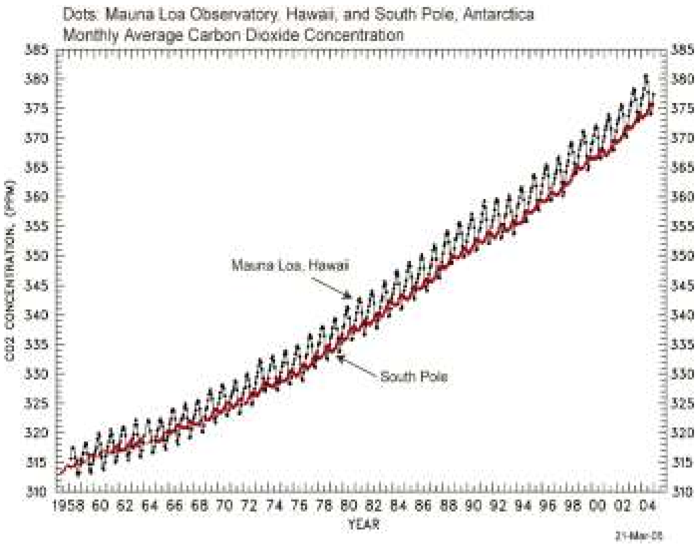

Figure 2: The Keeling curve showing the CO_2 concentrations in the atmosphere from Mauna Loa, Hawaii and the South pole from 1958 to 2005 (the year Keeling died). Source: C.D Keeling's Tyler Prize Lecture 2005.

In order to explain the increase in atmospheric CO_2, climate scientists started to analyse fluxes from other carbon reservoirs in the land surface and the oceans. The combustion of fossil fuels and human land-use change emerged as possible explanations to the elevated carbon concentrations. The correlation between the increase in global mean temperature and the CO_2 concentration has been widely debated during the past decades, not at least in the context of its attribution to man-made processes (e.g. Meadows et al. 1972) or other natural explanations (e.g. Landsberg 1970). However, in order to establish the causes of the observed changes in the global climate, more data was required than what traditional climate science could deliver. Hence, new scientific fields and disciplines entered the study of climate change. Human burning of fossil fuels called for studies of energy systems and their interactions with users. The possible climate impacts of a growing human population and human land use emissions, involved the farming and forestry sectors as well as urbanisation studies. In order to assess possible societal threats and risk of a changing climate, as well as feasible mitigation and adaptation options, a wide range of social sciences was mobilised in parallel to the climate sciences. The interdisciplinary field of *climate science and policy research* was born.

To give a visual illustration of the connections between the different strands of *climate science climate policy research* that have emerged from the 1990s and onwards, we have used and modified a model from UNDP/GRID (Figure 3). With the increasing evidence that climate change processes (middle top) within the larger climate system (top right) are driven by human activities (bottom left), there is an increased likelihood of societal risks (bottom right). To act upon this interdependent system of natural and human processes, there is a need for policies and measures such as subsidies for non-fossil fuel production or international policy mechanisms for reducing emissions from deforestation and degradation. It is primarily in this policy domain that the demand for an interdisciplinary field of climate science and policy research (middle bottom) has arisen (e.g. O'Connor et al. 1998; Magistro and Roncoli 2001). This last box is added to the figure on the basis of the argument in this paper.

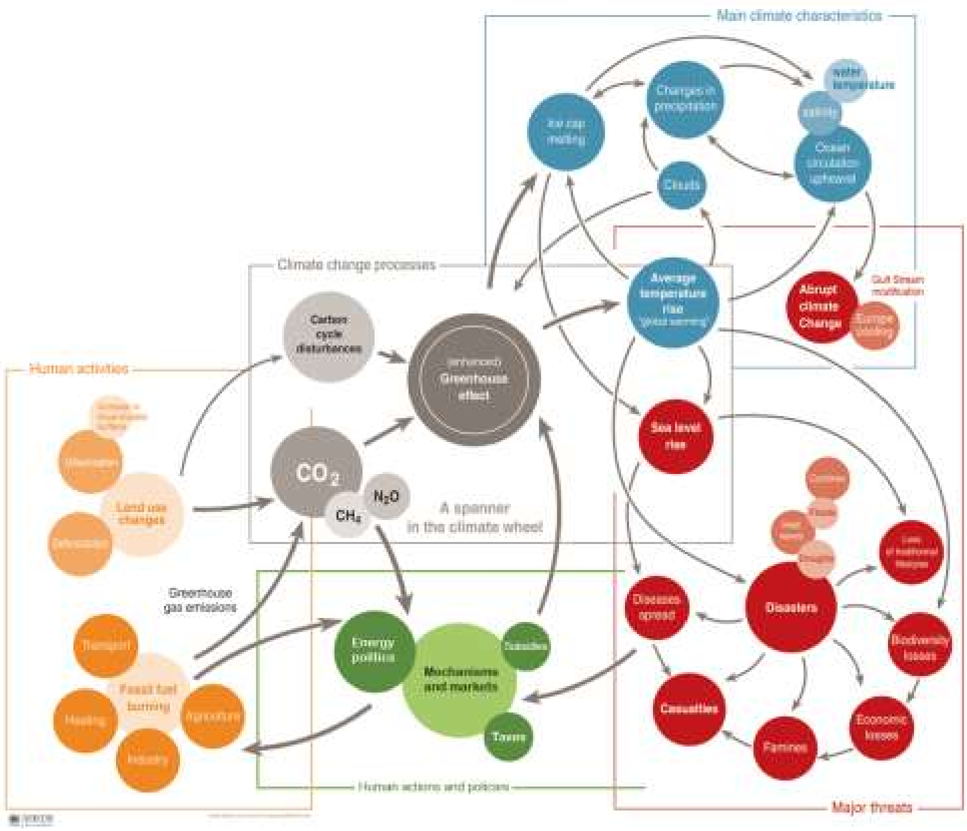

Figure 3: A conceptual graph of inter-linkages between 1) climate characteristics 2) climate change processes, 3) human activities such as fossil-fuel burning and land-use change, 4) climate change threats, and 5) human actions and policies. Modified from UNEP/GRID Arendal 2005.

Two of the areas related to human action and policies that we now would like to present as examples of the emerging interdisciplinary field of climate science and policy research are: i) the increasing political demand for carbon neutral energy, partially driven by scientific findings on the human impact on climate change, and ii) international efforts to increase carbon stocks within the terrestrial systems and the present focus on reducing emission from deforestation and forest degradation.

Examples from the international politics of bioenergy

Despite the fact that bioenergy production is not a new idea, the recent interest in biomass production for biofuels has been triggered by rural development strategies, rising energy consumption and climate change concerns (WorldWatch Institute 2007; FAO 2008). In recent years, scientists and policy makers have marketed biofuels as an alternative source of energy that could reduce global GHG emissions. Intergovernmental organizations such as the International Energy Agency (IEA), the Food and Agriculture Organization (FAO) and the United Nations Framework Convention on Climate Change (UNFCCC) have all framed and forwarded bioenergy as a solution to climate change mitigation (see for example: FAO 2005; FAO 2007; FAO 2008; IEA 1994; IEA 2004; IEA 2007; IEA Bioenergy 2007; IPCC 2007a; IPCC 2007b;, IPCC 2007c). As bioenergy strategies gradually have been incorporated into climate change policy, particularly on national levels (Steenblik 2007; WorldWatch Institute 2007; FAO 2008), the study of energy produced from biomass has become an integral branch of climate science and policy research.

The scientific study of bioenergy has gained particular attention through the work of the Intergovernmental Panel on Climate Change (IPCC). The Panel's latest Assessment Report (AR4) evaluates the critical role of bioenergy in climate change mitigation efforts (IPCC 2007a). The scientific body labels biofuels as the key mitigation technology that is currently commercially available, and advances biofuel blending as one of the policy options to be environmentally effective (IPCC 2007c). IPCC affirms that modern biomass can be carbon neutral and thus play a significant role in reducing GHG emissions, particularly in transportation (IPCC 2007b). In line with the IPCC, the IEA has framed energy produced from biomass as carbon free and thus advanced bioenergy as policy option with significant contributions to GHG reduction efforts (IEA 1994; IEA 2004; IEA 2007; IEA Bioenergy 2007). Simultaneously, the agency recognizes that bioenergy should be produced in a sustainable manner, particularly if it is deployed to play an important role in climate change abatement (IEA Bioenergy 2007). FAO argues in a similar fashion as IEA, stating that "when sustainably produced, bioenergy can provide a carbon-neutral or even carbon-reducing source of energy" (FAO 2007, p. 10), hereby contributing to climate mitigation efforts (FAO 2005; FAO 2007). Moreover, the organization tries to support developing countries in registering bioenergy projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol (Jürgens et al. 2004; Schlamdinger and Jürgens 2004; FAO 2005).

However, carbon-neutrality of different types of bioenergy options is a controversial issue, especially when it comes to ethanol and biodiesel production that requires land-use changes for agricultural cultivation and additional energy inputs for processing. These two activities could become a substantial source of GHG emissions undermining climate change mitigation efforts (Sachs 2007; BiofuelWatch 2007; Fargione et al. 2008). Moreover, despite the gradual process of international organizations' framing of bioenergy as a carbon neutral climate change abatement strategy, there is currently lack of coherent international policy measures and standards regarding the production of fuels from biomass. Thus, decisions made in the next several years about bioenergy policy will set the stage for alternative regulatory frameworks and development options available to decision makers, not only nationally but also on the international level, including the multilateral negotiations on climate change.

The issue of bioenergy is not only a great example of the strong interplay between energy security, food security and greenhouse gas mitigation policies. It is also en explicit case of climate science and policy research that seems to evolve and expand into new areas, depending on the geopolitical, socio-economic and environmental circumstances. Thus, it is of special interest to scrutinize how bioenergy is framed within a complex patchwork of climate change policy interactions. Moreover, to include studies of bioenergy in the expanding field of climate science and policy research also allows us to critically examine the condition of the climate change domain itself, together with its different mechanisms and interconnections hidden behind the front scene. Research in this field allows us to call into question established institutions involved in research and policy formation, understandings of climate change science and to explore the dominant structures and power relations of climate change policies by focusing on their origins and their process of changing.

The case of avoided deforestation

As with the earlier bioenergy example, deforestation is far from a new global issue. But with the demand for mitigation options framed by the climate change debate and the UN led climate negotiations, it has gained tremendous attention over the last few years. Tropical deforestation is the second leading cause of human induced GHG emissions, after energy production. In the 1990s the clearing of forests, mainly in tropical developing countries, contributed an estimated 5.9±2.2 $GtCO_2$/yr, or 7-16 percent of total anthropogenic GHG emissions (Denman et al. 2007), in level with the emissions from the global transport sector. Proximate drivers of deforestation and forest degradation are agricultural expansion for food or biomass for bioenergy, wood extraction and infrastructure development.

Quantifying emissions from reduced deforestation requires measurements of changes in forest cover, forest status and associated changes in carbon stocks. The uncertainties in emissions from deforestation remain large, primarily due to poor data from inventories at national level. However, the methods have improved over the last years through the use of satellite remote sensing. Leakage, or the issue of a particular forest management practice being moved to other areas or states, is also a troublesome issue, not the least as a result of the increased political interest in forests as a potential sink of atmospheric carbon. Avoided deforestation, or reducing emission from avoided deforestation and forest degradation (REDD), has entered as a key policy issue in the UN led climate change negotiations. At the 11th Conference of the Parties (COP) to the UNFCCC, several calls were expressed for inclusion of forests under Kyoto Protocol's trading instruments. The COP decided to evaluate the issue until COP13 in Bali, December 2007. Since the Bali meeting, there have been major research and policy activities in the area around REDD. One research area at CSPR is to study and analyze this process (see www.cspr.se/project).

Intergovernmental organizations such as the World Bank (World Bank 2009) and the United Nations Environment Programme (UNEP) (UN-REDD 2009), and donor countries such as Norway, have invested large funds to test the feasibility of REDD policies before their potential implementation after 2012, i.e. in a post-Kyoto climate treaty. The growing number of demonstration projects for REDD in tropical forest countries have thus spurred a great deal of research in recent years. Scientists have been involved in the analysis of these projects in order to i) evaluate the capacity in developing countries to monitor and assess national or sub-national baseline in the forest ecosystems and to develop methods to verify such estimates, ii) to assess the socio-economic and environmental impacts of REDD projects, iii) to evaluate the institutional capacity to canalize funds (e.g. Tanzania is receiving bilateral funds from Norway as well as through UN-REDD equal to US$ 70 million over 5 years**),** and iv) to organize a sustainable plan for the forest resource and related issues of payment for these environmental services. This policy driven research is mainly conducted through analyses of document generated from the ongoing policy initiatives, and through field experiences from case-studies in Bolivia, Cameroon, Costa Rica, Sri Lanka and Tanzania.

Leakage, land competition and low deforestation countries in future REDD schemes are reoccurring topics in the ongoing climate science and policy research in this field. Agricultural expansion for cattle and cultivation as well as the selling of timber, can produce lucrative incomes and thus be a strong incentive to deforest. In combination with poor governance in many tropical countries (Ebeling and Yasue 2008), legal regulation is in many cases not very successful. This has several implications for a possible future REDD regime. Financial incentives to keep forest need to be high enough to compensate for potential income from alternative activities. Even if forest protection is successful, revenue-strong activities might simply shift to other countries in order to meet increasing international demand. Hence there is a risk for leakage and countries such as Costa Rica and India that are currently not experiencing high rates of deforestation – and therefore see little reason or possibility of joining a REDD regime – may see increased pressure on their forests. Given that expansion of agricultural land is one of the key drivers of deforestation today, research efforts have also been initiated to assess how demand for agricultural produce (e.g. beef, soy, and palm oil) affects risk for leakage. Persson and Azar (2009) indicate that a price on the carbon emissions from deforestation may not offer enough financial incentives to protect tropical forests from expanding oil palm biofuel plantations.

In sum, the ongoing climate science and policy research on REDD has been closely aligned to the policy development in this field. Hence, the results from the scientific method development and assessments may therefore offer direct input to ongoing policy making process. In particular, research efforts in this field may add important pieces to the understanding of developing countries' potential to enhance their own natural resource management through inventories and national plans.

Conclusion

In this paper we have tried to map the evolution of climate science into the interdisciplinary field of climate science and policy research. By illustrating how a complex set of societal problems have been tied to the global concern for climate change, we have also tried to give some reasons why an increasing number of 'non-climate issues' have been incorporated into the study of climate change. From a science point of view we argue that this development of the climate change policy science calls for information and methods from different disciplines. This research field is still young and will most certainly continue to develop new methods and theories in the future. For the case of bioenergy, such theory development may well include critical analyses of the condition for bioenergy in the climate change domain itself, together with system analyses of how bioenergy production interplay with issues of land use and food production. For the case of avoided deforestation, new methods will most likely evolve from the interplay between policy-makers engaged in the international climate negotiations and scientists measuring and monitoring carbon stock in terrestrial ecosystem (through forest inventories and remote sensing techniques).

Maybe this need of interplay can be a driver generating more empirical testing of multidisciplinary research, and spur the development of methods and theories based on both natural and social scientific research traditions. The climate change policy science is in its structure in need of the reality including climate change and policy, which makes the science in itself contemporary, characterised by an applied and problem-solving ambition. Hence, we may expect that its value will decrease when/if the climate problem is solved. However, solving climate change is not really in sight. If we consider matters of natural and societal resilience and the challenges of adaptation in a time of human population growth and development (issues found in several of the boxes in Figure 3), the demand for climate science and policy research will most likely remain. We are therefore convinced that the CSPR has a crucial role to play in scientific and policy areas in the years to come, both internationally, and perhaps more specifically, on national and regional levels.

Acknowledgements

The authors wish to thank the colleagues at CSPR and Klaus Wyser at SMHI for valuable comments and input to the discussion in this chapter. Thanks are also extended to FORMAS and Swedish Energy Agency for financial support.

References

BiofeulWatch (2007), *Agrofuels: Towards a reality check in nine key areas*. Biofuel Watch.

Bolin, Bert (1977), 'The impact of production and use of energy on the global climate', *Annual Review of Energy*, **2**,197-226.

Denman, Kenneth L. and Brasseur, Guy (2007), 'Couplings Between Changes in the Climate System and Biogeochemistry', in Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 499-587.

Ebeling, Johannes and Ÿasué, Mai (2008), 'Generating carbon finance through avoided deforestation and its potential to create climatic, conservation and human development benefits', *Phil. Transactions of the Royal Society for Biological Sciences B*, **363**(1498), 1917-1924.

Etkins, Robert and Epstein, Edward S. (1982), 'The rise of global mean sea level as an indication of climate change', *Science*, **215**, 287-289.

FAO (2005), *Bioenergy. Item 7 of the Provisional Agenda*. Committee on Agriculture. Ninetieth Session. Rome, 13-16 April, 2005. COAG/2005/7.

FAO (2007), *Assessment of the World Food Security Situation*. Committee on World Food Security, Thirty-third Session, Rome, 7-10 May 2007, CFS:2007/2.

FAO (2008), *The State of Food and Agriculture. Biofuels: prospects, risks and opportunities*, Rome, FAO.

Fargione, Joseph, et al. (2008), 'Land Clearing and the Biofuel Carbon Debt', *Science*, **319**, 1235-1238.

Gan, Jianbang and McCarl, Bruce A. (2007), 'Measuring transnational leakage of forest conservation', *Ecological Economics*, **64**, 423-432.

IEA (1994), *Biofuels*. OECD/IEA.

IEA (2004), *Biofuels for Transport. An International Perspective*. OECD/IEA.

IEA (2007), *Bioenergy Project Development & Biomass Supply*. OECD/IEA.

IEA Bioenergy (2007), *Potential Contribution of Bioenergy to the World's Future Energy Demand*. IEA Bioenergy: ExCo: 2007:02.

IPCC (2001), *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, in Houghton, J.T.,Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (2007a), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, in M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds.), Cambridge University Press, Cambridge, UK.

IPCC (2007b), *Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, B. Metz, O. Davidson, P. Bosch, R. Dave and L. Meyer, Eds., Cambridge University Press, Cambridge, UK.

IPCC (2007c), 'Summary for Policymakers.' in B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds.), *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jürgens, Ingmar, Best, Gustavo and Lipper, Leslie (2004), *Bioenergy Projects for Climate Change Mitigation: Eligibility, Additionality and Baselines*. Food and Agricultural Organization, Environment and Natural Resources Service. 2nd World Conference on Biomass for Energy, Industry and Climate Protection, 10-14 May 2004, Rome, Italy.

Keeling,Charles D. (2005), Power point presentation at the Tyler Prize Lecture, http://scrippsco2.ucsd.edu/presentations/cd_keeling_presentations.html, accessed 08 May 2009.

Landsberg, Helmut E. (1970), 'Mand-made climatic changes', *Science*, **170**, 1265-1274.

Magistro, John and Carla, Roncoli (2001) 'Antropological perspectives and policy implications of climate change research', *Climate Research,* **19,** 91-96

Mann Michael E., Bradley, Raymond S. and Hughes, Malcolm K. (1999),' Northern Hemisphere temperatures during the past millennium: Inference, uncertainties and limitations', *Geophysical Research Letter*, **26**, 759.

Meadows, Donella H., Meadows, Denis L., Randers, Jørgen and Behrens III, William W. (1972), *The limits to growth*. Universe Books.

Neftel, Albrecht, Moor, E., Oeschger, Hans and Bernard, Stauffer. (1985), 'Evidence from polar ice cores for the increase in atmospheric CO2 in the past two centuries', *Nature*, **315**, 45-47.

NOAA (2009), http://www.noaanews.noaa.gov/stories2009/20090421_carbon.html, accessed 11 May 2009.

O'Connor, Martin, Faucheux, Sylvie and Sybille, Van Den Hove (1998), 'EU climate policy: Research support for Kyoto and beyond. Policy/research interface workshops series', *International Journal of Environment and Pollution*, **10**, 353-392

Persson, Martin and Azar, Christian (2009), 'Preserving the World's Tropical Forests: A Price on Carbon May Not Do', Submitted for publication in *Environmental Science and Technology*.

Sachs, Ignacy (2007), *The Biofuels Controversy*, UNCTAD, UNCTAD/DITC/TED/2007/12.

Schlamadinger, Bernhard and Jürgens, Ingmar (2004), *Bioenergy and the Clean Development Mechanism*. 2nd World Conference on Biomass for Energy, Industry and Climate Protection, 10-14 May 2004, Rome, Italy.

Schneider, Stephen J., Rosencranz, Armin and Niles, John O. (2002), *Climate change policy a survey*. Island Press.

Steenblik, Ronald (2007), *Biofuels – At What Cost? Government support for ethanol and biodiesel in selected OECD countries*. The Global Subsidies Initiative (GSI) of the International Institute for Sustainable Development (IISD), September 2007.

UN-REDD (2009), UN-REDD Programme, www.un-redd.net, accessed 12 February 2009.

World Bank (2009), Forest Carbon Partnership Facility, http://wbcarbonfinance.org/Router.cfm?Page=FCPF&ItemID=34267&FID=34267, accessed 04 February 2009.

WorldWatch Insitute (2007), *Biofuels for Transport: Global potential and implications for sustainable energy agriculture*. Earthscan.

3. Scientific knowledge and knowledge production. How do different traditions inform climate science and policy research?

Erik Glaas, Mathias Friman, Julie Wilk and Mattias Hjerpe

Introduction

Scientific knowledge production is disciplined to certain logics and locations, often associated with the university. In this chapter we draw attention to these logics and locations in an attempt to discuss the contemporary rhetoric on scientific knowledge and knowledge production. In order to produce knowledge, researchers use different theories and methods which both depend on the demands from society and from the academic culture in which they are situated. During recent decades, scholars of science and society have debated how to best produce knowledge that is useful to society. What constitutes useful knowledge is controversial and the rhetoric is built on different rationalities and perceptions about the role and purpose of science in society.

In this chapter we present two epistemological traditions that specify how knowledge production ought to be initiated and carried out, and how the process and results should be communicated to give the highest societal benefit. Meta-theoretically, these two traditions have been crystallized into two ideal types or end points in a continuum. Rhetorically they are often referred to as Mode 1 and Mode 2 respectively (cf. e.g. Nowotny et. al. 2001; Klein, 1990; Klein, 2001; Gibbons and Nowotny, 2001; Gulbenkian Commission, 1999; Gibbons et al, 1994). In the following sections of this chapter we compare the rhetorical underpinnings of each mode of knowledge production in an attempt to examine how their relationship to society is constituted. Ultimately, we do so in order to reflect upon the function, place and usefulness of the knowledge produced by the emerging field of climate science and policy research.

Mode 1 vs. Mode 2 knowledge production

Before embarking on our overview of Mode 1 and Mode 2, an explanatory note of caution is in order. Mode 1 is an academic concept that was first coined by Gibbons and colleagues

(1994) in a quest for a new social contract for science. Hence, the concept has emerged as a stereo-typical category or ideal type among scholars of science and society calling for a new mode of knowledge production. Although this chapter seeks to offer a balanced picture of Mode 1 and Mode 2 science, it is important to note that the concept of Mode 1 was originally produced by spokespersons for Mode 2. Hence, we use these two categories even though researchers defending the tradition of Mode 1 would hardly label themselves as something like “Mode 1-ers”.

Mode 1 knowledge production

Mode 1 is often referred to as autonomous or curiosity-driven ‘basic research’ produced in traditional university settings. Cannons promoting this traditional mode of knowledge, typically argue that it will benefit society precisely due to its independent character. Insensitive to shifting political trends in society, Mode 1 science proceeds and focuses on important questions despite rapid changes in societal knowledge demands. In other words, according to advocates of this research tradition, Mode 1 knowledge production can prosper without input from any other societal actors than academia itself (Bush 1945). Researchers provide knowledge to society for the benefit of whatever purpose that is deemed appropriate by science itself. Hence, it is not in the interest of Mode 1 scientists to decide what societal use their knowledge will have (Bush, 1969).

In its refined form, one can say that the researcher is the principal agent deciding whether the research activity is useful or not. Knowledge production is, according to this rhetoric, often framed as autonomous (Bush 1945, Widmalm 2008, Hansson 2007). Mode 1 knowledge production earns legitimacy through its independence from society, culture and politics. Following this rationale, the quality of research results is primarily determined by other researchers through established academic peer review processes (cf. e.g. Lundgren, 2000).

Mode 2 knowledge production

In contrast to Mode 1, Mode 2 science has been described as a socially embedded research practice performed in the context of application (Gibbons et al. 1994). Cannons promoting Mode 2 science rhetorically argue that it is beneficial to society precisely since it is attuned to the knowledge needs of various societal groups. As such, it grows from an inclusive and open-ended collaboration with societal actors outside academia and is therefore at mercy of inputs beyond the university setting. Mode 2 science is typically produced to be used by a pre-determined receiver for a pre-set purpose. To meet the needs of these user groups is therefore of highest importance to the Mode 2 researcher.

When successful, the Mode 2 knowledge becomes an integral part of the decisions or policy plans of the identified user. Hence, the knowledge user emerges as the principal agent who takes priority over the interpretation and assessment of what constitutes useful research results. Knowledge production is, from this perspective, often framed as a use-inspired or co-produced endeavor that earns legitimacy from its societal application (cf. e.g. Nowotny et. al. 2001; Klein, 1990). The quality of Mode 2 science is therefore typically judged through 'extended peer processes' including non-academic experts, and is seen as a means in a societal goal achievement process (cf. e.g. Lundgren 2000; Bernal, 1996).

Initiating scientific knowledge production

The two stereo-typical categories or ideal types for scientific knowledge production presented above, represent very different understandings of how science is (and should be) linked to society. Nevertheless, we will in the following argue that the design of a research process under these two modes of knowledge production tend to be more alike than what is typically recognized. When initiating Mode 1 knowledge production, the researcher carefully plants his/her research idea in well established academic theories and methods. The idea, however, will always originate from a socially embedded interpretation or understanding of the natural or social reality that is to be studied. In other words, initiating Mode 1 knowledge production can never be a totally autonomous procedure. Mode 2 knowledge production consists of essentially the same building blocks as Mode 1. The research idea is planted in theories and methods, even if these are more explicitly discussed or 'co-produced' with societal user groups.

Rhetoric behind Mode 1 science

Historically, Mode 1 science has been considered the most respected forms of knowledge (Gulbenkian Commission, 1999). When scientists initiate a research process according to this tradition, they ensure that the academic foundation is scientifically robust and authoritative. Focus is put on how the research process will advance the scientific understanding within a particular field and thus fill knowledge gaps within the academic curriculum. If the right books are read and followed to perfection, Mode 1 knowledge production is expected to deliver scientifically reliable results. This apparent 'robustness' makes Mode 1 knowledge production less vulnerable to social critique and influence from politics, media and public opinion than Mode 2. While a robust academic foundation is central for the legitimacy and authority of Mode 1 science, Mode 2 science draws its legitimacy from its very embeddedness in society (Gibbons et al. 1994). Hence, engagement with social context is at the heart of this research tradition.

Although this rather stereo-typical distinction runs the risk of turning Mode 1 into a strawman, the scholarly literature continues to highlight the usefulness and value of Mode 1. Many scholars have argued that traditional basic research builds a solid foundation for knowledge production in society, and hereby helps canalize the scientific energy (Gulbenkian Commission 1999). As opposed to the production of Mode 2 science, Mode 1 has been considered less vague and its methods more well-proven. The underlying promise of this traditional kind of knowledge production is that it may fill knowledge gaps which society did not even know it had (Bush 1969).

Rhetoric behind Mode 2 science

Under the heading "use-inspired" or "co-productive", Mode 2 knowledge production aims at integrating societal perspectives (values, norms and knowledge) in the research design (Gibbons and Nowotny, 2001). This research tradition has in recent years gained a great deal of attention in the meta-theoretical and epistemological debate in the science and society literature. Mode 2 science is typically advanced as more transparent and "socially robust" than Mode 1, and therefore also more legitimate (cf. e.g. Klein 2001, Gibbons et al. 1994, Nowotny et. al. 2001, Etzkowitz and Leydesdorff 2000). By including members of the public and/or societal stakeholders in the design and implementation of this applied kind of science, Mode 2 scientists are generally claimed to pave the ground for transparency (cf. e.g. Gulbenkian Commission 1999).

During the last decades, an increasing number of scholars have sought to translate these meta-theoretical claims into research practice, which has led to a gradual expansion of Mode 2 knowledge production (van Asselt Marjolein and Rijkens-Klomp 2002). As we have learned, it generally argued that this kind of applied science extends far beyond traditional academic research methods. Mode 2 science has to open up for the input of societal knowledge users when designing the research agenda. When formulating their research questions and choosing methods, it is argued that Mode 2 researchers must carefully analyze changing conditions in society. These conditions are not as easily controlled, but when producing science changes will occur and the research approach will therefore have to be altered along the way. Spokespersons of Mode 2 typically call for an iterative research process developed in collaboration with users. Hence producing Mode 2 knowledge puts high demands on the researchers, making the research more vulnerable although it in the end may add useful results to the surrounding society.

Producing and communicating scientific knowledge: usefulness in society
Mode 1 and Mode 2 both produce knowledge, yet are depicted as having different characteristics. In sum, Mode 2 is more transparent to society, directly useful, but less likely to ask critical questions challenging the core foundations in and of society (Widmalm 2008). Mode 1 science is depicted as more likely to produce predictable and reliable results and have a higher potential for critical perspectives even if these, by no means, always are used. Mode 1 science, it is argued, is also more likely to be used as tools in ideological struggles, especially if framed as apolitical and objective (cf. e.g. Lundgren 2000).

According to advocates of Mode 2, Mode 1 science has historically had monopoly on knowledge production. But during the last half century "society has begun to speak back to science" (Nowotny et al. 2001). In this chapter we argue that this is hardly any news. Society has always spoken to science. Yet, Mode 2 has perhaps made this communication easier and more transparent. We further propose that sometimes such communication can be hugely beneficial, in other cases not. As we have argued, Mode 1 knowledge production can never be totally autonomous. Mode 1 would soon suffer malnutrition from an autonomic environment, so it seems hard to understand how a refined Mode 1 knowledge production would ever be possible. At the same time, we would argue that Mode 2 can never be totally co-produced. Applied knowledge is always rooted in academia and tended by the researcher, making its existence meaningful. Thus, Mode 1 and Mode 2 have obviously more common features than what has been rhetorically presented in the literature. In the following we will try to see how the two modes of scientific knowledge production play out in our scientific field: namely climate science and policy research.

Knowledge production in climate science and policy research

We are here interested in the opportunities and challenges of producing knowledge under the conditions brought on by climate change. When examining research proposals from the Centre for Climate Science and Policy Research (CSPR), as well as the field climate science and policy research at large, we find a strong resonance with the theoretical debate on Mode 1 and Mode 2 outlined above. Drawing upon three research proposals at the CSPR, we find traces of both logics. Firstly, the research project 'Enhancing cities' capacity to manage vulnerability to climate change' advances stakeholder meetings as the primary means to gather empirical material and produce results that will be used by local stakeholders. To a great extent, the rhetoric of this project proposal lines up with the logic of Mode 2 knowledge production. Even so, an important project aim is also to strengthen scientific methods and theories on how to assess local vulnerability to climate change, using a combination of both non-climate factors and physical risks. This latter project aim departs from the Mode 2 logic and resonates better with traditional Mode 1 knowledge production.

The opposite holds for the research project 'Who gets what and when in international climate politics' which includes clear strains of Mode 1 knowledge production. The aim of this particular CSPR project is to analyze the role of science in the UN negotiation on climate change, and it is to a large degree based on traditional research methods and theoretical perspectives. However, the rhetoric of Mode 2 is also clearly present. The collection of empirical material and the testing of research hypotheses will to a large extent be conducted through participatory observations and workshops, i.e. in direct or indirect collaboration with stakeholders. Finally, the project 'Participatory catchment modeling for sustainable water management' (further discussed in chapter 5 in this report) aims to develop a strategy for production and communication of model based information through an integration of natural and social sciences. The method used in this particular project is informed by an interactive process of communication between local stakeholders, local authorities and researchers. Although the project may emerge as a typical example of Mode 2 science, the Mode 1 logic of Mode 1 is also present in the aim and method of this project. While usefulness for society in forming policies and deliberating the processes emerges as an overarching goal, academic method development and theory testing are also strong components.

When looking at these three CSPR projects, we see a high degree of both rhetorical logics. This finding suggests that researchers at the CSPR think it possible to combine the strengths of these two research traditions, a conclusion opposite to the rhetoric used in the stereo-typical descriptions of Mode 1 and Mode 2.

Concluding discussion

In this paper we have attempted to compare and test what rhetoric Mode 1 and Mode 2 knowledge production are built upon. We did so to explore strengths and weaknesses in different traditions of knowledge production, as explained by the literature. Table 1 offers an overview of our comparison.

Table 1: Emblematic characteristics of Mode 1 and Mode 2 science

Mode 1 science is useful since it is…	**Mode 2 science is useful since it is…**
Autonomous from society	Embedded in society
Has a critical potential	Socially legitimate
Often universal	Particular
Explorative	Problem-solving
Scientifically transparent	Socially transparent
Under academic peer review	Under extended, societal peer-review
Objective, apolitical	Embedded, politically engaged
Information for decision makers	Tool for decision makers
Scientifically robust	Socially robust

In this comparison, the two modes of knowledge production are depicted as each others' opposites. Most prominently, Mode 1 is built on autonomy whereas Mode 2 is 'contextualized' or embedded in society (Nowotny et al. 2001). In contrast to this schematic comparison derived from the literature, we have in this chapter tentatively argued that these modes have more common features than generally stated. In practice, we think, the rhetoric of both modes is hard to uphold. As argued above, Mode 1 can never be totally autonomous. Many years of social constructivist scholarship have taught us that the scientific autonomy is constructed and simply hides social bonds. This finding does not, however, mean that such a constructions are meaningless; rather the opposite, for good and bad. Also, as mentioned, Mode 2 would be meaningless to society if it was not to some extent rooted in academic theories and methods. This means that Mode 2 also is legitimated by its scientific virtues. For example, even when participatory methods are used, Mode 2 researchers make a number of (scientific) choices both when deciding which social groups to collaborate with and when analyzing the resulting material. Along the same lines, we argue that Mode 1 often is engaged with society, albeit indirectly. For instance, also the analysis of documents can be seen as an indirect participation from the wider society.

As such, both Mode 1 and Mode 2 researchers have to take societal partaking and exclusion into account. They both have to include society, if for no other reasons than for an appropriate choice of empirical material. Each research tradition also has to relate to what makes science scientific, as opposed to other forms of knowledge (e.g. forms practiced by consultants). The rhetorically constructed differences indeed have value and consequences, yet below the rhetoric a set of practical similarities surface. According to the present rhetoric, research is political or apolitical, co-produced or autonomous and so on. Although scholars of science and society typically challenge such stereo-typical distinctions, we would argue that the Mode 1 and Mode 2 debate paradoxically has reinforced the very same distinctions. Hence, in order to move the debate further, we find it timely to recognize and discuss the similarities between the two modes. Such a discussion, we argue, would strengthen scientific fields such as climate science and policy research that often balance in between the two modes. The complex field of climate science and policy research would gain from mixture of the two, in something that could be described as *Mode 1.5* or reflexively co-produced knowledge.

Applied science in the shape of Mode 2 is indeed valuable when gathering knowledge from various actors, making the research results more legitimate and likely to be successfully implemented. On the other hand, Mode 1 could provide an important forum for critical examination in scientific fields driven by policy demands. When looking at a few research projects in practice at the CSPR, we found that these projects are informed by both Mode 1 and Mode 2 logics. Accordingly, many projects already seem to combine the strengths of both these modes of knowledge production. We argue that many research projects would earn from recognizing these strengths when putting together their agendas. In order to do so, however, there is an obvious need for a more nuanced debate about scientific knowledge production. Despite the scholarly resonance of Mode 1 and Mode 2, we argue that Mode 1.5 is perhaps the most common way of conducting research. Nevertheless, this hybrid form of knowledge production is rarely recognized and utilized fully.

Understanding the conditions under which Mode 1.5 is produced could hold serious advantages, if for no other reason than creating more modest and realistic expectations of what science can deliver. In such a light, the promises made by Mode 1 and 2 could be nuanced and prompt a more reflexive understanding of how scientific knowledge is produced. We have in this chapter not sought to end the debate on Mode 1 and Mode 2 science, but rather to create a more nuanced platform for further discussions. We ask, in the light of research practice, if there is any intrinsic value of separating Mode 1 from Mode 2. At least in the field of climate science and policy research, the research problems seem to demand both modes at the same time.

References

Anonymous (1890), 'The aim and future of natural science', *Science*, **16**(404), 239-244.

Bernal, J D (1996), 'The challenge to science' (originally published in 1939) in Nowotny, H and Taschwer K (eds.), *The Sociology of the sciences: volume 1*, Vienna: The international library of critical writings of science, University of Vienna.

Bush, V (1945), 'Science: The Endless Frontier', *Transactions of the Kansas Academy of Science*, **48**(3), 231-264.

Etzkowitz, H and Leydesdorff, L (2000), 'The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations', *Research Policy*, **29**(2), 109-123.

Gibbons, M, Limoges, C, Nowotny H, Schwartzman, S, Scott, P and Trow, M (1994), *The new production of knowledge: dynamics of science and research in contemporary societies*, Thousand Oaks: Sage.

Gibbons M and Nowotny H (2001), 'The potential of Transdisciplinarity' in Klein, J T et al (eds.), *Transdisciplinarity: Joint problem solving among science, technology, and society*, Basel: Birkhäser Verlag.

Gulbenkian Commission (Wallerstein, I, Juma, C, Keller, E F, Kocka, J, Lecourt, D, Mudimbe, V Y, Mushakoji, K, Prigogine, I, Taylor, P J and Trouillot, M R), (1998), *Öppna samhällsvetenskaperna*, Göteborg: Diadalos.

Hansson, S O (2007), *The Art of Doing Science*, Stockholm: Department of Philosophy and the History of Technology, KTH.

Kleiber, C (2001), 'What kind of science does our world need today and tomorrow? A new contract between science and society' in Klein, J T et al (eds.), *Transdisciplinarity: Joint problem solving among science, technology, and society*, Basel: Birkhäser Verlag.

Klein J T (1996), *Crossing boundaries: knowledge, disciplinarities, and interdisciplinarities*, University press.

Klein, J T, (1990), *Interdisciplinarity: History, Theory, and Practice*, Detroit: Wayne State University Press.

Klein, J T, (2001), 'The discourse of transdisciplinarity: An expanding global field' in Klein, J T et al (eds.), *Transdisciplinarity: Joint problem solving among science, technology, and society*, Basel: Birkhäser Verlag.

Lundgren L (2000), *Knowing and doing – On knowledge and action in environmental protection*, Stockholm: Swedish Environmental Protection Agency.

Nowotny, H, Scott, P and Gibbons, M (2001), *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*, Polity.

Pohl, C (2008), 'From science to policy through transdisciplinary research', *Environmental Science & Policy*, **11**(1), 46-53.

van Asselt Marjolein B A and Rijkens-Klomp N (2002), 'A look in the mirror: reflection on participation in Integrated assessment from a methodological perspective', *Global Environmental Change*, **12**, 167-184.

Widmalm, S (unpublished manuscript, 2008), *Innovationssamhället*, Linköping: Tema teknik och social förändring, Linköpings universitet.

4. The social researcher, the public and climate change research

Anders Hansson and Victoria Wibeck

Introduction

This chapter aims at discussing the roles of the researcher and the public when studying social phenomena such as public understanding of climate change and public acceptance of climate-related technologies. We will argue for the need of increased reflexivity about how we as researchers influence the people we study, as well as increased sensitivity to how social science is used in science- and policy debates. We take our starting point in the observation that over the past few decades, awareness has mounted worldwide of the urgency of managing complex environmental problems. It is increasingly evident that as regards environmental issues, 'nothing can be managed in a convenient isolation; issues are mutually implicated; problems extend across many scale levels of space and time; and uncertainties and value loadings of all sorts and all degrees of severity affect data and theories alike' (Funtowicz and Ravetz 1999, p. 1). The traditional university system, which is often hierarchical and bound by disciplinary structures, faces limitations when confronted with research problems evoked by complex environmental research problems, such as those related to climate change (Nowotny 2007). Thus, the past few decades have witnessed increasing efforts to step away from the traditional system where science and policy were clearly separated domains, and where the goal of scientists was to 'speak truth to power' (Price 1965).

Along with trends in the policy arena to increase public participation in political processes (e.g. European Council 2006), there have been similar calls for public engagement in science (e.g. Rogers-Hayden and Pidgeon 2006). For instance, scholars have argued that research into complex environmental issues demand a transition from the traditional disciplinary academic system into a different system of knowledge production where research is increasingly carried out in the context of application, with involvement by a multitude of stakeholders (Funtowicz and Ravetz 1993; Gibbons et al 1994; Nowotny et al 2001). In the following we will provide a few examples of ongoing research into public understanding and public acceptance of climate change and climate-related technology. These examples will serve as a basis for a discussion about the changing role of the researcher and the public in climate-related social research.

Public understanding and social representations of climate change

Previous studies of public perceptions of climate change have mainly been of two types. First, there is a relatively long tradition of studies focusing on how lay people understand and relate to the issue of climate change (e.g. Kempton 1991, Seacrest et al. 2000, Ungar 2000, Etkin and Ho 2007). It has been shown that public interest and engagement in climate issues has increased markedly during the past year (Eurobarometer 2006a, 2007, Naturvårdsverket 2007). This type of studies provides an interesting, broad, picture of *what* people think, but with less focus on the arguments and value premises underlying their opinions. In addition, some of these studies start from a 'deficit model' of science communication, assuming that lay people need more knowledge in order to regain trust in scientific authorities and to change their life styles in favour of more climate-friendly behaviour (cf. Kahlor and Rosenthal 2009).

However, the deficit model has been criticized for assuming that merely providing more information is enough. It has been argued that if lay people perceive information as lacking context or utility, they will not assimilate it (*ibid.*). Another problem that has been discussed in relation to studies of people's opinions or attitudes is that such studies risk treating people's minds as "*little black boxes, contained within a vast black box, which simply receives information, words and thoughts which are conditioned from the outside in order to turn them into gestures, judgments, opinions and so forth*" (Moscovici 1984:15). Traditional attitude research has been criticized for presupposing the existence of stable attitudes among groups in society (Billig 1993). It has also been dominated by a focus on individuals' attitudes, thus ignoring the wider context of socially shared knowledge constructed within a 'thinking society' (Moscovici 1984). In traditional attitude research, which is often undertaken via structured questionnaires, the role of the researcher is usually perceived to be that of an objective recorder, 'tapping off' people's opinions.

The second type of studies focuses on the construction of lay knowledge and can be seen as a reaction to individual-oriented traditional attitude research. Such studies start from the assumption that ideologies, opinions, attitudes, emotions and value premises form part of a complex argumentative web made manifest (and at the same time established, changed and reinforced) and used as a resource by the interacting participants in a discursive process. This type of studies is often conducted within the frameworks of discourse analysis or the theory of social representations. A few examples could be mentioned here. At Universidade do Minho, Portugal, the ongoing project 'The Politics of Climate Change: Discourses and Representations' studies the relation between the discourses of various social actors on climate change, their representation in the media and citizens' perception of the issue.[4] In the project 'Social Representations of Climate Change in the Media and among Citizens', undertaken at Örebro University, social representations of climate change are being studied primarily in the media, but also among lay people.[5] At CSPR, the recently initiated project 'Making sense of climate change: A study of the formation and maintenance of social representations' analyzes how lay people form and maintain social representations about climate change, and how they use different communicative strategies to make sense of the conflicting messages.[6]

These projects take their point of departure in the theory of social representations, which is a theory offering tools for illuminating how individuals jointly construct (partially) shared representations about the surrounding world (Moscovici 1984). As a contrast to attitude studies employing questionnaires and other types of quantitative interviews, the studies mentioned above are based on qualitative methods such as focus groups, in-depth interviews and discourse analysis of media texts and political documents. The theory of social representations is regarded as particularly suitable when studying what happens when expert knowledge and 'common sense' meet (Bauer and Gaskell, 1999). It also provides a framework for studying implicit assumptions underlying the argumentation in different contexts (Wibeck et al. 2007). There is an emerging international literature which understands the formation of social representations from a dialogical perspective, and which elaborates on the use of focus groups as 'thinking societies in miniature' well suited to study joint meaning-making in action (e.g. Marková et al. 2007).

In contrast to research inspired by the deficit model of science communication, projects based on the theory of social representations emphasize the power and dynamics of lay thinking and arguing, and the ability of the 'ordinary person' to handle complexities and produce subtle lines of argument (e.g. Billig 1993, Wibeck et al. 2007). Nevertheless, researching public understanding of climate change from the perspective of social

---

[4] See http://www.necs.ics.uminho.pt/disclimate/indexi.htm

[5] See http://www.oru.se/templates/oruExtNormal____45595.aspx

[6] See http://www.cspr.se/projects

representations theory confronts the researcher with new dilemmas. The study of joint meaning-making in action means that the interviewees construct new knowledge during the data collection process. Even the researcher is involved in this process. As a moderator or interviewer, the researcher is not an objective recorder of attitudes, but an active part in the co-construction of meaning taking place in the interview situation. Far from assuming that stable attitudes could be 'tapped off' from the study subjects to be reported in an objective way, the creation of 'thinking societies in miniature' gives room for interaction between interviewees which may result in learning processes potentially (at least partly) changing their opinions. Thus, the crucial question in analysing data changes from 'what are the interviewees' opinions?' to 'what do they learn?' (Wibeck et al 2007), or 'how are social representations of climate change formed, maintained and modified throughout the study'?

It is worth noting that research on public understanding of climate change does not necessarily imply that the public is actively engaged in the scientific process. However, studies of public understanding of climate change are often akin to action research. Underlying much research within the framework of science for sustainable development is a normative standpoint that lifestyle changes are necessary to accomplish sustainability. This means that research on public understanding of climate change could have a double aim; to collect and analyse data on socially shared knowledge, and to constitute a tool to bring about social change. There are, however, few examples of studies problematizing this double aim or evaluating learning processes initiated among lay people participating in interviews and focus groups. The normative agenda could take two forms in social research: first, the study subjects participating in e.g. a focus group could be encouraged to explore new ways of acting climate-friendly in their everyday life; second, the results of the study could be used as a basis for forming new policies, information campaigns etc.

We argue that any researcher studying public understanding of climate change need to reflect upon how he or she influences the study subjects, as well as upon the relation between social research and climate policy. To elaborate this further, we will discuss a type of studies where the idea of lay knowledge deficit may be traced, as well as the co-constructive role of the researcher, i.e. studies of public acceptance of carbon dioxide capture and storage (CCS).

The case of Carbon dioxide capture and storage and public acceptance

CCS has recently been proposed as one of the major technologies for climate change mitigation.[7] It may, according to the Intergovernmental Panel on Climate Change (IPCC), mitigate 15-55% of the required global greenhouse gases until 2100 (IPCC 2005). Furthermore the technology is deemed as indispensible by the European Commission and several major fossil fuel corporations (EC 2008). The technology is still not commercially available, and will probably not be until 2020-2030 (IPCC 2005, Hamilton et al. 2008, EC 2008). It is also complex, costly and interrelated to the management of hazardous waste (CO_2 in huge quantities). Because of these problems, among others, CCS is contested by a number of environmental organisations (ENGOs) and countries due to environmental and ethical concerns. In addition, several industries question the economic effectiveness of the technology, since it implies high costs at the same time as there is a lack of economic incentives for CCS deployment today (de Coninck 2008, Rochon 2008, Stigson, Bryngelsson and Hansson, forthcoming).

Beyond the potential barriers mentioned above, one of the major potential barriers to CCS' development, maybe even the most significant according to Reiner (2008) and IPCC (2005), is the lack of public acceptance. The history of energy politics provides numerous examples of intense public controversies halting large-scale implementation of energy technologies (Anshelm 2000). In public surveys, CCS often comes out as one of the least wanted mitigation options. To gain public acceptance for the technology, the CCS community has the ambition to enrol ENGOs and social scientists in research on public perceptions of CCS as well as on how to influence public opinion, present information or initiate education campaigns concerning climate change and technological solutions (Curry et al. 2004, Andersen et al. 2007, Reiner 2008).

A large number of public acceptance studies on CCS have been carried out in specific countries and regions. In an ongoing project, involving CSPR and IVL[8], a critical literature review on all available CCS acceptance studies has been conducted. The public's lack of knowledge or awareness of CCS has been found repeatedly as well as the relative minor

[7] A brief definition from IPCC of CCS is as follows: "Carbon dioxide (CO2) capture and storage is a process consisting of the separation of CO2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere" CCS may only be applied to large point sources and mainly for coal fired power production. (IPCC, 2005)

[8] Swedish Environmental Research Institute Ltd

support for CCS. Only 4-22% of the laymen in the acceptance studies have heard of CCS. However, many of them do not have more knowledge on CCS than those who have never heard of it (IPCC 2005, Best-Waldhober et al. 2008, Itaoka 2008 et al., Reiner 2008). The issues that raise most concern among lay persons are related to risks, geological storage (NIMBY and NIABY), costs and whether the development of renewables will be delayed if a large scale CCS deployment takes place. So how should a social scientist navigate in a situation like this; a new untested grand technology, a fossil fuel industry with vested interests and technicians and natural scientists trying to spread their word of the necessity of CCS?

Like in several studies of public perceptions of climate change in general, some of the acceptance studies on CCS rest upon the deficit model for science communication. The perspective is prevalent in acceptance studies conduced by for example Itaoka et al. (2006), Daamen, et al. (2006) and Best-Waldhober, et al. (2008). In those studies the most influential factors explaining the public acceptance of CO_2 storage were investigated, e.g. how to decrease risk perceptions on CCS, emissions, awareness of climate change, willingness to pay, the importance of trust in various messengers and demographic factors. In Reiner et al. (2006) the public's knowledge on different mitigation technologies where tested; hence several 'misperceptions' where detected. The importance of correcting these 'misperceptions' is emphasised and is suggested to be done by outreach campaigns, community engagement and educational strategies.

Among the most important factors in many studies, besides risk perceptions, is willingness to pay and consequently the extra costs a mitigation technology adds to the householder's electricity bill. In Curry et al. (2004) information declaring it is about twice as expensive with renewable electricity as coal and CCS is presented for the informants in their study. Thus, the researcher is an active part in the co-construction of knowledge. However, presenting information on CCS' costs is highly problematic, especially as the alternatives are downplayed and as long as CCS does not exist commercially. Furthermore, the recent price fluctuations on cement, steel and coal had large impacts on the implementation of CCS, witnessing of the difficulties to estimate future costs (Hamilton, et al. 2008, Hansson and Bryngelsson 2009). Thus, the merits of CCS are not proven yet, and we claim that they should be a matter of societal debate, rather than a starting point for information in outreach activities and acceptance studies. Furthermore, several scientific uncertainties remain unresolved.

Climate change issues may be framed as post-normal science since the facts are uncertain, values are disputed, the stakes are high and the decisions are urgent (Funtowizc and Ravetz 1993). There are few clear cut scientific issues in the climate domain, and what is considered as the scientific truth at one moment is not at another. This may also be exemplified by the case of CCS. The Norwegian Utsira formation which probably is the 'safest', most famous, and most monitored CO_2 storage area in the world had an unexpected leakage in 2008. Hence, the potential of the formation was re-labelled from being *"able to store all European emissions for hundreds of years"* to "*it remains uncertain whether Utsira is suitable for large-scale storage Europe's carbon emissions*" (Oljedirektoratet 2009). Even though CCS abates carbon dioxide emissions and has potential co-benefits (e.g. lower emissions of hydrogen fluoride and hydrogen chloride), these trade-offs allow for increases in human toxicity, ozone layer depletion and increasing fresh water consumption. These are trade-offs that, according to Koornneef et al. (2008), cannot be defined by scientists themselves but they need a broad public debate. On top of that, several scientific knowledge gaps remain regarding e.g. the permanence of CO_2, global and technological storage capacity, power plant availability and cost reductions; topics that have been brought up at research conducted at CSPR (Bryngelsson and Hansson 2009, Hansson and Bryngelsson 2009).

A number of studies exist where the purpose merely is to investigate people's attitudes towards CCS, which risks that are perceived as most significant or how people change attitudes when they receive various kind of information. Even though the purpose of such studies seems objective and neutral, implicit normativity may be found. After reviewing seven acceptance studies, Malone et al. (2008) came up with a conclusion regarding CCS and acceptance studies: "Finally, one result of quantitative surveys has been to create or reinforce the implicit idea that the goal of public involvement is to gain complete, or almost complete, agreement about the need to implement CCS, including confidence that safety and legal issues will be resolved. The discussion sections try to probe, in an advertising-like way, what characteristics of respondents could be used to 'sell' the idea of CCS." This perspective may be justified by a view that the urgency for implementing technologies to manage climate change legitimize scientists to not only take a stand, but also to manipulate people's opinions. However, we argue for more reflections on the role of the researcher since the requirement for sound scientific facts as the basis for rational policy making and outreach campaigns in the case of CCS is hard to fulfil. In these cases, invoking the truth as the goal of science may be distractive and manipulative, or even counterproductive. This will be further discussed in the final section below.

Discussion

We are convinced that there is much to be gained from engaging a multitude of stakeholders, including the general public, in deliberations about the use and consequences of scientific research and technological innovations, especially if this is done at an early stage in the scientific process. An 'upstream', or early, public engagement could, according to its proponents, forge a democratic approach to the governance of science (Rogers-Hayden and Pidgeon 2007). Upstream dialogue could also enhance trust in the policy-making process and generate better quality outcomes. The importance of early upstream engagement may be exemplified by another CCS case. In 2007 a new CCS bill (AB705) governing the geologic sequestration of greenhouse gases was withdrawn in California. The bill covered underground site characterization, approval, well permitting, monitoring, remediation and construction specifications, and was endorsed by the mayor of Los Angeles as well as the relevant major NGOs. In spite of its broad support among major NGOs and politicians the concrete storage project was halted due to local social protests and local NGOs even though their arguments were not considered as scientifically legitimate by the CCS operators. The opposition to the CCS bill illustrates potential conflicts which could arise in meetings between the global and the local arena, and between expert and lay knowledge (Brown 2007).

However, Juntti et al. (2009) also gives examples of when the involvement of laymen in scientific controversies causes new problems. In a case study of North Sea fisheries governance the lay perspective got a disproportionate prominence and influence in the negotiations. The lay men successfully refuted the scientific knowledge claiming the fishing stocks were diminishing and managed to move the negotiations towards more personally favourable conditions. Obviously there is a need for balancing different perspectives and also highlighting the normativity embedded in different claims and positions. We claim that the engagement is not a goal in itself. Otherwise, there is a risk that calls for upstream engagement in science end up as yet an expression of the deficit model of science communication, only with the exception that the focus is moved from a perceived deficit of public understanding of science to a deficit of public engagement with science (Rogers-Hayden and Pidgeon 2007).

The examples of social research on public understanding of climate change and CCS discussed in this chapter demonstrate how new research agendas highlight a number of questions concerning the roles of social science, policy and the public. We argue that it is important for the social scientist to be attentive to the often hidden agenda in science for sustainable development and climate policy research to combine normative and descriptive aims of research. If the aim is e.g. to both study public understanding and to contribute to the development of climate-friendly lifestyles, or to inform climate policy and technologies, it is crucial that the researcher acknowledges this and reflects on the consequences for the design of the study. The 'double aim' will affect e.g. recruitment of informants so as to include participants from underrepresented or local groups as well as participants from more privileged social groups. Methods for following up on and evaluating the processes started by participatory research or 'upstream' public engagement need to be developed and integrated into the research project.

However, the idea of conducting normative research on public understanding of climate change is not unproblematic. Scientific uncertainty regarding e.g. the risks and benefits of CCS technology, or what constitutes a 'climate-friendly lifestyle' still remains. Moreover, it has been argued that attempts to change individual behaviour and social consumption patterns represent a type of social engineering which starts from the assumption that it is possible to control and master climate as well as individual choices and behaviour (Hulme 2008). Perhaps a middle way could be to conduct research neither with a purely normative nor descriptive aim, but with a *critical* aim of analyzing as well as problematizing public understanding.

Acknowledgements

The authors wish to thank the colleagues at CSPR, the Department of Water and Environmental Studies, LiU, and , School of Life Sciences, Södertörn University, for valuable comments and input to the discussion in this chapter. Thanks are also extended to the Swedish Research Council and Mistra's Climate Policy Research Program for financial support.

References

Anderson, J., de Coninck, H., Curnow, P., Flach, T., Groenenberg, H., Norton, C., Reiner, D., Shackley, S., Upham, P., Eldevik, F., and Sigurthorsson, G., (2007), *The ACCSEPT project: Multidisciplinary analysis and gapfilling strategies.* Det Norske Veritas AS.

Anshelm, J., (2000), *Mellan frälsning och domedag: om kärnkraftens politiska idéhistoria i Sverige 1945-1999* [Between salvation and judsments day: on nuclear powers' political history of ideas in Sweden 1945-1999]. Brutus Östlings Bokförlag Symposion.

de Best-Waldhober, M., Daamen, D., and Faaij, A., (2008), 'Informed and uninformed public opinions on CO2 capture and storage technologies in the Netherlands', *International Journal of Greenhouse Gas Control*

Bauer, M. and Gaskell, G., (1999), 'Towards a paradigm for research on social representations', *Journal for the Theory of Social Behavior*, **29**, 163−186.

Billig, M., (1993), *Arguing and Thinking. A Rhetorical Approach to Social Psychology.* 2nd ed. Cambridge: Cambridge University Press.

Brown, V., J., (2007), 'Of Two Minds – Groups Square Off on Carbon Mitigation', *Environmental Health Perspectives,* **115**, 546-549

Bryngelsson, M. and Hansson, A., (2009), 'Energy policy on shaky ground? A study of CCS scenarios', *Energy Procedia*, **1**, 4673-4680.

de Coninck, H. (2008), 'Trojan horse or horn of plenty? Reflections on allowing CCS in the CDM', *Energy Policy* **36**, 929-936.

Curry, T., Reiner, D., M.,Ansolabehere, S., and Herzog, H., J., (2004), 'How aware is the public of carbon capture and storage?' Conference Paper, GHGT7.

Daamen, D., de Best-Waldhober, M., Damen, K., and Faaij, A., (2006), 'Psuedo-opinions on CCS technologies', Conference paper, GHGT-8.

EC (2008), European Commission's *DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL: on the geological storage of carbon dioxide.* COM(2008) 18 final 2008/0015 (COD).

Etkin, D. and Ho, E., (2007), 'Climate change: perceptions and discourses of risk', *Journal of risk research*, **10**, 623-641.

Eurobarometer 2006a (2007), *Attitudes on issues related to EU energy policy.*

European council (2006) *Renewed strategy on sustainable development.*

Funtowicz, S. and Ravetz, J., (1993), 'Science for the post-normal age', *Futures*, **25**, 739−55.

Funtowicz, S. and Ravetz, J., (1999), *Post-normal science: environmental policy under conditions of complexity.* URL: http://www.nusap.net/sections.php?op=printpageandartid=13.

Hamilton, M., R., Herzog, H., J. and Parsons, J., E., (2008), 'Cost and U.S. public policy for new coal power plants with carbon capture and sequestration', *Energy Procedia.* Article in Press.

Hansson, A. and Bryngelsson, M, (2009), 'Expert opinions on carbon dioxide capture and storage: A framing of uncertainties and possibilities', *Energy Policy,* **37**, 2273-2282.

Hulme, M., (2008), 'The conquering of climate: discourses of fear and dissolution', *The Geographical Journal*, **174**, 5-16.

IPCC (2005), *Carbon Dioxide Capture and Storage. IPCC Special Report on Carbon Dioxide Capture and Storage.* Prepared by the Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge (USA).

Itaoka, I., Saito, A., and Akai, M., (2006), 'A path analysis for public survey data on social acceptance of CO2 capture and storage technology'. Conference paper, GHGT-8.

Juntti, M., Russel, D., and Turnpenny, J., (2009), 'Evidence, politics and power in public policy for the environment', *Environmental Science and Policy.* Article in Press.

Kahlor, L. and Rosenthal, S. (2009), 'If we seek, do we learn? Predicting knowledge on global warming'. *Science Communication,* **30,** 380-414.

Kempton, W.. (1991), 'Lay perspectives on global climate change', *Global Environmental Change*, **1**, 183—208.

Koornneef, J., van Keulen, T., Faaij, A. and Turkenburg W., (2008), 'Life cycle assessment of a pulverized coal power plant with post-combustion capture, transport and storage of CO2', *International Journal of Greenhouse Gas Control* **2**, 448-467.

Malone, E., Bradbury, J., A., and Dooley, J., J., (2008), 'Keeping CCS stakeholder involvment in perspective', *Energy Procedia*. Article in Press.

Marková, I.., Grossen, M., Linell, P. and Salazar Orvig, A. (2007), '*Dialogue in Focus Groups: Exploring Socially Shared Knowledge'.* London: Equinox.

Moscovici, S., (1984), 'The phenomenon of social representations'. In: Farr, R. and Moscovici, S. (eds.) *Social Representations.* Cambridge: Cambrigde University Press.

Naturvårdsverket (2007), *Allmänheten och klimatförändringen 2007.* Report 5760.

Reiner, D., M., (2008), A looming rhetorical gap: a survey of public communications activities for carbon dioxide capture and storage technologies. Judge Business School, University of Cambridge. (Available at www.electricitypolicy.org.uk/pubs/wp/eprg0801.pdf, accessed 16 Mars 2009)

Rochon, E., (2008), *Why carbon capture and storage won't save the climate*. Greenpeace International, The Netherlands.

Nowotny, H., (2007), The potential of transdisciplinarity. URL: http://www.interdisciplines.org/interdisciplinarity/papers/5.

Price, D., (1965), *The scientific estate.* Cambridge, Mass., Harvard University Press.

Rogers-Hayden, T. and Pidgeon, N., (2007), 'Moving engagement "upstream"? Nanotechnologies and the Royal Society and Royal Academy of Engineering's inquiry' *Public Understanding of Science*, **16**, 345-364.

Seacrest, S., Kuzelka, R. and Leonard, R., (2000), 'Global climate change and public perception: the challenge of translation'. *Journal of the American Water Resources Association,* **36**, 253-263.

Stigson, P., Bryngelsson, M., and Hansson, A., 'CCS deployment obstacles: A critical study of deployment obstacles perceptions', (Forthcoming).

Wibeck, V., Öberg, G. and Abrandt-Dahlgren, M., (2007), 'Learning in focus groups: an analytical dimension for enhancing focus group research'. *Qualitative research,* **7**, 249-262.

5. Participatory research in theory and practice: why, how and when?

Anna Jonsson, Eva Lövbrand and Lotta Andersson

Introduction

The relationship between science and society has been widely debated in recent years. In an age of food scares such as the mad cow crisis in the UK or global environmental risks such as climate change, scholars and practitioners alike have suggested that scientific experts need to test the validity of their knowledge claims outside the laboratory. Rather than approaching the world of science as separate from society, there is today an extensive literature that seeks to hold science accountable to its public constituencies. Post-normal science (Funtowicz and Ravetz 1993), citizen science (Irwin 1994), Mode 2 science (Gibbons et al. 1994) and co-production (Jasanoff 2004, Lemos and Morehouse 2005) are just some of the many concepts currently employed to rethink the role of science in society. Central to all these concepts is the idea that science cannot function in isolation. Instead of building the scientific claim to authority on its presumed autonomy from societal context, a growing scholarship today seeks to make science more "socially robust" (Nowotny et al. 2002) through direct engagement with societal context.

In this chapter we discuss these scholarly efforts to establish a new social contract for science from the vantage point of two participatory research projects designed and implemented by researchers at the CSPR. The first project called DEMO *(*Participatory Catchment Modelling of Nutrient Transport for Sustainable Water Management) was carried out in collaboration with the Swedish Meteorological and Hydrological Institute (SMHI) and the Lund University Centre for Sustainability Studies (LUCSUS) during the years 2005-2007. In this project the research team tested a participatory methodology in the drainage area of the Kaggebo Bay in the Baltic Sea in South-eastern Sweden. The project aimed to assess how mathematical models can be used in stakeholder dialogues with emphasis on reduction of nitrogen and phosphorus loads in local lakes and the coastal zone. The second project called PAMO (Participatory Modelling for Assessment of Climate Change Impacts on Water Resources) is still ongoing in the Thukela River Basin in South Africa. The project, developed in cooperation between SMHI and the University of KwaZulu Natal, aims to assess how various stakeholders perceive climate induced risks on water allocation, farming and the environment, and with what means adaptation to such risks can be met.

The chapter draws upon these practical efforts to engage stakeholders in the research process to critically assess contemporary calls for more "socially robust science". We use the term "participatory research" to denote the range of methods and techniques used by scientists to invite lay and stakeholder groups to articulate their knowledge, preferences and values in relation to the issues at stake (e.g. focus groups, stakeholder dialogues, model facilitated dialogues and tool development workshops). Hence, rather than referring to an academic analysis of participatory processes in society, participatory research is here approached as an example of Mode 2 science co-produced in "the context of application" (Gibbons et al. 1994). The role of the stakeholder participants in the process is not to be observed, but to actively contribute to the conclusions. Following the experiences of DEMO and PAMO, we pay particular attention to participatory research organised around mathematical models. In both projects such models have been used as a platform for communication among different stakeholder groups and scientists. Model facilitated dialogues, as defined in this chapter, thus implies modelling *with* people, in contrast to agent based modelling which is based on modelling *of* peoples' behaviour and its consequences (Pahl-Wostl 2002).

We organise our chapter around three central questions. Firstly, we ask *why* stakeholder groups should be involved in matters of science. Drawing upon the rich literature in this field, we identify a substantive and a normative rationale for participatory research. In the second section we make use of examples from the DEMO and PAMO projects to discuss *how* these theoretical imperatives can be translated into practice. We note that efforts to *do* participatory research are fraught by many practical constraints and contingencies. While the two projects have been informed by both substantive and normative aims, they raise the question to what extent it is possible to realise the high theoretical expectations tied to participatory research. Hence, we end by asking *when* participatory research makes sense. Although the ambition to open up science to public scrutiny and debate remains an attractive ideal, we note that meaningful stakeholder involvement in matters of science is a challenging and time consuming task (for researchers as well as for the invited stakeholders) that requires further scholarly scrutiny and debate.

Why do participatory research?

Despite the recent celebration of public and stakeholder involvement in the production and use of scientific knowledge, a quick review of the literature in this field suggests that the debate is marred by murkiness (Kleinmann 2000). The lack of clarity is partly related to the range of different rationales for doing participatory research. In an attempt to map the debate, Stirling (2008) has made a useful distinction between substantive and normative imperatives. The substantive rationale for participatory research is primarily focused on outcomes. From this perspective, the involvement of representatives from various sectors of the society in the research process is approached as a means to broaden and enrich the knowledge base in a given issue area. Particularly in cases of high uncertainty or risk (e.g. anthropogenic climate change, biotechnology), the diverse "knowledge-abilities" of lay and stakeholder groups have been highlighted as a resource that will enhance the scope and quality of scientific risk assessment (cf. Funtowicz and Ravetz 1993, Felt and Wynne 2007). By creating conditions for meaningful deliberation on the unknown, unspecified and indeterminate aspects of scientific and technological development, participatory exercises are in this case thought to bring reflexivity to modern risk governance and thus increase society's ability to deal with unforeseeable contexts (Nowotny et al. 2002, p. 167).

While analytically distinct, this substantive argument for public or stakeholder involvement in the production and use of science is often closely tied to the normative imperative. The normative imperative can be interpreted as critique of the use of science in society. Rather than working for the benefit of society as a whole, scholars of science and society have argued that science too often serves an ideological function of legitimising the interests and decisions of societal elites (Fischer 2005, Wynne 2007). From this vantage point participatory research is promoted in the name of democracy and the empowerment of people as citizens (Irwin 1994, Leach et al. 2007). If members of the public are invited to question how experts frame an issue and thus "open up" unexplained assumptions and tactic value choices, they may, it is argued, challenge science-based claims made by social elites and hence build more legitimate forms of political authority (Stirling 2008, Fischer 2005). Beyond this broader ambition to enhance the democratic quality of public decision processes, the normative imperative also holds the promise of increased public acceptance of scientific knowledge. If social actors directly affected by research results are invited to validate the assumptions made in the various steps of a research process, it is assumed that they will gain trust in the findings (Andersson et al. 2008).

The DEMO and PAMO projects draw upon both these imperatives. While placed in different geographical and social contexts, the two projects have been designed to include stakeholder groups in the setup and use of natural science modelling tools. On the substantive side, such "co-production of knowledge" is expected to be beneficial to model development and application. By integrating stakeholders' perspectives in the research process, the projects have sought to enrich the understanding of environmental risks (eutrophication in the DEMO case, climate impacts on water resources in the PAMO case), and the range of societal obstacles that challenge the management of such risks. On the normative side, the involvement of affected social groups has aimed at increasing stakeholder confidence and ownership of the results and conclusions from the projects, including the formulation and dissemination of local adaptation and/or mitigation plans. In the following section we discuss how the DEMO and PAMO projects have translated these substantive and normative ambitions into practice.

How to do participatory research?

The substantive and normative promise of participatory research rests upon a number of procedural requirements. Below we highlight three procedural aspects of relevance to the participatory quality and substantive output of the DEMO and PAMO projects; 1) the selection of participants, 2) the framing of the issues at stake, and 3) the design and implementation of the process (Jonsson and Alkan-Olsson 2005, Andersson et al. 2006).

Participant selection

The selection of participants is of central importance to any participatory research process. Depending on the aim and scope of the exercise, the participants can either be members of a specific civic constituency, representatives of organised interests (i.e. stakeholders), or experts with academic or non-academic training. Following their substantive rationale, the DEMO and PAMO projects have targeted affected stakeholder groups that are expected to add important knowledge to the research process. The DEMO project came about upon the initiative of local stakeholders within the agricultural sector, more specifically, a local branch of the Federation of Swedish Farmers, LRF, and particularly one enthusiast, in the Kaggebo region. This circumstance facilitated the stakeholder selection process and allowed the participatory modelling process to gain legitimacy by linking into local networks at an early stage. However, whereas the farmers involved in the process were part of a well-developed national farmers' network and therefore emerged as a strong stakeholder group, house owners with private sewages were less organized and therefore required more efforts to reach, motivate and engage.

In contrast to the DEMO experience, the PAMO project was not initiated by local stakeholders but by foreign researchers seeking to test a predefined research agenda in a new country context. The Swedish research team identified, in collaboration with their South African colleagues, three central stakeholder groups for which separate workshops were arranged, (i) government authorities; research institutes; and companies; (ii) commercial farmers; and (iii) small-scale farmers. In a heterogeneous society such as South Africa, with large asymmetries in income, educational level, landownership and race, there are fundamental differences in how environmental risks and water allocation problems affect rich and poor. Although the main opportunity for a better future lies in cooperation between these various social groups, the asymmetries in wealth and voice made it difficult for the PAMO project to initiate a discussion about climate change in meetings with all groups participating.

However, also in the PAMO project the research team managed to involve a local enthusiast who helped to overcome the historical mistrust among the involved stakeholders. Working as a well-know and respected agricultural extension officer, this key actor facilitated the participation of small-scale farmers. He also functioned as a bridge between the local farming community, the commercial farmers and the representatives from local authorities. Consequently, both DEMO and PAMO demonstrate the trust and confidence building role that local enthusiasts or "fire souls" (Blomqvist, 2004) can play in participatory research.

Issue framing

The DEMO and PAMO experiences also suggest that the framing of the issues at stake is of great importance. When setting up computer-based models of environmental conditions, substantial amounts of information about landscape characteristics, human activities and observed variability of climatological and hydrological/oceanographic variables are needed. Earlier experiences (Alkan-Olsson and Berg 2005, Brandt et al. 2007) have shown that models used for the national scale (e.g., for national reporting) can use standardised input data such as soil type, vegetation, topography and climatic regions. However, when applying models to local conditions (where mitigation/adaptation measures are carried out), the quality of such standardised data increases significantly when verified locally. Hence, in the DEMO project, stakeholders were invited to perform such verification in the model setup. At this early stage of the research process, farmers provided data from soil sampling at the farm level and identified "typical management practices" at various types of farms. The stakeholders also participated in the monitoring of water levels and sampling of water for nutrient analyses, verified official databases and included "soft data" (e.g. observations of overland flow or of flow in macropores).

The substantive value of this stakeholder input was demonstrated at an early stage of the project when the participants noted that the hydrological boundaries, as shown on official maps, had been altered with the consequence that a substantial amount of riverine water did not reach the coastal zone in focus for the project. Had the incorporation of this knowledge not been considered in the model setup, the results may have been seriously questioned and the overall confidence in presented results low. Thus, in the DEMO case, stakeholder participation led to a better model description of reality due to inclusion of local information, as well as improved possibilities for model calibration and validation.

In the PAMO project, however, there was no stakeholder involvement in the actual setup of the climatological and hydrological models. Instead of inviting the stakeholders to provide descriptions of current hydrological conditions and possible impacts on these by local actions, the aim of the model exercise was to provide information about projections of relative *change* of climate-related conditions deemed important by the stakeholders. To that end the PAMO researchers asked the stakeholder participants to select what projections to provide and to respond to the three climate impact scenarios provided. The issue of climate change scenarios was explained by the researchers at an early stage of the project and it was made clear to all participants that the scenarios represented thinkable pathways to future development, not predictions. On the basis of this discussion, the participants were invited to assess the robustness of the three provided climate change scenarios, produced with different combinations of Global Circulation Models and emission scenarios.

Although guided by a substantive rationale, the researches did not have time enough to include the rainfall and temperature data collected by the farmers in the area in the setup of the hydrological model for the area. This demonstrates that sometimes compromises have to be done, where the degree of participation has to be limited in order not to slow down the process too much. Since climate change scenarios containe a great deal of uncertainty and since many participants need to focus on today's problems rather than on planning for the future, the researchers let the participants address their *present* vulnerability to impacts of climate variability. This exercise helped the researchers to better adjust their climate scenarios to local needs. In addition, exercises were included to assess the participants' overall fears and visions for the future. Consequently, the framing of the project over time shifted from a strict focus on climate change, to issues of more relevance to the participating stakeholders.

Project design and implementation

The design of a participatory process represents the third procedural aspect of importance for participatory research. Davies and Burgess (2004, p. 352) observe that participatory exercises rests upon messy and socially embedded encounters in which a complex series of judgements are negotiated around the knowledge and identities of all involved actors. To structure such processes in accordance with procedural ideals is a methodological challenge that draws attention to participatory researchers themselves. Practical choices made by this emerging epistemic community (Chilvers 2008) shape the dynamics of the exercise in a manner that affects its normative and substantive potential.

The DEMO and PAMO experiences suggest that practicalities such as meeting venue, time during of the day and year, food and drink for the participants affect the willingness of the targeted stakeholder groups to participate in the exercise. To organise meetings in locations familiar to the participants is also of importance, not the least because it gives the project scientists the role of guests rather than hosts of the meetings. This change of roles affects the power dynamics of the exercise and facilitates local trust building. In the DEMO and PAMO cases, the scientists started off the process with lectures containing facts on the issues at stake. These lectures ensured that all participants received a shard understanding of eutrophication (in the DEMO case) and climate change impacts on water resources (in the PAMO case). Gradually, however, a different division of roles between researchers and local stakeholders developed. Lively discussions took place and several types of knowledge surfaced, i.e. both expert and local. This more open-ended type of deliberation allowed the participants to develop "interactional expertise" (Carolan 2006) that enhanced the co-production process substantially.

Although the DEMO and the PAMO experiences differ, they both suggest a transformed role for the research team. Rather than acting as a distant provider of information, the DEMO and the PAMO researchers turned into equal participants in the process of compiling a picture of environmental conditions today and possible scenarios for the future. As argued by Schulze (2001) the use of models as a policy-making tool makes it necessary for scientists to shift from a "research thinking" to a more outcome based "policy thinking" to fit the needs and demands of stakeholder groups involved in a research process where policy is in focus. However, far from all participatory research projects result in this transformation. The DEMO and the PAMO projects suggest that the number of meetings organised is one central factor that affect the trust and confidence building potential of the exercise.

In the DEMO case the stakeholders were invited to participate in the research process in three phases. After having given significant input to the model setup, the stakeholders were also asked to present their local "water visions", i.e. desirable services from lakes and the coastal zone translated into desirable levels of nutrient concentrations optimal for these services. These locally formulated goals, in combination with the EU Water Framework Directive (WFD) and the Swedish national environmental quality objectives, then fenced the discussion on how much reductions of nutrient levels that were needed (Andersson et al. 2008; Jonsson et al., in prep.). The invited stakeholders also contributed to the identification of obstacles for the implementation of suggested mitigation measures. During the DEMO meetings, the involved groups got to know each other well which contributed to a high degree of perceived ownership of the process and the final project report. Since PAMO is not yet finalized, it is too early to draw any final conclusions about the quality of the participatory process. However, the lower number of meetings is likely to be one of several factors that will lead to a less pronounced perception of ownership from the involved stakeholder groups. Considering the complex socio-economic setting of the project area and the researchers' foreign passports, it can be questioned, however, if it at all is possible to obtain the same degree of stakeholder engagement in the PAMO project.

When does participatory research make sense?

In this brief paper we have discussed findings from two participatory modelling projects carried out in Sweden and South Africa. Both research projects have taken place in parallel to local policy making, although the institutional framework for actually ensuring that the research-driven process has a real impact on local policy is rather vague. Driven by both substantive and normative ambitions, the projects have sought to create a consensus among local stakeholders around the nutrient pollution problem and possible ways forward in the Kaggebo Bay and its drainage area, as well as around the climate change and water resources issue and possible ways to adapt in the upper Thukela basin in South Africa. The extents to which these ambitions have been met vary in the two projects. In the DEMO case the input from local stakeholders was substantial, resulting in a high degree of confidence and trust in the project results. Most stakeholders concluded that it was the process in itself, including dialogues with external experts, people in their own sector, as well as other local groups with other perspectives, that influenced their understandings and possible future action. The scientific models as such were only useful to the extent that they were included in these dialogues.

The socio-economic complexity of the PAMO project has resulted in a different project dynamics. While it is too early to determine the final results from this South-African experience, it remains clear that successful participatory research requires substantial investments in time and trust. The issue at stake must be seen as meaningful by all those involved, and a fair balance needs to be found between science and stakeholder influence. As demonstrated by the DEMO and PAMO experiences, projects initiated locally by the involved stakeholders seem to have better potential to realise their substantive and normative promise than projects with a scientific bias. Moreover, projects with a high degree of stakeholder input and many project meetings are likely to gain more trust among the involved participants, than projects organised around a pre-determined scientific agenda. However, meaningful involvement is seldom straightforward. No matter how much resources that are spent on process design, a risk always remains that powerful groups, whether experts or dominant stakeholders, “highjack” the process. Rather than opening up the issues at stake to scrutiny and debate, such participatory exercises may instead legitimise the interests and agendas of the few at the expense of the many (Stirling 2008, p. 278). To reduce this risk requires a great deal of awareness and motivation within the research team.

Beyond these procedural challenges, meaningful involvement is also closely tied to the substantive outcome of the exercise. As noted by Abelson et al. (2005), the willingness of non-scientific actors to invest time and resources into participatory exercises often hinges on their ability to make a difference and have real policy impact. While both DEMO and PAMO have tapped into pressing environmental policy issues, the direct influence of the research process over political decision making will always be limited. In order to secure a continued social interest in participatory research, we conclude that involved scientists have to reflect upon their role and specify where the research process ends and policymaking begins. They also have to strike a balance between the willingness among various stakeholder groups to engage in participation, and the value such engagement adds to the research process. Since participatory research is a challenging task that requires a great deal of commitment by all involved actors, it does not fit for every purpose. Hence, before embarking on time consuming participatory exercises, we conclude that scholars need to take careful note of the circumstances when and how they add value to the research process.

References

Alkan-Olsson, J. and Berg, K. (2005), 'Local stakeholders' acceptance of model-generated data used as a communication tool in water management – The Rönneå study', *AMBIO*, **7**, 507-512.

Andersson, L., Jonsson, A., Alkan Olsson, J., and Arheimer, B. (2006), 'Participatory Modelling as a Tool for Public Participation in Water Resource Management, in J.C. Refsgaard and A.L. Höjberg (eds), *Proceedings of the XXIV Nordic Hydrological Conference 2006*, NHP Report No. 49, 226-233.

Andersson, L., Wilk, J., Warburton, M. and Graham, P. (forthcoming), 'Use of participatory modelling to assess risks and adaptation strategies to cope with climate change impacts on water resource in the Thukela river basin, South Africa', manuscript for submission to Climate Change during 2009.

Andersson, L., Alkan Olsson, J, Arheimer, B, and Jonsson, A. (2008), 'Use of participatory scenario modelling as a platform in stakeholder dialogues', *Water SA* **34**(3), HELP Special Edition.

Blomqvist, A. (2004), 'How can stakeholder participation improve European watershed management? The water framework directive, watercourse groups and Swedish contributions to Baltic sea eutrophication', *Water Policy* **6**, 39-52.

Brandt, M., Arheimer, B., and Andersson, L. (2007), 'Catchment modeling for quantification of Swedish nutrient transport to the sea and effects of measures', in Schumann, A. and Pahlow, M. (eds), *Reducing the Vulnerability of Societies to Water Related Risks at the Basin Scale*. IAHS Publication 317, 84-89.

Carolan, M. S. (2006), 'Sustainable agriculture, science and the co-production of "expert knowledge": the value of interactional expertise', *Local Environment*, **11**, 421-431.

Fischer, F. (2005), *Citizens, Experts, and the Environment*. Durham and London, Duke University Press.

Funtowicz, S.O. and Ravetz, J.R. (1993), 'Science for the post-normal age', *Futures* **25**(10), 739-755.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. (1995), *The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies*, London, Thousand Oaks and New Delhi, Sage Publications.

Irwin, A. (1995), *Citizen Science: A Study of People, Expertise and Sustainable Development*. London and New York, Routledge.

Jasanoff, S. (2004), *States of Knowledge. The Co-Production of Science and Social Order.* London and New York, Routledge.

Johansson, M., (2008). *Barriärer och Broar. Kommunikativa Villkor I det Svenska Miljömålsarbetet.* Linköping studies in arts and science, No. 469, Linköpings universitet, Sweden.

Jonsson, A., Andersson, L., Alkan Olsson, J. and Arheimer, B. (2007), 'How participatory can participatory modeling be? A discussion of the degree of influence and stakeholder and expert perspectives in six dimensions of participatory modeling', *Water Science and Technology* **56**, 207-214.

Kleinmann, D. L. (2001), 'Democratizations of Science and Technology', in D Kleinmann (ed), *Science, Technology and Democracy,* Albany, State University of New York Press.

Leach, M., I. Scoones, and B. Wynne (2007), *Science and Citizens: Globalization and the Challenge of Engagement*. London and New York, Zed Books.

Lemos, M.C. and Morehouse, B.J. 2005. 'The co-production of science and policy in integrated assessments', *Global Environmental Change* **15**: 57-68.

Nowotny, H., Scott, P. and Gibbons, M. (2002). *Re-thinking Science. Knowledge and the Public in an Age of Uncertainty,* Polity Press, Cambridge.

Pahl-Wostl, C. (2002), 'Towards sustainability in the water sector – The importance of human actors and processes of social learning', *Aquatic Sciences* **64**, 394-441.

Schulze, R.E. (2001), 'Managing Water as a Resource in Africa: Are we Asking the Right Questions?', in Gash, J.H.C., Odada, E.O., Oyebande, L. and Schulze, R.E. (eds), *Freshwater Resources in Africa*, Potsdam; BAHC International Project Office.

Stirling, A. (2008), ''Opening up' and 'closing down': Power, participation, and pluralism in the social appraisal of technology', *Science, Technology and Human Values* **33**(2), 262-294.