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How Do Scientific Assessments Learn? A Comparative Study of the IPCC and LRTAP

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The Global Environmental Assessment Project is a collaborative team study of global environmental assessment as a link between science and policy. The Team is based at Harvard University. The project has two principal objectives. The first is to develop a more realistic and synoptic model of the actual relationships among science, assessment, and management in social responses to global change, and to use that model to understand, critique, and improve current practice of assessment as a bridge between science and policy making. The second is to elucidate a strategy of adaptive assessment and policy for global environmental problems, along with the methods and institutions to implement such a strategy in the real world.

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Publication abstracts of the GEA Project can be found on the GEA web site at http://environment.harvard.edu/gea. Further information on the Global Environmental Assessment Project can be obtained from the Project Associate Director, Nancy Dickson, Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, 79 John F.

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FOREWORD

This paper was written as part of the Global Environmental Assessment Project, a collaborative, interdisciplinary effort to explore how assessment activities can better link scientific understanding with effective action on issues arising in the context of global environmental change. The Project seeks to understand the special problems, challenges and opportunities that arise in efforts to develop common scientific assessments that are relevant and credible across multiple national circumstances and political cultures. It takes a long-term perspective focused on the interactions of science, assessment and management over periods of a decade or more, rather than concentrating on specific studies or negotiating sessions. Global environmental change is viewed broadly to include not only climate and other atmospheric issues, but also transboundary movements of organisms and chemical toxins. (To learn more about the GEA Project visit the web site at http://environment.harvard.edu/gea/.)

The Project seeks to achieve progress towards three goals: deepening the critical understanding of the relationships among research, assessment and management in the global environmental arena; enhancing the communication among scholars and practitioners of global environmental assessments; and illuminating the contemporary choices facing the designers of global environmental assessments. It pursues these goals through a three-pronged strategy of competitively awarded fellowships that bring advanced doctoral and post-doctoral students to Harvard; an interdisciplinary training and research program involving faculty and fellows; and annual meetings bringing together scholars and practitioners of assessment.

The core of the Project is its Research Fellows. Fellows spend the year working with one another and project faculty as a Research Group exploring histories, processes and effects of global environmental assessment. These papers look across a range of particular assessments to examine variation and changes in what has been assessed, explore assessment as a part of a broader pattern of communication, and focus on the dynamics of assessment. The contributions these papers provide has been fundamental to the development of the GEA venture. I look forward to seeing revised versions published in appropriate journals and books.

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ABSTRACT

When carried out over a longer period of time with several recurrent processes, assessments provide an outstanding opportunity for learning from past experience and from other assessment experiences. Through learning, assessments could improve their procedures and enhance their effectiveness in regard to issue development in the thematic areas they are targeting at. If assessments were perceived as continuous learning processes, they could be organized as processes of perpetual improvement and reflective change of the assessment as an institution itself and, consequently, they might become more powerful institutions in the process of solving environmental problems.

The paper will address the following questions: How did the assessments at hand learn over the years and in the different phases of the assessment process? Which mechanisms had been in place to reflect on past experiences? How could the learning process be characterized, as an adaptation to given targets and belief systems or as a more self-reflective process that even induces changes of the objectives and underlying convictions of the actors involved? How could it have been done better when compared to insights from literature and to experiences from other assessments? Which internal structural, cultural, and personal factors could facilitate learning by and in assessments?

To answer these questions, I first develop a conceptual framework drawing particularly on literature on policy learning, on organizational learning and on learning of networks (section 2). Second, I address the questions mentioned above in two case studies, on the Intergovernmental Panel on Climate Change (IPCC) (section 3) and the assessments under the Convention on Long-Range Transboundary Air Pollution (LRTAP) (section 4). Both cases are iterative processes with significant changes of the assessment institutions over time. Nevertheless, they differ in some of their basic structures and in their effectiveness with regard to political outcomes. Third, I compare the results of the two case studies and draw conclusions in section 5.

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ACRONYM LIST

AGGG	Advisory Group on Greenhouse Gases
COP	Conference of the Parties (to the UNFCCC)
EMEP	Cooperative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
GCC	Global Climate Coalition
GEA	Global Environmental Assessment Project
IIASA	International Institute for Applied Systems Analysis
ICP	International Cooperative Programme (under the LRTAP Convention)
IPCC	Intergovernmental Panel on Climate Change
JWG	UNFCCC/IPCC Joint Working Group
LRTAP	(Convention on) Long-Range Transboundary Air Pollution
NGO	Non-Governmental Organization
POP	Persistent Organic Pollutant
RAINS	Regional Acidification Information and Simulation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SBI	Subsidiary Body for Implementation
TFI	IPCC Task Force on National Greenhouse Gas Inventories
TSU	Technical Support Unit (of IPCC Working Groups)
WHO	World Health Organization
WMO	World Meteorological Organization
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

TABLE OF CONTENTS

1 Introduction 1
2 Learning in and of assessments – A Conceptual Framework 2
2.1 Assessments as learning processes 2
2.2 The learning agent in assessment processes 4
2.3 Types of learning 6
2.4 A conceptual framework 7
Structural factors 8
Cultural factors 9
Personal factors 11
External factors 12
3 The case of the IPCC 12
3.1 Reflective mechanisms 13
First Assessment and Supplementary Reports (1988-1992) 13
Second Assessment Report (1992-1995) 16
Third Assessment Report (1995-2001) 18
Options for future developments 20
3.2 Influences on learning 21
4 The LRTAP Convention 25
4.1 Reflective mechanisms and learning 26
Setting up the organizational structure (1979-1988) 26
Introduction of the critical loads concept and the RAINS model (1988-1999) 28
Restructuring after the Gothenburg protocol (1999-2001) 30
4.2 Influences on learning 31
5 Comparison and conclusions 33
References 37
Figures 45
Endnotes 49

1 INTRODUCTION

The issue of learning has gained considerable attention in the field of policy analysis and in studies on environmental policy in particular. It provides an approach to explain policy change that is different from traditional approaches focusing predominantly on interest and power as driving factors of political change. Until recently, it was the shared conviction among scholars of political phenomena that changes in public policy are merely caused by economic interests or political power (Nordlinger 1981). Meanwhile, numerous studies have illustrated the ways how and the extent to which knowledge, ideas and values influence national and international public policy making.[1]

In the context of policy learning, scientific advice becomes increasingly important. Being confronted with a high extent of uncertainty in a large number of political issues, political decision makers turn among others to scientists soliciting their advice. It is not only conceivable that more and more staff members of public authorities and bureaucracies have scientific training (Haas 1992) but also that governments and international bodies increasingly organize scientific assessments to obtain information about the problems at hand (Biermann, 2000).

This observation holds especially true for international environmental policy. In areas such as climate change, ozone depletion, and transboundary air pollution, decision-makers as well as scientists are confronted with a new and unknown quality of complexity, uncertainty, and dynamics given the worldwide scope, the large number of relevant factors and the long time horizons to be considered. To cope with these problems, societies, groups and individuals have to develop their abilities to learn and to consequently change actual behaviors (Lee 1993, Parson & Clark 1995, The Social Learning Group 2001).

In these learning endeavors, scientific assessments play an important role – especially if they themselves exhibit the ability to learn. When carried out over a longer period of time with several recurrent processes, assessments provide an outstanding opportunity for learning from past experience and from other assessment experiences. Through learning, assessments could improve their procedures and enhance their effectiveness in regard to issue development as defined by Clark & Mitchell (forthcoming). If assessments were perceived as continuous learning processes, they could be organized as constant processes of improvement and reflective change of the institution and, consequently, they might become more influential in the process of solving environmental problems.

In this context, the paper will address the following questions: How did the assessments at hand learn over the years and in the different phases of the assessment process? Which mechanisms had been in place to reflect on past experiences? How could the learning process be characterized, as an adaptation to given targets and belief systems or as a more self-reflective process entailing changes of the objectives and underlying convictions of the actors involved? How could it have been done better when compared to insights from literature and to experiences from other assessments? Which internal structural, cultural, and personal factors could facilitate learning in assessments? Which conclusions can be drawn to improve learning processes in assessments in general?

To answer these questions, I first develop a conceptual framework drawing particularly on literature on policy learning, on organizational learning and on learning of networks (section 2). Second, I address the questions raised above in two case studies, of the Intergovernmental Panel on Climate Change (IPCC) (section 3) and the assessments under the Convention on Long-Range Transboundary Air Pollution (LRTAP) (section 4). Both cases are iterative processes with significant changes of the assessment institutions over time. Nevertheless, they differ in some of their basic structures and in their effectiveness

with regard to political outcomes. Third, I compare the results of the two case studies and draw conclusions in section 5.

2 LEARNING IN AND OF ASSESSMENTS – A CONCEPTUAL FRAMEWORK

Across various academic disciplines, learning is a largely discussed topic that has been defined in numerous ways. In the context of scientific assessments, a broad but comprehensive approach is called for providing ways to successful description and analysis of the learning processes involved. Moreover, this approach should help to generate insights to solve problems in social reality. Mainly drawing on concepts of learning from political science, organizational studies and network analysis, this section attempts to develop a conceptual framework for the analysis of learning processes in and of global environmental assessments.

2.1 Assessments as learning processes

Assessments have been defined in various ways. Most of the definitions available focus on the output in form of reports, documentations or policy recommendations in order to specify what an assessment is. Since this approach underestimates the internal dynamics that lead to the final product, assessments have been defined more broadly as "the entire social process by which expert knowledge related to a policy problem is organized, evaluated, integrated, and presented in documents to inform policy or decision-making" (GEA 1997, p. 53). This definition focuses on the numerous and overlapping social processes within the production of a document, which seems to be crucial for the understanding of the final outcome.

Since many processes of change and development are perceived as learning processes by diverse actors, a clear delineation is required for the purposes of this study in order to specify what could count as learning. There is a broad range of phenomena that fall under the general category of learning starting from animals that "learn" to produce saliva when they see a flashing light to fundamental changes in the cognitive framework of humans.[2] In the context of scientific assessments, not all of them seem to provide useful pathways for the analysis of the learning processes involved.

In social psychology, learning phenomena on the individual level have been examined for a long time. A broad definition was developed by Swenson (1980, p. 3) who framed learning as "the most important process (or processes) by which we manage to change, adapt, and become (hopefully) more competent." Therefore, he focused on the outcomes of the learning process resulting in changes in behavior. However, this definition does not contain any indication about the processes behind the changes in behavior and capabilities. By contrast, Schunk (1996, p. 2) attempted to capture this phenomenon in his definition. He stated, "learning is an enduring change in behavior, or in the capacity to behave in a given fashion, which results from practice or other forms of experience." Both definitions encompass changes in behavior and changes in the capabilities to behave in a certain manner whereas Schunk particularly highlights the need for training or experience from which people learn. Nevertheless, these definitions solely refer to individuals and not to collective actors like groups, networks or organizations, and they do not specify the direction of what should be learned and why.

Definitions of learning in the realm of policy making partly draw on the general notion of learning in social psychology. For example, Heclo (1974, p. 306) formulates that "learning can be taken to mean a relatively enduring alteration in behavior that results from experience; usually this alteration is conceptualized as a change in response made in reaction to some perceived stimulus." In a shorter form, Ernst Haas (1991, p. 63) has a similar idea of the topic: "I define learning as any change in behavior due to a change in perception about how to solve a problem." Thus, learning obviously comprises two different but connected processes: changes in human cognition and changes in their behavior. This notion is challenged by Paul Sabatier's definition of policy-oriented learning. He states that learning processes are "relatively enduring alterations of thought or behavioral intentions that result from experience and that are concerned with the attainment or revision of the precepts of one's belief system" (Sabatier 1987, p. 673). His reference to the belief system incorporates more than mere cognitive processes but it comprises values and emotions that lay behind the actual cognition. Thus, a wider understanding of knowledge behind behavioral changes seems necessary. However, even in these definitions no indication is given about the direction of learning and the kind of knowledge that is being acquired. Therefore, nearly any process of behavioral change could be addressed as a learning process.

From these bodies of knowledge in could be summarized so far that learning is a process of long-lasting change in the behavior or the general ability to behave in a certain way that is founded on changes in knowledge.[3] Thereby, knowledge is understood in a broad sense incorporating cognitive, normative and affective elements but it still has to be specified in which respect learning distinguishes itself from any kind of behavioral change.

What is to be learned in assessments? Learning takes place in any kind of institution at nearly any time, the fundamental question, however, is whether it is heading into the right and productive direction. In previous studies (GEA 1997, p. 70), two major fields of knowledge have been identified as desirable in assessment processes: substantive and procedural knowledge. The former refers to the actual problems looked at, the details, the integration, and the general level of research. In the case of environmental assessments it will be the precise knowledge e.g., about climatic changes, their causes and impacts, or about causes for ozone layer depletion or the causes and abatement strategies for soil and water acidification. The latter field of knowledge is concerned with how the assessment is designed referring to questions like who participates in it, which decision-making procedures are adapted, on which scale and scope of the problem at hand it will focus, and how uncertainty is dealt with. For the purposes of feasibility of the subsequent case studies, it seems necessary to concentrate on the category of procedural knowledge in order to generate some kind of transferable and generalizeable conclusions. Moreover, the case could be made that obtaining useful substantive knowledge is possible without experience, but less so for procedural knowledge where learning from experience is more essential. Since substantive knowledge cannot be clearly separated from procedural knowledge, some reference to this category will be made, but the main focus should be put on procedural insights, which are transferable to other assessment processes.

With this specific focus, the problem of the direction of learning could be addressed more easily than in a more general approach to political processes. Preliminary research findings give hints for a possible answer to the question what learning could mean in respect to scientific assessments. Research conducted within the Global Environmental Assessment Project brought up insights in how an effective assessment looks like and which requirements have to be fulfilled for it being influential in decision-making processes. On the basis of the findings of the project it could be assumed that assessments have the most influence when they attain to be salient to the potential users, credible in regard to the scientific methods, and legitimate in the way the assessment is designed (Clark & Dickson 1999, Clark & Mitchell forthcoming). Thus the following three criteria indicate the direction in which learning in a qualified sense takes place:

- *Saliency:* Learning in assessments takes place when the assessment process or its products are made known to participants in a certain area of policy making so that they will perceive the assessment as relevant to them and their decision-making situations.
- *Credibility:* As assessment or its participants are learning to become more credible when the facts, causal beliefs, and options outlined in the assessment are regarded as "true" or, at least, worth using instead of other, competing information.
- *Legitimacy:* Learning in an assessment takes place when it is increasingly able to convince a participant that the goals pursued in the assessment correspond to those that the recipient would have kept in mind had she conducted the assessment.

For the purposes of this study, it could be summarized that *scientific assessments learn when they change the way the assessment is conducted in order to become more salient, credible and legitimate or when participants acquire general abilities to conduct more salient, credible and legitimate assessments which are founded on changes in knowledge and beliefs*. This concept follows the notion that learning is not necessarily an absolute increase in knowledge because there are always losses of knowledge that allow for the acceptance and memorization of new knowledge.

2.2 The learning agent in assessment processes

What is the agency of learning? Or put differently: Who learns in assessments? Assessments mostly are carried out by several individuals in some kind of collective effort. Therefore, the question arises what the learning agent is. It could be merely the individuals by themselves, but it could also be the social entity they form as a group of individuals. Insofar, the analysis of assessments has to face the same problem like the examination of policy learning: "Within learning theory the location of the agency of policy learning is as complex a matter as is the location of the agency of power within conflict-based theory" (Bennet & Howlett 1992, p. 282).

As shown in figure 2, learning can take place in all the phases of assessments. We have to consider different crucial phases within assessments as mentioned in the definition employed by GEA (1997). These are knowledge organization, evaluation, integration into certain documents, and presentation to the interested stakeholder groups, mostly political decision-makers. Here, the original generation of new knowledge is not seen as part of assessment processes neither the resulting political action to solve the problems at hand. However, it can be assumed that in factual assessments these phases are not clearly separable since they overlap and influence each other.

In addition, learning can take place on several levels. First, individuals involved in the assessment process, like scientists, political decision-makers, representatives from industry or from NGOs, can learn how to run an assessment, how to organize, evaluate, integrate, present and implement knowledge in order to make the assessment more salient, credible and legitimate. Second, learning could occur on a collective level. In the processes that are of interest in this paper either whole assessment organizations, or assessment networks, working groups, specific scientific or epistemic communities could be the agents of learning. Third, we could assume learning processes to take place in society as a whole, which has been framed as social learning where entire social systems change their behavior on the basis of new knowledge that might have been provided by assessments (Parson & Clark 1995, NRC 1999, The Social Learning Group 2001).

Assessment processes are never linear and straightforward procedures, they include multiple processes and feedbacks. As Jasanoff (1990, 1995) and others have pointed out, the generation of policy relevant

knowledge is always influenced by political and more general cultural norms, procedural requirements, and interests. Consequently, learning cannot only be directed onto the policy side of assessments and their influence in this realm but also onto how scientific knowledge generation is and will be influenced by political processes and by assessments in particular. For instance, assessors often shape research agendas which might result in shifts in governmental funding programs that affect the way scientific research is conducted and directed.

Given these three layers of learning, the question is still unanswered how the collective level could be grasped in theoretical terms and how the collective and the individual level relate to each other. Is it an organization comparable to business companies or public authorities that we are confronted with or is it some kind of loosely connected network? Approaching this set of questions, I refer to the relevant literature on learning organizations and learning network structures in order to generate a conceptual framework for the subsequent analysis of learning processes in assessments.

Concepts of organizational learning – also named as "the learning organization" – have been developed in management studies to describe processes of organizational change that take place at a collective level.[4] In this body of literature the distinction between individual and collective action is crucial – in particular for the choice of the appropriate theoretical and analytical approach. It is commonly assumed that organizations exist on the basis of collective action. According to Argyris & Schön (1996, p. 8), it is the precondition of collective action that the individual member "must (1) devise agreed-upon procedures for making decisions in the name of the collectivity, (2) delegate to individuals the authority to act for the collectivity, and (3) set boundaries between the collectivity and the rest of the world." These requirements could be found fulfilled in assessments to different degrees:

1. Concerning *agreed-upon procedures*, participants of assessments could be said to follow certain rules and procedures in the assessment process such as rules of interaction, meeting procedures habits, and review processes.
2. The second requirement leaves room for interpretation since it does not clarify to which extent the *authority* has to be handed over to certain individuals. In this case, assessments certainly do not fulfill very strong criteria. Although most of the assessments do have leaders and directors, many important decisions, e.g., about proper policy measures to solve certain problems, are made by the participants themselves.
3. Although the *boundaries* of assessments are somehow less formal and thereby less clear than those of commercial corporations, even in assessments it could be determined who the participants are, even though their affiliation with the assessment collectivity might be loose. In most cases, assessments have some kind of network structure with a weak organizational framework.

Based on these considerations, it seems justified to assume that collective action exists within assessments and to analyze collective processes herein. Nevertheless, questions remain concerning the relationship between individuals and the collectivity and the relatedness of their learning processes. Although the notion of collective learning implies that it is more than the mere sum of individual learning by its members, it is dependent on individuals, their learning and their behavioral changes. In this line of thought, collective learning can be seen as the change of procedures, structures, shared beliefs and knowledge that are assembled from individual contributions. For instance, the knowledge how to produce cars, telephones or computers is inherent to the relevant organization but individuals usually oversee only a small part of the whole production process. Applied to assessments one could assume similarly that participants barely know all aspects of the problems at hand when they discuss, arrange and put together their report, but they know parts of it very well. In this sense, division of labor in an organization allows for the possibility of collective learning.

Another argument comes from systems theory, which regards organizations as entities by themselves that are more than the sum of their individuals. In this view, organizational learning is mostly studied on the basis of analogies to individual learning. Probst & Büchel (1997, p. 15) define organizational learning as "the process by which the organization's knowledge and value base changes, leading to improved problem-solving ability and capacity for action." Similarly, Marquardt (1996, p. 22) points out that "organizational learning represents the enhanced intellectual and productive capability gained through corporate-wide commitment and opportunity for continuous improvement. [It] occurs through the shared insights, knowledge, and mental models of members of the organization [and it] builds on past knowledge and experience – that is on organizational memory which depends on institutional mechanisms (e.g., policies, strategies, and explicit models) used to retain knowledge."

In sum, it is the general assumption underlying the following research that assessments could be seen as endeavors of collective learning that cannot be reduced to the sum of the individual learning processes although it is based on individual contributions and on individuals as changes agents. This assumption does not imply a complete analogy between assessments and commercial organizations. It merely states that learning of and in assessments could be more than mere individual learning because of the existence of division of labor and a network of internal relationships between the participants of the process.

2.3 Types of learning

In the various models of learning, different kinds of learning processes have been distinguished. With regard to the definition of learning employed in this study, further specification seems appropriate. Therefore, I adapt a typology based on Argyris & Schön (1996). The fundamental criteria for this classification is how far the underlying objectives, norms, and beliefs of the assessment bodies have changed during the learning process. According to this approach, organizational learning is a change in the behavior of the organization or its members that is triggered by a change in the underlying "theory in use", i.e., the often unconsciously and tacitly used set of values and causal beliefs that the members of an organization share. Thus, individuals of the collectivity are seen as the carriers and developers of the theory-in-use, which might be changed through learning. Argyris & Schön distinguish the following types of learning:

- *Single-loop learning:* The simplest form of learning is the adaptation of new knowledge to existing frameworks of objectives and causal beliefs. Based on a simple feedback loop between given expectations and the real outcomes of a process, this instrumental type of learning allows for error correction and leads to adjust results that defer from the preexisting expectations. For example, a product manager may detect unexpectedly high emission rates from one production process and his search for the causes might lead him to a technical flaw that has to be corrected (see figure 1).
- *Double-loop learning:* According to Argyris and Schön (1996), the advanced form of learning could be framed as "double-loop learning" which also includes the underlying objectives, values, norms and belief structures into the learning process. Thus, there will be two feedback loops, an instrumental one of error correction and a more fundamental one that connects the former to changes in the general framework of beliefs, norms and objectives. For example, new results in ecological research might require a company to overturn existing orientations on a certain product type, e.g., CFCs, and call for a reorientation on substitution technologies with far reaching consequences on the whole organizational setup (see figure 2).

- *Deutero-learning:* If learning takes place on a meta-level of how to learn, one could speak of deutero learning. This is a form of learning of the ability to learn itself. For example, an organization might gather experiences with certain approaches to learning and attempt to improve its internal learning system consisting of – among others – communication channels, information systems, training procedures, and routines (see figure 3).

In their studies of business corporations, Argyris and Schön could hardly find forms of deutero-learning. Most learning processes usually remain in the scope of the first two categories of learning. In general, single-loop learning is largely sufficient when limited errors or deviations from goals have to be corrected, but it is not sufficient any more when the underlying norms and belief systems of an organization or other agents conflict with new internal or external developments or requirements. It could hardly be expected that assessments do exhibit patterns of deutero learning. Thus, in this study, I will focus on phenomena of single- and double-loop learning.

By way of focusing on what I call *reflective mechanisms*, this study attempts to get hold of the learning phenomena taking place in the assessment under examination. These are mechanisms that should help to make use of past experiences by reflecting on them and to turn them into action of any kind. Reflective mechanisms might be very informal like personal communication among participants in the assessment and they might be highly formalized and sophisticated in the form of institutionalized committees with a distinct set of rules of procedure. As part of the learning system of the assessment organization, these mechanisms might either be able to facilitate instrumental single-loop learning or more demanding double-loop learning.

2.4 A conceptual framework

The application of organizational learning to assessments has to bear in mind crucial caveats since there are significant differences between business companies and institutions of scientific advice. For instance, the members have different economic, social, and mental relationships with the organization, in assessments they mostly are less strong and less formal. Since assessments in most cases are not organized in a clear organizational structure, they often have more resemblance to network structures than to business organizations. Whereas business companies have a clear formal structure in the sense that membership is based on contracts, networks are bound together mostly by informal relationships like communicative or friendship ties. However, there are significant exceptions to this observation. Firstly, many private organizations who organize assessments and publicize their results are run as quasi- or actual corporations, e.g., the Worldwatch Institute. Secondly, there is a tendency to provide firm organizational frameworks for long-term assessments in order to give them among others wider public recognition and more secure funding.

Nevertheless, assessments could still be addressed as organizations when the broader notion of organization is applied as espoused by North (1990, p. 5) describing organizations as "groups of individuals bound by some common purpose to achieve objectives." In that sense, even networks can be perceived as organizations since its members also have a purpose in common.

But what precisely are social networks? In a broad definition they have been framed as a "finite set of actors or sets of actors and the relation or relations defined on them" (Wasserman & Faust 1994, p. 20). This definition allows for the integration of a large number of social phenomena, since it does not specify which kind of relation is at issue. It could be hereditary connections among different families or the exchange of goods and money among a certain set of actors. A more focused definition has been phrased by Keck & Sikkink (1998, p. 8) who define networks as "forms of organization characterized by

voluntary, reciprocal, and horizontal patterns of communication and exchange." Here, it is the specific form of communication and exchange among the actors that constitutes the network. Thus, networks have to be distinguished from formal and strictly hierarchical structures as those existing in public administration and governmental systems as well as in many business companies.

The special focus of the network perspective based on this definition is on the communication and exchange relations among a certain set of actors. Therefore, the main focus of the analysis of social networks is on relations among social actors or actor groups rather than on the actors themselves. It is the number, the intensity, and the strength of interpersonal relations that is at issue. These topics have mostly been approached from quantitative and numerical perspective. The analysis of qualitative aspects such as the role of values, beliefs or even emotions, communication patterns or power structures has fallen short in some parts, and learning processes in network structures have scarcely been the subject of thorough scrutiny. However, some basic insights could be deduced from this body of literature that might shed light on learning processes in scientific assessments.

For the purposes of this study, a conceptual framework is required that helps to generate hypotheses about possible influences on learning in assessments. Drawing on literature on organizational learning and on network analysis, I developed a framework as depicted in figure 2. This concept distinguishes between external and internal factors, the latter related to the organizational structures, to organizational culture and to the individuals involved. In the following, these factors will be explained on the basis of the insights from organizational learning and network analysis. Thereafter, the concept will be applied to two cases of global environmental assessments.

Structural factors

In management studies, significant attention has been paid to the formal structures of organizations and the impact they have on the behavior of the individuals and on processes of change and development. In regard to organizational learning the following factors have been identified in the relevant literature to be influential.

In business contexts, regular *exchange of individuals* among different units or departments has oftentimes triggered changes and the fast distribution of specific and new knowledge throughout the whole organization (Marquardt 1996). People or teams who possess new kinds of knowledge are supposed to spread out into other organizational units where they could transfer, generally speaking, this knowledge to other people. Nevertheless, it seems important that there is some kind of commitment to the transfer of knowledge in order to generate the desired snowball effects. If individuals simply exchange their working environment without communicating their knowledge to others, there will hardly be any learning at the collective level. While exchange can lead to increased capacity at the receiving end, it might create a void causing major problems at the other. As far as assessments are concerned, it could be assumed that a transfer of (procedural) knowledge from one working group to another or from one assessment process to another could best be carried out through real people who carry this knowledge. Therefore, learning in assessments seems most likely when possessors of crucial (procedural) knowledge move from one part to another or from one assessment to another as long as they, thereby, do not compromise the ability of one organizational unit to generate new knowledge.

Organizational learning requires the *storage of knowledge* from past learning experiences. In most cases computer technology provides the necessary support for this task in the field of numerical data, but these information systems have to be maintained and fed by the personnel that is working with them (Marquardt 1996). However, values, norms and beliefs as ingrained in the predominant theory-of-use are stored and transferred by humans who stay in certain positions or communicate them to new members of the organization. In assessments, documentation plays an important role in order to give an account to

outstanding people what has happened inside. But good documentation is also a requirement for lesson-drawing from past experiences. In regard to people, the maintenance of certain values and norms requires some continuity of personnel in the assessment from one period to another. A constant exchange of personnel will probably hinder the storage of crucial knowledge that has been accumulated in the past.

The formal structure of an organization defines the roles the individuals have to play; it clarifies the *hierarchy* and the formal *leadership* structures; and it structures working processes. Learning organizations require formal structures that on the one hand are clear in the attribution of responsibilities and in the leadership. On the other hand the structures have to provide enough flexibility and individual freedom for learning on the individual as well as on the collective level. Therefore, a balance between openness and guidance is asked for (Schwandt & Marquardt 2000). In empirical studies (e.g., Beer & Eisenstat 2000) it turned out that both the traditional top-down management style and the permissive laissez-faire style hamper effective learning processes. Accordingly, successful organizational learning requires some kind of leadership that leaves enough room for the development of new ideas and for the learning dynamics. Since assessments usually have less clearly defined formal structures than commercial organizations, one has to look at the degrees of openness, flexibility and guidance they provide for the individual participants. It might be assumed that assessments will be better able to learn when they have clear responsibilities combined with openness and flexibility in the roles the individuals play.

One crucial characteristic of networks is their *density* measured in the number of actors, groups or organizations participating in the network and the number and strength of their ties (Keck & Sikkink 1998). Very dense networks with numerous individuals linked together in an abundance of relationships and connections almost resemble a formal organization and could presumably act better collectively than a loose network. However, Granovetter (1973) has developed a theory of the "strength of weak ties" which states that personal and social networks extensively rely on the existence of weak ties that could be activated when needed. Although Granovetter argues that networks are stronger with more weak ties, it seems more plausible that strong ties among the actors are inevitable for the functioning of the network. In relation to learning, it could be hypothesized that dense networks are more likely to learn because they have a better flow of information and more resources to fall back on or to get initiatives from. Therefore, they require additional mechanisms to distinguish between valuable and useless information in order to avoid information overload. However, empirical evidence on this hypothesis is scant.

Communication structures in formal organizations as well as in networks seem to be fundamental for collective learning. When compared to business organizations, networks could be expected to exhibit different forms of information diffusion. Due to the more horizontal structure with less important hierarchical communication, information could flow more freely and presumably in a little more addressee-oriented way (Powell 1988). Since information flow is an important element of every learning process, the intensity, the openness and the transparency of the communication structures in any kind of organization seem pivotal in respect to collective learning. Therefore, it could be assumed that the better, i.e., the more frequent and the more addressee-oriented the communication and the flow of information is in an assessment, the more likely is it to learn.

Cultural factors

Apart from the formal organizational structure, informal aspects of the organization have gained increasing attention by scholars of management processes in recent years. These so-called "soft factors" refer to the human relations inside the organization. In relation to learning within assessments, I will concentrate on three essential factors: values and norms, the informal communication networks, and the role of trust and reputation.

Organizational culture when understood as the set of shared *values and norms* in an organization is an important denominator for any kind of organizational activities (e.g., Schein 1985). Openness, flexibility, commitment to the solution of actual problems, or creativity are elements of an organizational culture that is most likely to support organizational learning (Senge 1990). By contrast, taboos that may not be discussed or altered, dedication to formal procedures or top-down implementation of strategies will lead in most cases to little learning progress in the organization (Probst & Büchel 1997). Therefore, it is likely that learning in and of assessments will hardly occur when taboos and a strict dedication to formal procedures are part of the shared norms of the participants of the assessments.

Many networks are bound together on the basis of values or certain belief systems commonly held by their members. In the field of policy learning, two approaches have demonstrated the key role of common values in international networks. Networks of NGO-activists, addressed as "advocacy networks" by Keck & Sikkink (1998, p. 1) are constituted by the "centrality of principled ideas or values." Examples for this kind of networks include human rights movements and environmental networks. Within the scope of "epistemic communities," commonly shared values and beliefs are central for keeping together this kind of network of policy-oriented experts. According to (Haas 1991, p. 3), epistemic communities not only have the same fundamental values and beliefs, but also the same idea of scientific standards and of policy measures that are needed to achieve these values.

Even if actual assessments do not meet all the requirements of these approaches, it could be assumed that values play an important role for the constitution and the integration of the assessment network as well. It is, however, a partly open question to which extent shared values foster or hamper learning in networks. Based on the insights from organizational learning, it could be argued that a more comprehensive form of learning, e.g., double-loop learning, could be triggered by value conflicts. In networks, on the other hand, fundamental value conflicts might turn destructive for the whole network once the social glue is gone. Therefore, it could be expected that the stronger the controversy over the underlying values the less likely is learning of the whole network.

Without communication no learning could take place at all. In business organizations several levels and channels of communication exist in parallel. Apart from the formal channels along hierarchical relationships there are *informal communication networks*. The experiences with organizational learning demonstrate that top-down communication in the formal channels hardly suffices for the initiation and continuation of learning processes in an organization. In most cases the informal communication networks are crucial for the success of learning initiatives. If the dominant opinion among the members of the informal networks of employees is not to subscribe to the learning initiative, it will be very hard to push it on the formal paths (Krackhardt & Hanson 1993, Groat 1997, Crampton et al. 1998, Klimecki & Lassleben 1998).

Accordingly, the style of communication counts as well. One-way communication that is reduced to instructions and commands will hardly facilitate commitment and self-organization among the employees. Therefore, open multilateral communication and the dedication to mutual understanding could be seen as supporting factors for organizational learning processes since they allow for the unhampered flow of information and for the spreading of new ideas (Senge 1990). Assuming that informal communication is similarly fundamental to assessments as it is to business companies and networks in general, it could be assumed that the existence of informal communication networks with rather open ways of communication among the participants of assessments generally facilitates learning processes in assessments.

Apart from values, social networks oftentimes are bound together by direct personal relationships based on *trust or reputation*. When formal structures are lacking, informal and emotional factors become important for the way people deal with each other. Trust denominates the ability to rely on another person without opposing any kind of force on him or her. In scientific contexts, many people put less emphasis

on trust rather than on reputation according to generally agreed upon scientific standards. These standards might be publications in peer-reviewed literature, awards, or certain positions in academic institutions. In particular in scientific networks, these factors could be assumed to be important for the existence and the developments of networks.[5] Where they are absent, no strong network links could be expected at all. But when seen in the light of learning, trust and reputation could be assumed to play ambivalent roles. On the one hand they might enhance learning from those people who have a high reputation or who are entrusted; on the other hand, this learning might stay mono-directional when the information provided by this people is not questioned any more. In sum, it is likely that a moderate amount of trust and reputation in social networks supports learning.

Personal factors

Since human relations are perceived as influential to the outcomes of organizational processes, the individuals themselves have to be taken into consideration as well. It is the humans that organizations consist of and that have to carry out the learning processes.

The individual employees are the core elements of business organizations as social systems. Their *personal capabilities* determine to a large extent how far an organization is able to learn on an organizational level. In other words, although organizational learning has to be more than individual learning, it cannot occur without individual learning. It is the people's ability to learn and to reflect on their individual and collective learning that is clearly the foundation for the organizational learning (Senge 1990, Simon 1991).

Nevertheless, as Levitt & March (1988) point out, the accumulation of individual skills could also lead to so called "competency traps", where people stick to one area of competence. Once a certain competence has proven to be successful people will stick to it even if is not the appropriate answer to current problems any more. In dynamic environments it seems problematic to stick to one way of dealing with problems and to develop one type of competency. In order to overcome this competency trap a reflection process on the actual developments and the successes of learning efforts in relation to the broader environment is required. Here, the organization has to rely on individuals with the capability of double-loop learning. This type of learning does not only relate certain outcomes of organizational processes to a given set of targets or strategies but it also includes a feedback to the underlying set of targets and values whether they are still appropriate given the current overall situation. Organizations could institutionalize this type of learning but they have to rely on individuals, who have the ability to fulfill the task. In sum, demands concerning the individual capabilities are numerous when in comes to effective organizational learning. Apart from showing proficiency in reflecting on past learning experiences, individuals in an organization are required to be able to generate, collect and accumulate new knowledge. Therefore, they have to be flexible and open-minded with a view for the overall processes in order to make individual learning a fruitful contribution to learning on the organizational level. When we apply this to assessments, we could suspect that successful learning in or of assessments in total requires individuals with those personal capabilities that enable them and the collective process to learn.

On the side of individuals not only cognitive capabilities are of importance for the general ability of an organization to learn. It is also the attitudes of the people involved that could either foster or hamper organizational learning. In many cases, dissatisfaction of employees has triggered learning that was directed at solving the problems that presumably caused the dissatisfaction (March & Simon 1958). Oftentimes *dissatisfaction* goes along with *conflicts* among the individuals in an organization, in particular across hierarchical levels. These conflicts could result in further learning and in the sense that they could be seen as productive in the long run (Probst & Büchel 1997). Since conflicts could also be highly destructive and energy consuming, the number of conflicts inside an organization could hardly constitute an indicator for organizational learning in general. However, dissatisfaction and conflict are

indicators for internal pressures based on people's discomfort with the current situation that could be seen as triggers for learning processes in general. Since assessments seem to be even more dependent on individual attitudes and cognitive capabilities than business organizations, these factors deserve thorough examination. Hence, it is plausible that people's discomfort or dissatisfaction trigger learning processes in assessments.

External factors

Many of the observable learning processes in organizations are triggered by external factors rather than by internal ones. Changing consumer preferences, intensified competition on markets, the introduction of new technologies, accidents or catastrophes in certain production fields, or alterations in political regulation are external factors that could initiate learning on the side of the organization. Companies could prepare themselves to encounter several of these risks. The creation of a learning-stimulating organizational structure and culture is an important element of this kind of preparation (Argyris & Schön 1996). For the study of learning processes in organizations as well as in assessments, these external influences could be highly significant. Changes in the external framework conditions of an assessment could trigger changes in the assessment process itself or in the internal factors as described so far. These factors include political pressures, new scientific findings, criticisms from NGOs, industry or from the media, and experiences with other assessments.

3 THE CASE OF THE IPCC

Climate change has been subject of scientific debate since the 19th century when Svante Arrhenius phrased his hypothesis that global temperatures will rise due to man-made emissions.[6] Interestingly, Arrhenius already served as a scientific advisor to the Swedish government. He stressed the need for international cooperation in this field and was very much concerned about the clear distinction between science and policy-making (Elzinga 1997). Therefore, he pioneered a tradition in policy oriented climate change research whose latest and most prominent outcome is the IPCC.[7]

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 as a scientific advisory body to the United Nations Environmental Programme (UNEP) and the World Meteorological Organization (WMO). It has been designed as an intergovernmental organization that is basically scientific in its membership but involves governmental participation in the process of approval of the major conclusions. Since its beginning, the IPCC has produced three major assessment reports (concluded in 1990, 1995 and 2001) and a sizeable number of special reports and technical papers as well as supporting materials such as guidelines and documentary materials. Over the years the IPCC has undergone several changes in regard to the internal structures and procedures, which makes the case worth examining from a learning perspective.

In the following, I will firstly focus on reflective mechanisms and procedures used in the IPCC processes in order to get hold of learning phenomena that will be classified with regard to the predominant types of learning. Secondly, I will analyze internal and external factors as laid out in the conceptual framework that might have had an influence on the organization's ability to learn and on its original learning processes.

3.1 Reflective mechanisms

Which kind of mechanisms were in place in the IPCC assessments to reflect on past experiences, to make use of experiences from other assessments and to feed them into changes of future assessment designs? As a long-term recurrent assessment the IPCC provides an excellent opportunity to learn from the past and to achieve a continuous improvement of its assessment design and its effectiveness. However, in their comparative study of learning in the early stages of the IPCC Haas and McCabe (2001) conclude that the "INC and the IPCC learned very little." Looking at the whole period of its existence since 1988, new evidence might lead to a reversed picture of the IPCC learning processes. Therefore, the following section will focus on the way the IPCC learned on a collective level and how the learning was facilitated. It will delineate the mechanisms that have been used for learning over the period of the IPCC's existence.

Although there has never been an official systematic evaluation or institutionalized reflection process within or outside the IPCC to examine the experiences and results of previous work and to draw conclusions about necessary changes in the structures and processes of the assessments, there have been several unofficial ways of doing so. In parallel to the design elements mentioned above, also the learning mechanisms of the IPCC evolved over time. Therefore, I will describe them chronologically following the sequences of the assessment reports.

First Assessment and Supplementary Reports (1988-1992)

When the IPCC was founded in 1988, it was more than the mere addition of another scientific advisory body in the climate change arena. Although it was not the first international assessment forum for climate change, it had a unique and innovative structure and design. Whereas its precursor in the international arena, the Advisory Group on Greenhouse Gases (AGGG), established in 1986, consisted of a handful of scientists almost exclusively from Northern industrialized countries (Agrawala 1999), the IPCC was based on an intergovernmental approval mechanism being open to governments from all over the world. The centerpiece of this intergovernmental mechanism was the involvement of numerous governments in the formulation of the questions addressed and in the approval of the final reports. Thereby, it was different from national assessments, which were hardly noticed or accepted in nations other than those where they originated. The IPCC allowed for a broader acceptance among the large number of governments that were hitherto skeptical or ignorant of climate change. The intergovernmental approval mechanism provided the chance to deal with the inevitably global structure of the problem of climate change and to ensure the government's ownership of the resulting reports (Bolin 1994a, Watson 2001).

As formulated in its first assessments report (IPCC 1990), the original objectives of the IPCC were threefold; it was charged with:

- assessing the state of existing scientific knowledge on climate change;
- examining the environmental, economic, and social impacts of climate change;
- formulating response strategies.

The IPCC responded to these objectives by setting up three Working Groups that were more or less charged with one of these three tasks.[8] By and large, the formal objectives remained unchanged over the three following assessment reports (Houghton 2001). Nevertheless, the way how the IPCC complied with these objectives, how it specified the tasks and organized the division of labor varied over time and was subject to reflective and adaptive adjustments.

In the beginning of IPCC, lesson-drawing from other environmental assessments was the predominant learning mechanism in place. Here, the example of the ozone assessment was perceived to provide this lesson. Having resulted in strict and effective political regulation, the international ozone assessment concluded in 1985 was handled as a success story that should provide a blueprint for the climate assessments in IPCC.[9] The former co-chair of the stratospheric ozone assessment and the incumbent chair of the IPCC, Robert Watson, makes that clear: "So when we designed the IPCC, we certainly had in mind some of the experiences from the international ozone assessment. ... We looked at the ozone assessment for lessons learned and how to get the really world-class people involved as the co-chairs et cetera" (Watson 2001). However, there was only a handful of people who participated in both assessments and who were able to bring in their experiences. In addition, the leaders of the IPCC assessments did not have this kind of experience in international assessments.

Nevertheless, even within the climate area, experiences were available with other international assessments. These had hardly been successful and threw some doubt on the idea that a simple repetition of the ozone case would be realistic. The AGGG, existing from 1985 until 1992, was by far means less effective in terms of political outcome than any of the ozone assessments and significant design flaws could be held accountable for that. Firstly, the participating members represented only a very limited number of countries and therefore the assessment's legitimacy has been questioned (Boehmer-Christiansen 1994b). Secondly, saliency to policymakers was rather low since no serious links to the political process had been institutionalized. Thirdly, the organization was lacking financial resources and political support. Last but not least, participation in the Group entailed few scientific credits to the members so that many of them displayed little commitment to the Group's activities (Agrawala 1999).

These experiences could explain – among other factors – the call for the intergovernmental mechanism of the IPCC which emerged from intensive consultations between the WMO, UNEP, and several foreign affairs ministries of WMO member countries, in particular the US (Agrawala 1998a). As a means to push the assessment closer to the political process, the intergovernmental approval process was set up without precedent in the environmental area. Lessons could only be drawn from other UN processes with which most of the scientists involved were hardly familiar due to their almost exclusively scientific career paths.[10] Thus, the mechanism was new to most of its participants and they had to learn how to use it effectively and how to develop it further given the little formalization it had in the beginning.[11]

When looked at the first phase of the IPCC in the light of the typology of learning, one could find the set up of the IPCC with its unique organizational structure as a form of double-loop learning in comparison to the previous attempts to design the science-policy interface in the climate area. The IPCC provided a new and advanced way to facilitate the science-policy communication by ensuring saliency and credibility. The government's ownership of the whole process and the final documents lead to a significant increase in saliency when compared with the loosely connected AGGG assessment. Credibility was granted through the design of the IPCC as a scientific body with no political decision makers being involved as authors. Moreover, even the First Assessment Report had a review procedure that was deemed to ensure high scientific standards. Even legitimacy had been increased through the establishment of the IPCC when compared to previous climate assessments. The attempt to include scientists from all parts of the world was a significant progress in this respect – even though scientists from developing countries were highly underrepresented in the preparation of the First Assessment Report.

From the beginning in 1988 on, one of the key issues to ensure the IPCC's legitimacy was how to achieve balanced participation of scientists from all parts of the world. Since the international set up and the involvement of governments from all over the world was the centerpiece of the IPCC, the participation of experts from all regions of the world was regarded crucial for the acceptance of the assessment results by policy makers in the industrialized North as well as in the developing South.[12] As expressed by WMO Secretary General Godwin O. Obasi, it was the initial goal of the IPCC to ensure membership of the

major greenhouse gas emitting countries, of all geographic regions and of those countries with outspoken scientific expertise in the field. Since especially experts from the developing world were lacking the necessary funding opportunities and a great deal of crucial research capacities, their participation has been a constant subject of debate in the IPCC Bureau (Agrawala 1998b).

To encounter this problem, in 1989 the Bureau established a "Special Committee on the Participation of Developing Countries" that could be seen as a reflective mechanism tailored to this specific problem. It succeeded an "Ad-Hoc Group on Ways and Means to Increase the Participation by the Developing Countries," which was exclusively composed of representatives from the developing countries. By contrast, the Special Committee also included members from industrialized countries which reflected the need for communication between the two groups – in particular as far as funding issues were concerned (IPCC 1989). In the beginning, while facing severe budgetary restrictions the Committee suggested short term measures such as information exchange seminars to educate experts in the developing world[13] about issues of climate change and long-term measures that were targeted at building research capacities in the developing countries. In subsequent sessions, the Committee managed to persuade the IPCC panel to impose quotas for the composition of the IPCC Working Groups and to establish a trust fund to provide funding opportunities for travel expenses of participants from developing countries to attend the IPCC meetings. Thereby, the segment of experts from these regions increased over time but representation of world regions among the IPCC lead authors is still not equally balanced in all Working Groups (Leary 2001).

On the political side, a broader and more balanced participation could be observed. Starting out with 30 participating governments in 1988, the IPCC's plenary sessions now usually attract government officials from more than 100 nations. This number might not only demonstrate the improvement of the international balance on the side of the political decision makers but also a growing interest in the issue of climate change and its ecological, social, economic and political outcomes in general. Although industry groups and environmental organizations echoed this development, non-governmental organizations do not have an official say in the plenaries.[14] However, some of them like the Global Climate Coalition (GCC) were approved as reviewers in the revision process of the assessment reports (Franz 1998).

The finalization of the First Assessment Report in 1990 provided the opportunity to reflect on the experiences of the IPCC processes themselves and what could be learned for future assessments. This reflection took place in form of discussions in the Bureau and the plenary sessions but there was no formal document prepared. One of the main lessons learned by the participants of the first assessment certainly was the political aspects of the IPCC process, which was new to most of the scientists. When they had to adapt to the fact that the agenda of the assessment was mostly set by political needs, major discussions emerged and significant skepticism was expressed by some of the scientists involved.[15] Nevertheless, acknowledging the political function of the whole endeavor, a supplementary report was prepared that – together with the first assessment report – was said to be highly influential on the negotiations of and final agreement on the framework convention in 1992 (Agrawala 1998b, Bolin 1994b). Therefore, this reflection process could be seen as helpful to increase the effectiveness of the IPCC assessment by raising saliency for political decision-makers.

However, these learning processes in the later period of the First Assessment Report could merely be characterized as single-loop learning since they did not lead to fundamental changes of the underlying assumptions and norms of how to conduct the assessment. The changes in regard to saliency, credibility or legitimacy of the assessment process were rather small since the general design of the assessment was untouched. The preparation of a supplementary report with the objective to influence the negotiations about a climate framework convention at the Rio summit could be seen as a significant adjustment to lead the assessment closer to political processes and therefore slightly increase the saliency of the IPCC work.

Second Assessment Report (1992-1995)

The Second Assessment Report was completed in 1995. In the time of its preparation mainly one incidence of learning in the sense of reflection of past experiences could be detected. At its sixth session, the Panel established a special Task Force on the IPCC Structure that reported to the eighth session of the IPCC in 1992. Its purpose was on the one hand to comply with the requirements of the framework convention introducing several new bodies like the Conference of the Parties et cetera. On the other hand, the Task Force was asked to outline the Working Group structure of the second assessment and to suggest ways to allow for the participation of NGOs in the IPCC process, which was claimed by several environmental NGOs (Bolin 2001). The Task Force was open to all the members of the IPCC including government representatives, authors and the Bureau members. Therefore, it had the size comparable to a Working Group and allowed for the representation of the diverse perspectives like in the general sessions of the IPCC (Sundaraman 2001). It met three times and prepared a report that led to the adoption of a 4-page-long document about new rules of procedure of the IPCC at its ninth plenary session (IPCC 1992).

The core of these new rules dealt with the specific and highly sophisticated type of review procedure that was imposed to ensure scientific quality and credibility to both the scientific and the political community. Whereas in the first assessment each chapter had, in general, been reviewed by two or three experts and government officials simultaneously and no precise formal rules on the issue had been available, in the second assessment the review process was much more refined (Parry 2001). The review process took place in two rounds. First, the drafts prepared by the lead authors had to be circulated among specialists in the area at hand, other lead authors and experts from relevant international organizations. Then in the second round the revised drafts were to be distributed among governments soliciting their comments. Finally the lead authors had to include the comments into a final draft that was submitted for acceptance to the Working Group Plenary meeting. While the lengthy chapters in the bulk of the IPCC reports only required the acceptance by the Working Group, the shorter and more focused Executive Summaries and the Summaries for Policymakers had to be approved line by line by the IPCC Plenary consisting of all the government officials.

It was the main intention of this iterative review and approval process to "ensure that the reports present a comprehensive, objective, and balanced view of the areas they cover" and not to allow for the intrusion of political or economic interests in the assessment process (IPCC 1995). Although government officials are always tempted to include politically biased statements into the reports to promote their national interests, experiences with the intergovernmental approval process have shown that they cannot significantly harm balanced judgment and scientifically solid reports.[16]

The report of the Task Force paid attention to several critical issues inherent to the IPCC and its procedures. It addressed the criticism of lacking transparency and suggested to make more efforts to inform nations about ongoing IPCC activities and its decision-making processes (Bolin 1994b). Moreover, broader participation of developing country experts was seen as pivotal to the IPCC process and recommendations were made by the Task Force to facilitate scientific exchange between industrialized and developing countries, to foster international cooperation in climate research, and to integrate more experts from developing countries.

By and large, the report and the resulting decisions by the plenary reacted to critical comments from governments or NGOs. While these changes resulted mainly from claims from the political world, only a few criticisms from the scientific community were addressed in the report and in the revision of the rules of procedure. Nevertheless, the Task Force could be seen as a first institutionalized effort to reflect on the experiences of the first period of the IPCC's existence and it was fairly successful in promoting changes of its procedures. Moreover, due to its setup it was open to all the members of the IPCC and provided a high degree of legitimacy to the outcome.

In terms of a learning typology, these learning efforts could be characterized as single-loop learning considering that the changes were rather reactive and complied to external criticisms. There was no fundamental change in the underlying assumptions perceivable that would allow for a characterization as a double-loop learning process. Such a double-loop process would have required changes in the direction of significant increases in saliency, credibility or legitimacy. The acknowledgement of the role of NGOs and industry in the preparation of the assessment was an important step towards increased legitimacy but their actual impact in the process remained limited because the vast majority of participants were either scientists or governmental experts. The additional formalization of the peer-review process as expressed in the document prepared by the special Task Force aimed at increasing credibility, but the suggestions made implied few significant changes to the processes already in place. However, they led to a tremendous increase in the number of reviews each author had to take into account. By contrast, significant changes in the direction of increased credibility while maintaining legitimacy and saliency might have lead to a more reflective selection of reviewers, e.g., through a voting mechanism by all the governments and scientific experts. This kind of learning might have been characterized as double-loop learning.

In the period of the preparation of the Second Assessment Report, there were also significant organizational innovations that aimed at clarifying the relationship between politics and science in the field of climate change. When the First Assessment Report was under preparation, the political nature of their work became obvious to the participants through the high level of contestation they had been confronted with especially after the publication of the first report. On the other hand they had to provide credibility to the scientific community and are intended to feed scientific and technical information into the political negotiation and implementation processes (Bolin 2001). This was a difficult learning task for several participants who had to find a balance between credibility and saliency to the policy makers.

Therefore, the science-policy interface had been filled with a number of committees (see figure 3). In 1993, a Joint Working Group (JWG) in between the IPCC and the negotiating bodies for the framework convention on climate change was established to facilitate direct communication among the scientific and political committees.[17] On the side of the IPCC, the group consisted of the chairperson of the IPCC and several members of the Bureau, on the side of the FCCC delegates are the director of the UNFCCC-secretariat and several of his staff members as well as members of the Subsidiary Bodies under the Convention. The Group provided a comparatively informal forum to discuss the projects of the IPCC and the information needs of the negotiation processes. Since the group was established at a rather advanced stage of the Second Assessment Report, its influence in this phase remained limited. However, during the preparation of the Third Assessment Report, it became significantly more influential (Moss 2001).[18]

Apart from this Group, the Framework Convention on Climate Change (FCCC) – as adopted in 1992 – established two standing bodies consisting of government delegates: the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI). It is the task of the former to advice the negotiating parties on scientific, technological and methodological matters relating to the Convention. Therefore, it should link scientific information provided by the IPCC to the policy-oriented needs of the COP. In this function, the SBSTA has to cooperate closely with the IPCC and could request specific studies from it. The latter, the SBI, is charged with the assessment and review of the implementation of the Convention. Among others, it has to examine the national emission inventories submitted by the parties and, thereby, has to cooperate especially with the IPCC Task Force on National Greenhouse Gas Inventories (TFI). Through these bodies communication between political decision makers and IPCC-scientists has been significantly formalized since questions coming out of the negotiation process have to be discussed in these bodies and forwarded as official requests to the IPCC.

What can be said about learning in respect to these changes of the organizational structure at the science-policy interface? From a learning perspective the introduction of new bodies can be seen as a response to criticisms concerning unclear boundaries between scientific and political aspects of the assessment. But, it did no lead to major changes of the assessment itself since the bodies were additional entities that were implemented by the framework convention, i.e., by a predominantly political process in which the IPCC hardly participated. Therefore, it seems obvious that these changes could rather be labeled as single-loop learning. If we ask the reverse question how double-loop learning could have looked like, we might think of other responses to design the science-policy interface of scientific assessments. For example, the LRTAP case as described below demonstrates that a closer and less formalized interaction and cooperation between scientists and political negotiators is feasible enhancing saliency of the assessment while maintaining its scientific credibility.

Third Assessment Report (1995-2001)

A somehow different approach has been taken to facilitate the learning from the second assessment and to feed the results of the reflections into the design of the Third Assessment Report starting in 1996. At that time, the first chairman of the IPCC, Bert Bolin was about to step down and Robert T. Watson had been elected new chair. In a one-year transition period both were working closely together to ensure continuation of the work and to allow for a transfer of knowledge from the predecessor to the successor.

The new chairman started out with the attempt to "really consider what was the right structure of the IPCC" (Watson 2001). Instead of establishing a specific task force, he himself prepared a White Paper addressing a number of key questions and suggesting a new structure and procedural improvements for the third assessment (Watson 1997). The draft was based on critical articles in the scientific literature, on government critiques and on a number of workshops on specific substantial matters such as mitigation technologies, regional projections of impacts and on uncertainty (Moss 2000, 2001). In a first consultation round, the co-chairs of the Working Groups and the head of the Technical Support Unit of Working Group II, Richard Moss, commented on the paper and a revised version was presented to the IPCC Bureau which requested several revisions (IPCC Bureau 1996). In a second round, comments on the revised version of the paper were solicited and collected from governments, NGOs and scientific experts. The chairman received over 90 responses and he attempted to acknowledge them in the preparation of the final decision paper on the design of the Third Assessment Report, which was adopted in September 1997 by the plenary session. Altogether, this iterative process took over one year and it was certainly a larger effort than the design of the second assessment when measured in comments considered and in rounds of iteration.

A number of suggestions came out of this process that were influential for designing the final structure of the third assessment in 1998. Based on criticisms on the artificial separation of Working Group II and III in the second assessment, a new Working Group structure emerged that was designed to allow for a better integration of socio-economic and technical/scientific aspects of adaptation and mitigation (see endnote 8). Another substantive issue was the treatment of cross-cutting themes such as uncertainty, costing methodologies, and equity issues. These have either not been dealt with in a consistent manner or have not been addressed at all in the second assessment report (Moss 2000). Therefore, a special subgroup under Working Group III was established that prepared guidance papers on each of these issues in a lengthy review process (Pachauri et al. 2000).

One of the main challenges for the design of the third assessment report was how to deal with the criticisms raised in the so-called chapter-8-debate.[19] In the aftermath of the release of the second assessment report, a number of US-based scientists backed by the Global Climate Coalition (GCC) launched a massive assail against the final version of chapter 8 of Working Group I which concluded that "the balance of evidence suggests a discernible human influence on global climate" (Houghton et al.

1996, p. 4). The accusations published in widely read magazines like the Wall Street Journal were serious; they charged that the lead authors of the chapter had changed the text of the final version after it had already been officially approved by the Working Group plenary. Thereby, they claimed, the chapter authors violated the IPCC's rules of procedure and the fundamental standards of peer-review. However, the accused authors and the leaders of the IPCC process could successfully prove these accusations wrong and no IPCC-member state government joined in the criticism (Edwards & Schneider 2001). Yet, the debate brought some deficits to the surface that had to be addressed in future assessments.

One of the flaws was that the authors were allowed to change the text body of the chapters after the report had been accepted by the Working Group plenary. By contrast, the text of the summary for policy-makers must not be altered afterwards because it has been *approved* line-by-line.[20] The IPCC realized this deficit and reacted by adjusting its rules of procedure enforced in 1999. In this new set it rules, "Changes made after acceptance by the Working Group shall be those necessary to ensure consistency with the Summary of Policymakers." Lead authors have to indicate their changes to the Panel (IPCC 1999, p.5).

Moreover, in the Second Assessment Report, authors were not accountable to the reviewers or to anybody else when they finally revised their chapters. Thus, they could even ignore reviewers' comments without plausible reasoning. This deficit in the rules became apparent in the debate and lead to another institutional innovation in the preparation of the third assessment. The incoming chairman, Robert Watson, suggested in his White Paper the introduction of so-called "review-editors" whose function was to oversee the review process, i.e., to ensure that authors appropriately deal with the comments from the expert and government reviewers (IPCC 1999). Watson had already gathered some experiences with unofficial review editors in the preparation of the Working Group II report of the second assessment and was able to base his suggestions on these (Watson 2001). Because skeptics were afraid of delays in the timing of the assessment, the number of review editors was limited to two and they were invited to the author meetings to witness the processes and to give timely comments and suggestions. Thereby, their work was not a blind (i.e., anonymous) review process but on the other hand, no serious delays occurred due to review editors although they had to work under intense time pressures. Similar to the recruitment of the authors and reviewers, also the review editors were selected based on government and NGO nominations. Not all authors regarded the installation of review editors a completely helpful improvement of the process since not all of the review editors were similarly diligent in fulfilling their job. While some regarded it rather trivial, others took their task very seriously – a task that required readings and consideration of the various versions of the chapter drafts and of up to 200 comments (Leary 2001).

The introduction of the review editors could be seen as a clear result of the criticisms raised in the chapter-8-controversy. This innovation demonstrated a considerable degree of reflection of the ongoing processes and could be seen as more than a single-loop learning because it surmounts the framework of previous conceptions of the IPCC process. These changes got along with a shift in the general perception of the IPCC process. When the IPCC scientists were confronted with legalistic arguments in the debate about their scientific statement and the procedures that led to it, they had to realize that the form of scientific discourse they were used to was not appropriate under these circumstances. They encountered procedural arguments from lawyers that could not be dealt with on the basis of scientific arguments based on a common notion of truth and credibility (Schneider 2001). Therefore, they had to adapt to the conditions of legal discourse, which resulted in the more precise formulations of existing rules and procedures and in procedural innovations. It seems hardly exaggerated to state that the IPCC had to incorporate a new rationale that originated in the political realm. Nevertheless, the outcome of this reflection was the introduction of another refinement of the scientific procedures that were certainly able to increase credibility at the expense of further bureaucratization and extension of the assessment process. In so doing, saliency of the assessment has been put under jeopardy because the processes were extended and the IPCC had even more problems in delivering timely policy relevant information. Therefore, one could argue that there was an advanced form of single-loop learning that did not lead to fundamental

changes of the whole assessment process in regard to a better balance between scientific credibility, political legitimacy and overall saliency.

In the preparation of the Third Assessment Report another mechanism had been introduced to achieve more consistency on cross-cutting issues throughout the working groups and the individual chapters. Therefore, the Bureau agreed on a number of issues such as uncertainty, equity, sustainable development that had to be dealt with by a group of authors who were familiar with the IPCC procedures for quite some time. They prepared drafts and requested comments from all authors of the Third Assessment Report. Finally, after having revised the papers, they issued a small booklet that was sent to the authors in order to be included in the drafting process of the individual chapters.

The most successful effort in this respect was made in the field of the use of language on uncertainty. The relevant guidance paper was prepared by Moss & Schneider (2000). Within IPCC, the topic had been intensely debated since the beginning in 1988 and chapter authors had been using different approaches to estimate and document uncertainties. Many of them even refused to give any estimation on uncertainties because of their scientific ethos to focus exclusively on reliable and certain research findings. Several researchers had to be convinced that the policy-oriented approach taken by the IPCC urgently required these estimations to advise political judgements on specific risks – even when no scientific certainty was available. Moss and Schneider, hence, introduced a qualitative framework to describe "states of knowledge" and suggested a numerical scale of the various degrees of confidence. It should allow authors to make their partly inevitably subjective estimations more transparent and understandable for policy makers and to increase consistency in the whole report.[21]

While most authors adhered to this framework, authors in charge with one chapter within Working Group I refused to do so. Instead of using the suggested scale with intervals of 5 percentiles (5%, 10% ... 95% confidentiality) they employed numbers of a third or 99% likelihood and avoided the exact description of uncertainties by referring to the assumptions of various models leaving policy makers without clear guidance how to evaluate the related risks. After lengthy discussions among the authors and following a request from governments, the authors partly revised the chapter but the other Working Groups that had to build on the results from Working Group I had hardly any chance to adapt to these changes because of the short time frame in between the sessions of the Working Groups to approve the third assessment report (Schneider 2001). Therefore, minor inconsistencies could also be found in this report although the general treatment of uncertainties is significantly more reflective, consistent and clear than in the previous assessment reports.

This procedure could be seen as a significant improvement in providing credible information that is highly salient to the needs of policy makers and credible in the sense of being more realistic about the limitations of knowledge. Moreover, it changed the general way of dealing with the problem of uncertainty since the procedure was designed in a cross-cutting way on a consensus basis. Thereby, it remained legitimate without compromising scientific credibility. Thus, it could be argued that this was a case of double-loop learning because it was based on a more fundamental reflection of the whole assessment process with required changes in the treatment of uncertainty to deliver highly policy relevant information. The underlying theory-in-use had been changed since the authors had to rethink their estimations and related conclusions in the attempt to adapt to the suggested framework.

Options for future developments

Still being concerned with the process of completion of the Third Assessment Report in early 2001, the IPCC Bureau is already reflecting on the past assessment process and developing ideas about future steps. Like in the third assessment, it is again the chairman by himself who prepared a so-called "Issues Paper on the Future Work Program of the IPCC" and submitted it to the Bureau for discussion. Comments are

again expected from the vice-chairs, the co-chairs, the lead authors and the governments but hardly so from individuals or organizations external to the IPCC (Watson 2001). Although the discussion process is just about to start and external reactions have been scarce since the report has not yet been officially released, it could already be seen that a similar reflection mechanism is about to be employed here as in the previous assessment.

Nonetheless, there are alternative options available to organize the reflection process but surprisingly they have never been thoroughly discussed by officials in the IPCC. One option that has been outlined by Watson (2001) is an evaluation of the IPCC by a special commission to either WMO or UNEP or to both. This commission might consist of members of the central decision-making bodies of these organizations (Governing Council of UNEP and the WMO Executive Council) and it may also include individuals from the negotiating bodies that are closer to the political processes. Thereby the evaluation might be able to gain a broader perspective of the scientific and political functions of the IPCC.

Moss and Schneider (1997) developed another concept for evaluating the IPCC. They suggested the establishment of a so-called "assessment court" or a "panel of independent judges" which evaluates each assessment based on their observations of the debates, the recruitment of authors, the review procedures and the outcomes. This suggestion resembles the idea of an auditor critically examining the processes from outside. If it could be achieved to recruit highly respected and independent personalities for this kind of committee, credibility of the whole IPCC process might be increased due to this additional and institutionalized reflection process.

However, both concepts suffer significant shortcomings. In both cases it seems hardly possible to find a group of individuals that could be agreed upon by all parties involved as equally independent and competent. Given the intensity of political debate on issues of climate change that could not even be banned from predominantly scientific debates in the IPCC, it will be highly problematic to identify individuals that could claim to be "independent" from both, political interests and scientific prejudices or preferences, e.g., for certain approaches, models, or theories. The selection procedures could add another question mark because it could be doubted that all parties involved will accept the parent organizations as legitimate institutions to select the jurors, especially when politically sensitive issues such as response strategies are being discussed. Moreover, both forms would require significant financial means to provide the expenses for the committee. Since funding structures are usually linked to possible influences and interest structures, they would have to be designed very carefully and rather indirectly in order to ensure independence of the committee.

3.2 Influences on learning

Which factors have shown to be important for the learning of an organization like the IPCC? Following the conceptual framework, I will highlight some factors that could be regarded influential in the learning processes of IPCC as described above. Nevertheless, due to the complexity of social processes like the one at hand causal relationships can be traced back to these factors only with great difficulty.

Exchange of individuals: Given the structure of three parallel working groups, the exchange of individuals and their ideas and thoughts is, by and large, restricted to the chapters or the working groups the individual authors belong to. Exchange among the authors of different Working Groups was limited. Therefore, the exchange of new information between the Working Groups is much worse than the exchange within the Working Groups (Leary 2001). That might explain the crucial role of the chairpersons of IPCC to link together the Working Groups and their results but it also makes understandable the need for cross-cutting guidance papers and individuals to pull the knowledge together

in order to develop common standards and a language for all the Working Group reports in the third assessment.

Nevertheless, the IPCC could be seen as rather successful in including new authors from outside and their innovative ideas and findings into the assessment process. This is certainly a success factor for the learning that could be observed, although the IPCC mostly included scientists with a broad expertise in peer-reviewed literature and excluded those experts that could have important knowledge without these credentials. This turned to be problematic in the case of vulnerability assessments especially in the developing world where there are hardly any experts that have considerable publication records in the peer-reviewed literature although they have accumulated significant knowledge that might be valuable especially for more regionally focused assessments of climate impacts and mitigation strategies. On the other hand, the IPCC did not fully include those experts that could be helpful in procedural issues.

Looking at ways to *save existing knowledge* at the IPCC, one could find a fairly simple system in place. It is maintained in first place by the secretariat in Geneva where all the official documents are being stored. Given the heavy work load of the secretariat, its responsiveness to requests for certain materials is limited. Most of the procedural information and specific information about the individual Working Groups is held by the Technical Support Units (TSU) of each Working Group. They provide the necessary basic information for new participants in the progress, be they authors, reviewers or even review editors. Except for the TSU of Working Group I which always remained in the UK, the location and the staff of the TSU kept changing over the three assessment rounds due to changing host countries. Therefore, the continuation of the work and the ongoing processing of information could be suffering from these shifts especially because there is no advanced system of information storage in place.

In terms of *hierarchy*, on first sight the organizational structure of the IPCC seems very complex, there are various different functions, bodies and decision making procedures. But at second glance the organization proves to be rather lean. The chairperson is presiding over the IPCC Bureau consisting of five vice-chairs plus the co-chairs and vice-chairs of the Working Groups. Each Working Group has two co-chairs and six vice-chair positions that are usually equally given to representatives from industrialized and developing countries. The work of the Working Groups is coordinated and administered by individual Technical Support Units (TSUs) that are mostly located in industrialized countries from which they obtain their funding. Only the IPCC secretariat, based in Geneva, is funded by the parent organizations, the UNEP and the WMO. The Bureau prepares the decisions to be taken at the plenary sessions, which are attended by government officials from the member nations of UNEP and WMO. At these regular annual meetings, the Panel accepts and approves IPCC reports, decides on work plans, the structure and outlines of reports, the IPCC rules of procedure, and the budget; it also elects the chairperson and the Bureau. It is the responsibility of the co-chairs of the Working Groups to select the lead authors of the chapters based on government nominations and to coordinate their work.[22] Meanwhile the number of authors involved has risen up to nearly 1500 leading and contributing authors over all three Working Groups in the Third Assessment Report.

In terms of the *network structure*, the IPCC consists of a twofold arrangement: a dense and small network of the core group of people – mostly the Bureau members and some authors of the guidance papers and the synthesis report – and a huge but loose network of authors around the world. Whereas members of the core groups frequently met each other personally, most of the authors communicated only via electronic or regular mail. In this context, the ability to learn largely depends on the members of the core network and their willingness and capability to take up new knowledge and ideas form the bigger network and to transform it into practical innovations for the IPCC procedures. However, the huge but loose network implies severe difficulties in keeping together the network and to disseminate innovations as it was the case with the group of authors resisting the general framework of uncertainty measurements. In addition, the other cross-cutting issues such as costing methodologies or the treatment of equity issues have hardly

influenced the work of the authors either because the dissemination was too difficult and authors felt no commitment to the suggested measures. The tendency of ever growing numbers of authors from one report to the next might aggravate the problem. Moreover, the limited access to communication networks in the South might inhibit experts from this part of the world to actively become part of the core network.

Concerning the *communication processes* among the scientific and the political community, it has frequently been stressed by interviewees that – apart from keynote addresses – scientists involved in the IPCC process usually refrain from participating in the negotiation process in order to ensure their scientific neutrality (Houghton 2001, Moss 2001). However, no documented rules exist on this issue. Direct official interaction between both spheres is limited to the more formalized fora and processes. It is scientists of the Bureau who develop an outline of the report and or the division of labor among the Working Groups. They propose it to the political community at one of the plenary sessions where a final decision is to be made. Then they select the authors and reviewers based on the principles of scientific expertise and geographic representation. By contrast, the whole process of preparing the chapters and the first round of peer-review remains exclusively in the scientific realm. Governments come into play once again in the second round of review when their comments are being solicited and they have a major role in the approval of the Summary for Policymakers and the Synthesis Report.[23] There are only a few settings where both groups come together for direct communication. The most important one is certainly the Joint Working Group (JWP). It has been emphasized by interviewees that the introduction of highly specialized reports in 1994 and so-called 'rapid response' Technical Papers in 1996 was subject to intense discussions in the JWG. Since then, these reports have significantly facilitated the transfer of scientific and technical information into the political process (Agrawala 1998b). However, formal communication structures still have room for improvement as far as the internal interaction between the working groups is concerned. Moreover, also the external communication with the negotiating bodies and the general public is far from being perfectly designed to optimally facilitate mutual learning. Especially the dialogue with the general public is scant in the preparations of the IPCC reports. Communication remains in a one-way mode where scientists try to explain their findings to the public. The procedures are still scarcely prepared to foster a more open dialogue to include so-called lay knowledge or the general concerns, thoughts and attitudes of the public in different parts of the world which might trigger significant learning procedures within the IPCC. By taking this kind of knowledge more seriously, the IPCC might gain more saliency to users on the side of the general public and more legitimacy since even a broader range of perspectives could be encompassed in the process. This task might also be transferred to a collaborating organization in order to keep a clear delineation between the assessment functions and the external communication and information.

What are the underlying *cultural values and norms* that the people involved share and how did these values contribute to learning in the IPCC? It is one basic shared belief among the participants that science could lead to better decisions in the problem area at hand (Leary 2001). Because the IPCC assessments are being prepared by scientists, basic rules and principles of science also govern most of their discussions, arguments and ways of interaction in general. For example, a commonly shared notion of truth as being something that could be found through repeated testing and empirical research could provide a venue to bring discussions to a conclusion (Houghton 2001). In the case of the chapter-8-debate this was not a viable solution any more as soon as legalistic arguments were brought into the debate that had a largely different rationale to them. Here, the basic beliefs of most of the participants had been challenged and had to adapt to this kind of thinking which in the end lead to the adoption of new rules of procedures.

As far as taboos are concerned that might hamper learning effects, interviewees referred to the general reluctance of scientists in the IPCC to be prescriptive towards policy makers. Policy recommendations that can be found in the reports generally are phrased as options and possibilities. Only as far as research policy is concerned, some members support more clearly described recommendations, e.g., about needs

for further climate impact research. However, like any taboo, this one might hinder learning processes along the science-policy interface.

Informal Communication structures are regarded crucial for organizational learning. As far as learning mechanisms and other design issues in the IPCC are concerned the most important form of communication was informal communication among a core group of people. Mostly these individuals were members of the IPCC Bureau who met regularly to discuss and decide about certain issues and – among other things – also about the future design of the IPCC. This holds especially for the learning endeavors in the period of Bert Bolin's chairmanship from 1988 until 1997. It changed slightly when Robert T. Watson took over and kept the reflection mechanisms more under his personal supervision. In addition, informal communication is given high priority at the meetings of the chapter authors. These meetings give them the chance to interact with many of their collaborators and to establish personal relationships with them.

Reputation and trust play important roles in the IPCC procedures, since these are built on scientific reputation of the Bureau members and the authors. However, because the processes have been formalized tremendously over the past decade, individuals with a high reputation in the scientific field do not automatically have a larger say in the IPCC procedures than others with less reputation. It is the reputation of the chairpersons that is important for internal changes and learning. Here, none of the interviewees reported of any complaints or a questioning of their expertise. Trust seems to be the underpinning of informal communication and decision-making processes as they were fundamental to IPCC changes.

In general, the whole IPCC process heavily relies on the *individual personalities* involved and their personal contacts amongst each other. It is their constant contribution to and engagement in the IPCC procedures that keeps the process running especially since the IPCC does not provide any financial compensation for them (which again hinders Southern participation especially in the core group). Although the whole organization has gone through a process of bureaucratization of the past decade, it is still a core group of people knowing each other personally that prepares the important decisions. Nevertheless, the rules of procedures in place and the bureaucracy behind it are strong enough to keep individuals from dominating the process individually (Leary 2001). Fundamental decisions can only be made by the Panel itself and not by the chairperson or other Bureau members. However, the chairperson is powerful enough to keep certain ideas or concepts out of the process by executing his powers as chair of many sessions. In so far, learning of the IPCC on a collective level certainly is dependent on learning by individuals and on their willingness and ability to learn. As described above, they have proven to be flexible and able to learn in cases of several procedural innovations like the attempts to broaden participation, to introduce review editors, and to establish specialized technical papers.

One crucial initiator to learning processes in the IPCC has been the *conflict* about chapter 8 in the Second Assessment Report where several individuals form outside the IPCC felt dissatisfied with the final outcome and the procedures that lead to them. Their criticism sparked off a major conflict and lead to significant adjustments and changes in the IPCC rules of procedure. Internal dissatisfaction referred to the treatment of uncertainty, which was somewhat inconsistent in the First and the Second Assessment Report (Schnieder 2001). This dissatisfaction in combination with the personal skills of the main proponents of a standardization across working groups lead to the double-loop learning process in the Third Assessment Report

Which *external factors* influenced single- or double-loop learning within the IPCC? One of the main influences in the first phase of the IPCC was the success of the international ozone assessment as one of the interviewees pointed out. Participants in IPCC either took part in this assessment or knew about it from diverse sources. Its design as an international assessment and the close linkage to the negotiation

processes with strict regulation in the outcome convinced many people to regard the ozone assessment a success. However, a number of other factors apart from the assessment itself were also influential in this case, e.g., the availability of alternative technological solutions, political interests and the first signs of damages of the ozone layer. Over the years, it became also clear to many of the participants in the IPCC and in the climate change negotiations that the climate case was not entirely similar to the ozone case predominantly because of the importance of these underlying factors (Benedick 1999).

The *media coverage* on the IPCC and its reports grew enormously over the years and certainly lead to some adjustments in the IPCC procedures. Thus, Bureau members became rather cautious about releasing information to the press without having double-checked them (Houghton 1998). One reason for the careful interaction with the media was the fact that the criticism on chapter 8 in the Second Assessment Report was first published in the daily press raising public attention to the internal procedures of the IPCC. IPCC members realized at that time that wrong or unfortunately phrased press releases or interviews could do harm to the IPCC's reputation. On the other hand, through these incidents most of the IPCC members developed some kind of a fortress mentality as far as external relations were concerned. From a learning perspective, this mentality has to be seen rather critical since it inhibits the opportunities to bring in new knowledge into the organization and to foster dialogue and open exchange. Thus, by and large the intense media coverage seems to have had a slightly negative effect on learning in the IPCC over the years although it certainly led to a high public awareness of the problems of climate change.

Coming back to the chapter-8-debate, this *external criticism* certainly had a sizeable influence on the learning processes in the IPCC. Since the attack was backed by strong economic interests, it could be concluded that economic pressures also had an influence on the learning of the IPCC in regard to the internal procedures and the underlying rationale.

4 THE LRTAP CONVENTION

The Convention on Long-Range Transboundary Air Pollution is one of the main international efforts to combat acidification and other damages to ecosystems, buildings, and human health in Europe and North America. Due to the fact that the pollutants travel thousands of miles through the air, the convention addresses the problem of air pollution on an international scale. Having been signed in 1979 and having entered into force in 1983, the Convention was the first international legally binding instrument to deal with this problem. Since then, eight protocols on different pollutants and procedural matters of the convention have been signed under the auspices of the United Nations Economic Commission for Europe (UNECE). The first five of the following protocols have entered into force so far:

(1.) The 1984 Protocol on *Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP)*;

(2.) The 1985 Protocol on the *Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent*;

(3.) The 1988 Protocol concerning the *Control of Nitrogen Oxides or their Transboundary Fluxes*;

(4.) The 1991 Protocol concerning the *Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes*;

(5.) The 1994 Protocol on *Further Reduction of Sulphur Emissions*;

(6.) The 1998 Protocol on *Heavy Metals*;

(7.) The 1998 Protocol on *Persistent Organic Pollutants (POPs)*; and

(8.) The 1999 Protocol to *Abate Acidification, Eutrophication and Ground-level Ozone* (the so-called Multi-Pollutant/Multi-Effects-Protocol).

The Convention has set up a multi-layer organization to organize the participation of the various countries and to include scientific assessments on the numerous technical and scientific questions of air pollution.[24] All the protocols have been negotiated by the Working Group on Strategies including representatives from all the parties of the convention. It prepared the documents for the final decision-making by the Executive Body. Scientific assessments of the effects of air pollution have been carried out under the Working Group on Effects whereas assessments on methodological questions, like modeling, and the monitoring have been organized in the form of Task Forces that directly report to the Executive Body of the Convention. Generally speaking, the assessment bodies were more closely linked to the negotiation process than in the climate change area. However, the whole organizational structure and the institutions of scientific assessment evolved over the period of more than two decades since the signing of the convention. In these scientific bodies, some changes over time and some reflexive learning took place, which will be analyzed more thoroughly in the following sections.[25]

4.1 Reflective mechanisms and learning

Which kinds of reflective mechanisms were put in place to make use of past experiences and to which types of learning did they lead? Concentrating on the way the scientific assessments developed in regard to their organizational set up, their design, and the interaction with the negotiating bodies, I distinguish between three overlapping phases. These are not focused on the advancements in the negotiations and the different protocols established under the convention since these largely remain in the political realm.[26]

Setting up the organizational structure (1979-1988)

After the signing of the convention it took a while until the organizational structure with the two main working groups and various task forces had been established. The convention foresaw the establishment of the Executive Body and the secretariat for the administrative support. It put in charge the Executive Body to create "working groups to consider matters related to the implementation and development of the present Convention" and also stated the "desirability of establishing a framework for a cooperative environmental monitoring programme" (UNECE 1979, Articles 9 and 10). As a first important step towards implementation and towards setting up an effective organizational structure for the assessments, the first protocol under the convention ensured the funding for EMEP, the "Cooperative programme for the monitoring and evaluation of the long-range transmission of air pollutants in Europe".[27] By collecting, processing and analyzing air-pollution data, EMEP was the precondition for both, for the political negotiations and for their scientific advice. Moreover, EMEP grew out of an OECD research programme on long-range transboundary air pollution, which existed from 1973 until 1975. This assessment was effective inasmuch as it demonstrated that air pollutants have the potential to travel very long distances. Although this assessment had a large number of uncertainties in its final documents, it convinced many European policy makers of the need for pollution control (VanDeveer 1998). Nevertheless, due to its limited scope and design, this assessment could hardly be seen as a model for the following assessments but rather as an appetizer.

Also on a very early stage in the convention process, the Working Group on Effects came into being to provide the information on which the negotiations of further protocols were based. As phrased in the convention, its task was to conduct research on "effects of sulphur compounds and other major air pollutants on human health and the environment, including agriculture, forestry, materials, aquatic and

other natural ecosystems and visibility, with a view to establishing a scientific basis for dose/effect relationships designed to protect the environment." On each of these areas where effects of air pollution had been observable special international programmes had been established under the supervision of the Working Group on Effects.[28]

EMEP and the Working Group on Effects were both dedicated to providing information for the political process and they were seen as necessary to convince policy makers to take action but it was hardly used in the process of designing the first series of protocols. Although the convention considered scientific information pivotal to its processes, the first negotiations and the resulting protocols were hardly based on scientific information: "There was a link between policy and science but it wasn't very strong" (Bull 2001). Since the first three technical protocols were based on a flat-rate approach that pursued fixed rates of emission reductions without clear links to effects, scientific information about effects was peripheral. However, the work of these groups was important for the political process in three ways. Firstly, it helped to put pollution control on the political agenda and to raise policy maker's awareness for the problems caused by air pollutants. Secondly, scientific information helped to identify major sources of air pollution and, thirdly, it shaped the way how uncertainty was handled in the negotiation processes as carried out in the Working Group on Strategies (Eckley 1999).

The last working group that came into being was the Working Group on Abatement Technologies. It was focused on technologies and industrial processes to reduce emissions. Like the Working Group on Effects, it consisted of scientists working for governments or civil servants who were responsible for science. Therefore, they could be seen as scientific assessment bodies since they were in charge with providing scientific and technical information for the preparation of protocols to the Working Group on Strategies and to the Executive Body.

In terms of *reflective mechanisms*, these assessment bodies in this phase utilized mainly two means to facilitate learning: international workshops and critical discussions at the Executive Body. The workshops were organized around various specific questions that came out of the task forces and working groups and included scientific expertise from outside of the convention process. Thus, the set of participating external scientists varied from one workshop to the other. In the workshops, external scientists from the participating countries brought in their oftentimes detailed and highly specific knowledge and were asked to simplify it and to make it more accessible for policy makers and integrative modeling approaches (Bull 2001). Thereby, they helped to develop the integrated assessment models that became crucial in the second phase. Moreover, the workshops were a means to ensure scientific credibility by including high-ranking scientists. Since they were international in the participation, legitimacy was ensured as well. However, the organization of a workshop is a lengthy process. The idea to organize such an event has to be approved by the specific working group and the Executive Body in their annual work-plans. In total it might take a year or even longer from the idea to the actual event. Since the workshops – especially in the initial phase of the convention – were mostly centered around scientific issues, there was little room for reflection on general procedural questions like how the whole assessments process works and how it might be designed best.

Whereas the workshops provided rather indirect opportunities for reflection on procedural issues, occasional evaluation and discussion in the Executive Body were more focused on the development of the organizational structure, its functioning, its effectiveness and the assessment process. However, these discussions took place more on an ad-hoc basis and have mostly not been based on thorough evaluations. In most cases, hey were brought up by certain country representatives with the aim to reduce the costs of the LRTAP process (Wüster 2001).

Both of the reflective mechanisms used in this phase did hardly spur deeper reflection processes on the process of scientific assessment as a whole. The learning effects generated in these first years remained

mostly in the field of single-loop learning since the main task was to establish a functioning organizational structure for the negotiation and effective implementation of the convention and its protocols. The general tasks were already described in the convention itself so that there was little room for fundamental experimentation about how to conduct scientific assessments under the convention and how to feed scientific information into the process. Moreover, the newly established institutions for the provision of scientific information for the political processes remained rather marginalized since the first protocols were predominantly political. This is not to say that the assessment bodies were useless and ineffective. They managed to establish a scientifically credible and politically legitimate assessment process, which was still lacking some salience to the policy makers.

Introduction of the critical loads concept and the RAINS model (1988-1999)

It was already in the 1988 protocol on nitrogen oxides that the critical loads concept was mentioned as a possible conceptual framework for future protocols under the convention and it was through this concept that serious science was kicked into the process. Whereas the protocols of the so called "first generation" simply adapted a flat-rate approach using a fixed percentage of emission reductions, the "second generation" of protocols starting with the sulfur protocol of 1994 was effects-based and adhered to the critical loads approach. According to Haas & McCabe (2001), "the concept was virtually revolutionary in diplomacy because it assigned differential national obligations based on the carrying capacity of vulnerable ecosystems rather than a politically equitable (and arbitrary) emission cut." In regard to the evolution of the scientific assessments under the convention, the introduction of the critical loads concept was equally revolutionary even though the resulting changes were not based on a deep reflection of the assessment processes themselves but of the concept.

What was it about the critical loads concept that it managed to revolutionize the political as well as the assessment processes of the convention? As phrased in the Nitrogen Oxides protocol, "critical load means a quantitative estimate of the exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge" (Article 1). The 1991 VOC protocol also included damaging effects on human beings into this definition. In essence, this concept focused on the regional damages and approached pollution control from this end in order to effectively protect ecosystems and human health (Bull 1992, 1995). By contrast, previous pollution abatement strategies concentrated on overall emission reductions at all sources largely irrespective of the actual damages of specific emissions in certain regions. Whereas it was more or less a matter of political negotiation over how many emissions have to be reduced, in the critical loads approach, the different emission reduction requirements could be deduced for different regions. This allows for more cost-effectiveness. However, effective pollution control under the critical loads approach requires reliable scientific input in order to get some indication about the regional effects and emission reduction requirements.

Therefore, the "International Cooperative Programme for Mapping Critical Loads and Levels and their Exceedances" (ICP Mapping) was put in charge of collecting the available regional data on damages to forests, crops, natural vegetation, soils, surface and groundwaters, and materials based on data about the environmental sensitivities of these ecosystems. Subsequently, it produced maps on the state of ecosystems with a resolution of 150 square-kilometers. These maps indicated the exceedance rates against the commonly agreed 5-percentile damage of bearable emissions.[29] Data collection and mapping was exclusively carried out by scientists from the national focal centers.

In the LRTAP convention, the crucial means to link these scientific data systems with the political processes under the critical-loads approach was the RAINS model – an integrated assessment model developed by the International Institute for Applied Systems Analysis (IIASA).[30] It allows for the analysis of alternative strategies to reduce acidification and other damaging impacts on a regional scale and in this

respect it is a "scenario-generating device" (Alcamo et al. 1990, p. 1). The model integrates information on:

- projections of future economic, agricultural and energy development the participating countries,
- present and future emissions of air pollutants resulting from these activities,
- options for reducing emissions and the costs of these measures,
- atmospheric dispersion characteristics of these pollutants, and
- environmental sensitivities of ecosystems especially towards acidification.

Therefore, it could be seen as an approach to integrate the scientific and technical information generated by the various task forces and working groups under the convention in order to provide highly policy-relevant information. Since the critical-loads approach required significant scientific informational input to the political negotiation processes to determine the relevant emission reduction targets and to decide about the best abatement strategies to reach these targets, the RAINS model quickly gained great prominence, although alternative models were available but they could not catch up with the advancements of the RAINS model (Wüster 2001).

At the beginning of the development of the RAINS model in 1991, IIASA organized a workshop and invited one negotiator and one technical person from each delegation to the convention. As a learning mechanism, it was intended to demonstrate the model, to test the applicability of the model in negotiations and to train negotiators in the use of the features and capabilities of the model and its outcomes. As Hordijk (2001) points out, the workshop has been crucial for the non scientific people involved in order to capture the difficulties of the critical loads concept and to deal with the complexity of the model and the issues of air pollution in general.

In terms of saliency, the use of the RAINS model in the negotiations on further emission reductions, in particular in the preparation of the second sulfur protocol signed in 1994 gave a boost to the applicability of scientific information in political processes. In addition, the model was accepted by negotiators as scientifically credible and politically legitimate in its development (Patt 1998). Therefore, it seems justified to regard the introduction of the critical-loads concept a double-loop learning process within the scientific assessments under the LRTAP convention. It led to changes in the general perception of the role of assessments in the political process and in the way the assessments have been carried out.

In the period between 1988 and 1999 other reflective mechanisms had been used in the process of the LRTAP convention that led to learning processes. On the general level, the process had to go through two major review processes focusing on the activities and the national implementation of the protocols in particular. The first major review took place in 1994, the second in 1998 (UNECE 1994, 1998). Both focused on the documents and technical data submitted by the parties and were put in final reports that had been presented to the Executive Body. However, since these reviews concentrated on the actual implementation processes of the protocols themselves, they did not focus on the scientific assessments and the relevant bodies created. Thus, no direct learning effects in procedural matters could be detected from these reviews, but they provide an opportunity for this kind of evaluation of the scientific bodies as well which might be of use in the future.

On the level of the individual working groups, interviewees reported about two external reviews of the Working Group on Effects (Bull 2001). One took place in 1992/93 when government delegates at the Executive Body questioned the need for two additional groups, the ICP on Integrated Monitoring and the Task Force on Mapping. The Executive Body decided to request an external review from Tom Brydges who was perceived as an expert in the field of acid rain research in Canada. The report concluded that there was a need for better communication among the ICPs working under the Working Group on Effects.

Even the head of the Working Group on Effects at that time resumed: "Up to that point the different ICP were working rather independently, they were gathered together at the Working Group on Effects meeting each year to present their results but they didn't know each other and didn't talk to each other and didn't identify any commonalities" (Bull 2001). The results of the report had been discussed at a meeting of the Working Group in Sweden where the IPCs and the task forces started to find out commonalities and initiated intense communication among each other. Moreover, Bull (2001) concluded "from that point they started to develop work patterns that were more specifically tailored to the convention." Thus, a Bureau under the Working Group on Effects was established at that time including the chairpersons of the task forces and the representatives from the ICPs who were responsible for bringing the data together. This group of about 20 people met about 2 or 3 times a year and discussed the common issues among the programmes. They also produced joint reports on these issues, which went to the Working Group on Effects.

In sum, there is a tendency to increase saliency of the work of the various assessment bodies through an intensified and more focused communication among the subunits and through the integration of their results in the work of the Bureau, which tailored the outcomes to the political decision needs. Although these changes did not fundamentally change the whole assessment process of the convention, there is indication for double-loop learning processes given the reflective character of the report and the conscious redesign of the collaboration of the task forces and the ICPs. Moreover, the reflective mechanism of external reviews had been repeated since another review had been requested from and prepared by the same external reviewer four years later.

Restructuring after the Gothenburg protocol (1999-2001)

The Gothenburg protocol signed in 1999 is perceived as a "third generation" of pollution control protocols as it takes into account the interdependencies of environmental effects such as acidification, eutrophication and ground ozone accumulation and the related pollutants based on the critical-loads approach to achieve effective reductions of environmental damages at least cost (Jagusiewicz 1999). Given the current state of knowledge on the causes and damages of air pollution, the Executive Body decided that no further protocols will be negotiated under the LRTAP convention. Consequently, some major restructuring took place in order to redirect the organizational setup towards the reversed focus on implementation and review issues (Executive Body 1999).

The process of restructuring also affected the scientific assessment bodies and their work. The Working Group on Abatement Techniques was dissolved since its main task was the preparation of technical annexes to the protocols; the Working Group on Strategies had been renamed in order to add its responsibility for the review of the current protocols and for possible revisions and initiatives. In addition, the focus on health effects was introduced in collaboration with the World Health Organization (WHO). Moreover, the Task Force on Integrated Assessment Modeling had been moved from the Working Group on Strategies across to EMEP to link it more closely to the scientific activities. Thereby, the integrated assessment modeling was moved away from the political processes resulting in possible decreases in the saliency of its work for the political decision makers. In general, interviewees acknowledged that the political influence of the integrated assessment modeling in the LRTAP process decreased after the conclusion of the 1994 sulfur protocol while the scientific orientation of the modeling has been strengthened (Wüster 2001). Nevertheless, they were also quite confident that communication between the modeling community and the political bodies will continue given the history of their links in past negotiation processes (Bull 2001).

In terms of learning mechanisms, these changes had been prepared by the Bureau of the Executive Body consisting of the chairman and the vice-chairs of the Executive Body. They consisted of a five-page note that had been distributed among the government delegates of the Executive Body in 1997. For the

preparation of this note, the Bureau consulted the chairmen of the working groups and the "main subsidiary task forces" (UNECE 1999, p.1). The note had been distributed among the members of the Executive Body in order to initiate discussions and to lead to a final decision-making about the future priorities and the organizational structure, which was finally agreed upon in 1999.

However, the restructuring did not set an end to the reflection processes over the future strategies and pathways to combat transboundary air pollution. The topic has been discussed at a specific workshop in April 2000 in Sweden, which can be seen as a reflection mechanism *par excellance* that was intended to facilitate further learning – in particular since it covered topics central to the development of scientific assessments such as the sector integration, the linkages between global models and regional or national scales, the role of economic models and advancements in integrated assessment modeling (Nordic Council of Ministers 2000). New directions of the scientific assessment under the convention as described in the workshop documents include the integration of health aspects and the narrowing of the monitoring grids from 150 km^2 to 50 km^2 grids. These efforts might lead to a greater saliency to regional users as well as to users from other communities like the public health community. Moreover, the development and use of dynamic rather than static models and the close examination of uncertainties involved could serve to improve scientific credibility of the assessment (Bull 2000). Since the outcomes of the workshops could not be analyzed within this study due to the actuality of the event, it could be stated that the workshop has the potential to spark off tremendous learning effects – especially because the whole convention process is standing at some kind of a cross-roads and has to redirect its activities.

4.2 Influences on learning

Which factors could be held accountable for the learning processes within the scientific assessments of the LRTAP convention? In parallel to the IPCC case study, I address this question on the basis of the conceptual framework as developed in section 2. Thereby, I focus on structural, cultural and personal factors that are scarcely changing over time since they are more or less inherent to the design of the LRTAP assessment bodies and processes.

Concerning the *exchange of individuals* throughout the different organizational units of the convention, two observations could be made. First, there is a continuous exchange of individual negotiators and scientists between the political bodies of the convention, in particular the Executive Body and the Working Group on Strategies (and Review). It has been stressed by interviewees that most of the members of the Executive Body also take part in the Working Group meetings and allow for a transfer of knowledge among theses bodies. Second, the exchange of individuals between the different Working Groups and even between the Task Forces and ICPs under one Working Group is rare although there is an intense exchange of individuals and knowledge between the Working Groups and its affiliated Task Forces and ICPs since they have to report to the Working Group. Thus, no clear indication is given for an optimal flow of new knowledge (and therefore for good opportunities for learning) throughout the organizational structure as far as it is based on the actual exchange of people.

One of the main success factors for the LRTAP convention and its assessments certainly was the continuity of a large percentage of its personnel especially in the first decade of its existence. Thereby newly acquired technical and procedural *knowledge* could be *kept inside* the organization and passed on through individuals. However, in the beginning of the 1990s, a number of people in particular political officials left the convention and turned to the newly hot topic of climate change which attracted significantly more attention at that time (Hordijk 2001). Nevertheless, those individuals that were key to the advancements of the political processes and most of the scientists remained within the framework of the convention contributing to the successful input of scientific and technical information into the political

processes. In addition, the secretariat remained at the same location and had a rather staff, which allowed for the uninterrupted continuation of processes and for the accumulation of valuable procedural knowledge.

The *hierarchy* in the LRTAP organization could be characterized as rather flat since the main decision making body is the Executive Body which receives informational inputs from the subordinated Working Groups. Whereas the Working Groups supervise the Task Forces and the ICPs that are affiliated with them. Moreover, there are no specific rules of procedure for the LRTAP processes as in the IPCC case. The convention simply uses the general UN rules of procedure which are based on the consensus principle. Hence, there cannot be a strong individual leader dominating the whole process. Decision-making is highly participatory in terms of the involvement of the parties to the convention – at least as far as the Executive Body and the Working Groups are concerned. In comparison to the IPCC, the diversity of participants in the LRTAP process was lower as there were no developing countries participating. Jagusiewicz (1999, p. 17) points out that the Executive Body "has always been sensitive to new scientific evidence, to innovative approaches to solving the problem and to the need to protect human health and ecosystems effectively and cost-effectively." Given the body of evidence presented above, there seems to be some justification for this position. Thus, the Executive Body could be seen as a supporting factor for learning processes in the LRTAP convention in general.

When compared to the IPCC, the *network structure* of the LRTAP assessments under the convention does look very similar since it also consists of a small but dense core group of individuals active in advancing the political and the scientific assessment processes and larger network of loosely connected people, in particular scientists. However, it is the scientists in the Task Forces and ICPs who carry out the core of the assessments whereas the individuals of the bigger network only contribute occasionally to workshops or specific documents. Therefore, the whole assessment process is less dependent on their input than the IPCC is on the contribution from the authors, which renders the LRTAP structure comparatively more effective.

Most of the scholars examining the LRTAP assessments highlight the continuous, iterative communication among scientists and negotiators as one of the crucial preconditions for the successes of the convention process (Eckley 1999, VanDeveer 1998). However, it has to be questioned to which extent this has to be credited to formal *communication structures* versus informal communication networks. Formal communication relationships exist mainly between the Working Groups and its subordinate Task Forces and ICPs and between the Working Groups and the Executive Body – mostly mediated through the Working Group on Strategies and Review. Since the working groups and task forces had a constant exchange of people who attended meetings of other groups or of the Executive Body, intense interaction was possible (Bull 2001). This structure granted the flow of scientific and technical information into the negotiation processes. It was rendered highly effective through the informal communication among the members of the core group of active scientists and negotiators. Since there were personal relationships between the people of this core group, informal communication played an important role in the interaction between negotiators and scientists as well as among the two groups. In the negotiations about the second sulfur protocol, the scientists from the Task Force on Integrated Assessment Modeling even confronted the negotiators with an ultimatum in order to move the negotiations forward. After having informed the political decision makers about all the possible scenarios for emission reductions and their likely outcomes, the scientists refused to carry out any further modeling until the negotiators would agree on a clear emission target for the protocol. They finally succeeded in that the negotiators found some compromise on the issue and the negotiations continued (Hordijk 2001). Although the scientists clearly overstepped their traditional role as advisors, the attempt was successful which might be credited to the good informal communication networks and the *trust* negotiators had in the scientists and in particular in the modelers from IIASA.

As far as shared *values, norms, and beliefs* among the participants in the LRTAP process are concerned, it could be stated that the standards of technical knowledge even among the negotiators were high when compared to other international negotiations since most of the individuals involved are – or have been – scientists. Thereby, a common framework existed among them in the field of (natural) scientific methods and norms. In addition, interviewees pointed out that they also had a commonly held commitment to reduce air pollution and to improve the environmental situation in Europe and North America (Bull 2001, Hordijk 2001). Learning processes in regard to improvements of the assessment certainly profited from these commonalities. Thus, they might be addressed as an "epistemic community" in the sense of Haas (1992).

Given the intense informal interaction in the LRTAP process, *trust* played a significant role in it as far as scientists are concerned. It was build on their *reputation* in the scientific arena and on the reputation of IIASA as an independent and highly respected research institution among Western and Eastern countries. The extent of trust could also be seen in the absence of any peer-review procedure in the scientific assessments. Except from cross-checks of the data delivered by the member states, there is no formal review procedure in place that could be comparable to the IPCC. This fact is interesting inasmuch as effective assessments obviously could be carried out without a sophisticated peer-review procedure, when personal relations among the participants are based on mutual trust – in particular between scientists and political decision-makers. However, this trust-based relationship might be put under jeopardy when trust is misused by one side or the other and when there is no mechanism in place to ensure the reliability of information.

The LRTAP process has been driven by a small number of *individuals* from both sides, the political and the scientific realm. On the political side it was in particular the Swedish delegation leader who managed to push the process. In the scientific area, scientists involved in the negotiations were important for the progress of the process since they learned to think strategically in their interaction with the policy makers as the case of the ultimatum demonstrates. They became cautious in the provision of certain information and the timing of the release of information based on their growing insights in the dynamics of the political processes (Bull 2001). Thereby, the scientists adapted to the rules of the assessment processes and proved to be able to learn about the political functions of their engagement in the assessment.

Which influence did *external factors* have on learning in the LRTAP assessments? In the first phase until the beginning of the 1990s political pressures from the East-West confrontation permeated through the whole process and forced participants to follow the general rules of the political interaction among the different systems.[31] On the other hand, the LRTAP convention was one of the few fields of East-West cooperation at that time and thus it was given priority among policy makers who were interested in this kind of bilateral communication and collaboration. However, there were certain limits to the development of the convention and to the learning possible in the process, in particular with respect to the political functions of the assessment.

5 COMPARISON AND CONCLUSIONS

When compared, both cases do not differ tremendously in their ability to learn. The IPCC and the LRTAP assessments demonstrated their capabilities of learning in single- as well as in some rare double-loop learning processes. Therefore, it is difficult to judge which assessment proved to be better in this respect although they exhibited different degrees of effectiveness in regard to their influence on the political process. Under this perspective, the LRTAP assessments have been quite successful whereas the IPCC had problems in effectively influencing the political processes in the climate change area. However, the

overall effectiveness of the IPCC assessments is complicated to judge given the various factors affecting the outcomes of negotiations, especially in highly contested fields such as climate change. Nevertheless, even participants in the negotiation process claim that without the 1990 and the 1992 IPCC reports there would not have been such a thing as the Framework Convention on Climate Change (Cutajar 1999). Judgment becomes much more difficult where the Kyoto Protocol and its implementation process are concerned.

The comparison of the reflective mechanisms employed in the two assessments shows some differences. In the case of the IPCC from the Third Assessment Report onwards, there has been a tendency to keep the learning efforts under close control of the chairman. It was him who prepared the White Papers about the future structure of the IPCC and he collected the comments on it and poured them into a final suggestion to the IPCC Panel. By contrast, the first chairman attempted to involve all members of the IPCC process in the process of reevaluation and restructuring for the Second Assessment Report. Similarly, in the LRTAP assessments, the reflective mechanisms were open to all the members of the Executive Body or of the respective working group (Working Group on Effects). Whereas the first approach could be characterized as more centralized, the other approach might be seen as more participatory.

The examination of the structural, cultural, personal and external factors influencing learning processes in the two assessments has revealed some significant differences that might account for differences in the timing, the duration and the outcomes of learning processes in the two cases. The main differences were the following:

- The *communication structures* in the IPCC were more exclusive in their attempt to draw clear boundaries between scientists and government representatives. In the LRTAP case, there has been an open and intense interaction between the scientists and the negotiators which allowed for a better flow of information.
- In terms of the *internal structure*, the LRTAP processes seem to be a little less hierarchical and less structured by strictly defined rules of procedure than in the IPCC case. Thereby, participants in the assessment are allowed more liberty in regard to self-organization and informal communication.
- The *personal capabilities* of scientists and decision-makers involved differed in both cases to a certain extent. In the LRTAP case the scientists involved developed a more clearly detectable insight in the political nature of their endeavors by adapting a kind of strategic thinking, whereas in the IPCC case the scientists involved retained the position to stick to scientific methods and norms in order to maintain scientific credibility.
- The IPCC has been confronted with a high amount of *external criticism*, which on the other hand seemed to have contributed to some learning processes. By contrast, external criticism and contestation in the LRTAP assessments have been rare and did not directly lead to learning processes which might be explained by lower stakes and a smaller diversity of views and participants.

As shown in this paper, learning mechanisms are one part of the design-related decisions in assessments that organizers have to think of when planning and conducting the assessment. The way past experiences are brought into bearing could be viewed as crucial for the credibility, the legitimacy, and saliency – and, thereby, for the overall effectiveness of assessments.

What are the conclusions to be drawn from these findings and which are the facilitators of learning that should be given larger attention in future assessments? Summarizing the findings of this study, it could be distinguished between indirect and direct facilitators of learning processes, be they single- or double-loop

learning. Among the indirect factors that have to be at present in order to make learning possible or more likely to occur we have to think of the following:

- *Exchange of individuals* among the different organizational units of the assessment organization,
- Provision of *continuity in the basic administrative and organizational functions* through constant offices or a constant stock of people in charge with these tasks,
- Establishment of a *small but dense network of active people* who run the core activities of the assessment and who are in constant communication with each other,
- Establishment of *intensive informal communication relationships*,
- Existence of *energetic change agents* in key positions in the assessment organization.

On the side of the direct facilitators, the cases demonstrate the importance of conflicts or external criticism, which sparked off learning processes in both assessments. In the IPCC case it was the chapter-8-debate that led to a revision of the rules of procedure and a partial rethinking of the whole assessment endeavor. In the LRTAP assessment it was the external evaluation that initiated fundamental learning processes in the Working Group on Effects. However, conflicts and criticism is not the only immediate trigger of learning processes. The cases also show that some learning processes have been started because of interruptions or pauses in the assessment processes, e.g., after the finalization of a major assessment report.

On the whole, designers of assessments have several design options at their disposal to institutionalize learning procedures in particular through improvements of the indirect facilitators of learning processes and through the introduction of reflective mechanisms. However, the simple adoption of one of these mechanisms will hardly be sufficient for thorough learning processes when there are no structures in place that could correspond to the learning mechanism. Hence, both will be needed, improvements on the side of reflective mechanisms and in the indirect facilitators. On this basis, the following options for reflective mechanisms could be helpful in order to turn future assessments into permanent learning endeavors:

- External committees *consisting of politically independent personalities whose authority is derived from the institution that requests the evaluation,*
- *Workshops* with independent experts on certain issues,
- *Assessment courts* with a system of judges and lawyers on the contested issues of an assessment,
- *Internal iterative procedures* that lead to internal communication processes and result in a revision of the former assessment process, and
- *Specific task forces* that are charged with evaluating the assessment from inside.

REFERENCES

Adler, Emanuel. 1992. The emergence of cooperation: National epistemic communities and the international revolution of the idea of nuclear arms control. *International Organization* 46(1), pp. 101-145.

Alfsen, Knut and Tora Skodvin. 1998. *The Intergovernmental Panel on Climate Change (IPCC) and scientific consensus. How scientists come to say what they say about climate change.* CICERO Policy Note 1998-03. Oslo: Center for International Climate and Environmental Research.

Agrawala, Shardul. 1999. Early science-policy interaction in climate change: Lessons from the Advisory Group on Greenhouse Gases. *Global Environmental Change* 9, pp. 157-169.

Agrawala, Shardul. 1998a. Context and early origins of the Intergovernmental Panel on Climate Change. *Climatic Change* 39, pp. 605-620.

Agrawala, Shardul. 1998b. Structural and process history of the Intergovernmental Panel on Climate Change. *Climatic Change* 39, pp. 621-642.

Alcamo, Joseph, Roderick Shaw, and Leen Hordijk. 1990. *The RAINS Model of Acidification. Science and Strategies in Europe.* Dordrecht: Kluwer.

Argote, Linda. 1999. *Organizational Learning. Creating, Retaining, and Transferring Knowledge.* Boston: Kluwer.

Argyris, Chris and Donald A. Schön. 1996. *Organizational learning II. Theory, method, and practice.* Reading, MA: Addison-Wesley.

Argyris, Chris. 1990. *Overcoming Organizational Defenses. Facilitating Organizational Learning.* Englewood Cliffs.

Arrhenius, Svante. 1896. On the influence of carbonic acid in the air upon the temperature of the ground. *Phil. Mag.* 41, pp. 237-271.

Beer, Michael and Russel A. Eisenstat. 2000. The silent killers of strategy implementation and learning. *Sloan Management Review* 41(4): 29-40.

Benedick, Richard. E. 1999. *Contrasting Approaches: The Ozone Layer, Climate Change, and Resolving the Kyoto Dilemma.* WZB-discussion paper No. FS II 99-404. Berlin: Wissenschaftszentrum Berlin.

Bennett, Colin J. and Michael Howlett. 1992. The lessons of learning: reconciling theories of policy learning and policy change. *Policy Sciences* 25: 275-294.

Biermann, Frank. 2000. *Science as Power in International environmental Negotiations: Global Environmental Assessments between North and South.* ENRP Discussion Paper 2000-17. Cambridge, MA: John F. Kennedy School of Government, Harvard University (available at: http://environment.harvard.edu/gea/pubs/2000-17.html).

Boehmer-Christiansen, Sonja. 1994a. Global climate protection policy: the limits of scientific advice. Part 1. *Global Environmental Change* 4(2): 140-159.

Boehmer-Christiansen, Sonja. 1994b. Global climate protection policy: the limits of scientific advice. Part 2. *Global Environmental Change* 4(2): 185-200.

Bolin, Bert. 2001. *Telephone Interview with the Author*, March 13th.

Bolin, Bert. 1994a. Science and policy making. *Ambio* 23(4): 25-29.

Bolin, Bert. 1994b. Next step for climate-change analysis. *Nature* 368: 94.

Bower, Gordon H. and Ernest R. Hilgard. 1981. *Theories of Learning*. 5th ed. Englewood Cliffs, NJ: Prentice-Hall.

Breslauer, George W. and Philip E. Tetlock, eds. 1991. *Learning in U.S. and Soviet Foreign Policy*. Boulder, CO: Westview Press.

Bull, Keith. 2001. *Personal Interview with the Author*, Geneva, March 21st.

Bull, Keith. 2000. What are the needs for the revisions of the protocols and strategies on transboundary air pollution? In: Nordic Council of Ministers. *Workshop on Future Needs for Regional Air Pollution Strategies*. Copenhagen: Nordic Council of Ministers, pp. 59-64.

Bull, Keith. 1995. Critical loads – possibilities and constraints. *Water, Air, and Soil Pollution* 85: 201-212.

Bull, Keith. 1992. An introduction to critical loads. *Environmental Pollution* 77: 173-176.

Carnall, Colin A. 1999. *Managing Change in Organizations*. 3rd ed. Harlow: Prentice Hall.

Clark, William C. and Ronald Mitchell, eds. 2002. *Information as Influence: How Institutions Mediate the Impact of Scientific Assesessments on International Environmental Affairs*. Forthcoming.

Clark, William C. and Nancy M. Dickson. 1999. The Global Environmental Assessment Project: Learning from efforts to link science and policy in an interdependent world. *Acclimations* 8: 6-7 (available at: http://environment.harvard.edu/gea/pubs/99art_wc_geaacc.html).

Crampton, Suzanne M., John W. Hodge, and Jitendra M. Mishra. 1998. The informal communication network: Factors influencing grapevine activity. *Public Personnel Management* 27(4): 569-584.

Cutajar, Michael Zammit. 1999. Statement by the executive secretary of the UNFCCC, *Report of the 15th Session of the IPCC*, San José 15-18 April 1999.

Denton, John. 1998. *Organisational Learning and Effectiveness*. London: Routledge.

Eckley, Noelle. 1999. *Drawing Lessons About Science-Policy Institutions: Persistent Organic Pollutants (POPs) under the LRTAP Convention*. ENRP Discussion Paper E-99-11. Cambridge, MA: John F. Kennedy School of Government, Harvard University (available at: http://environment.harvard.edu/gea/pubs/e-99-11.html).

Edwards, Paul N. and Stephen H. Schneider. 2001. Self-governance and peer review in science-for-policy: The case of the IPCC Second Assessment Report. In: Clark Miller and Paul N. Edwards, eds. *Changing the Atmosphere: Expert Knowledge and Environmental Governance*. Cambridge, MA: MIT Press, forthcoming.

Elzinga, Aant. 1997. From Arrhenius to megascience: Interplay between science and public decisionmaking. *Ambio* 26(1): 72-80.

Etheredge, Lloyd S. 1981. Government learning: An overview. In: S.L. Long, ed. *The Handbook of Political Behavior*. Vol. 2. New York: Pergamon.

Executive Body of the Convention on LRTAP. 1999. *Report of the Seventeenth Session*. Geneva: United Nations (available at: http://www.unece.org/env/lrtap/conv/report/ebair68.htm)

Fourier, Baron Jean Baptiste. 1827. Mémoire sur les températures du globe terrestre et des espaces planetaires. *Mémoire de l'Académie des Sciences de l'Institute de France* 7: 572-604.

Franz, Wendy. 1998. *Science, skeptics, and non-state actors in the greenhouse*. ENRP Discussion Paper E-98-18. Cambridge, MA: John F. Kennedy School of Government, Harvard University (available at: http://environment.harvard.edu/gea/pubs/e-98-18.html).

GEA (The Global Environmental Assessment Project). 1997. *A Critical Evaluation of Global Environmental Assessments: The Climate Experience*. Calverton: CARE (available at: http://environment.harvard.edu/gea/pubs/97swr.html).

Granovetter, Mark S. 1973. The strength of weak ties. *American Journal of Sociology* 78(6): 1360-1380.

Groat, Malcolm. 1997. The informal organisation: Ride the headless monster. *Management Accounting* 75(4): 40-42.

Haas, Ernst B. 1991. Collective learning: Some Theoretical Speculations. In: George W. Breslauer and Philip E. Tetlock, eds. *Learning in U.S. and Soviet Foreign Policy*. Boulder, CO: Westview Press.

Haas, Ernst B. 1990. *When Knowledge is Power. Three Models of Change in International Organizations*. Berkeley: University of California Press.

Haas, Peter M. 1992. Introduction: epistemic communities and international policy coordination. In: *International Organization* 46(1): 1-35.

Haas, Peter and David McCabe. 2001. Amplifiers or Dampeners: International Institutions and Social Learning in the Management of Global Environmental Risks. In: The Social Learning Group. *Learning to Manage Global Environmental Risks: A Comparative History of Social Responses to Climate Change, Ozone Depletion and Acid Rain*. Cambridge, MA: MIT Press.

Hall, Peter. 1989. *The Political Power of Economic Ideas: Keynesianism across Nations*. Princeton, NJ: Princeton University Press.

Heclo, Hugh. 1974. *Modern Social Politics in Britain and Sweden: From Relief to Income Maintenance*. New Haven: Yale University Press.

Hergenhahn, B. R. and Matthew H. Olson. 1997. *An Introduction to Theories of Learning*. 5th ed. Upper Saddle River, NJ: Prentice Hall.

Hordijk, Leen. 2001. *Personal Interview with the Author*, Cambridge, January 16th.

Hordijk, Leen. 1988. A model approach to acid rain. *Environment* 30(2): 17-42.

Houghton, John. 2001. *Personal Interview with the Author*, Geneva, March 20th.

Houghton, John. 1998. *Personal Interview with Myanna Lahsen*, Boulder, July 12th.

Houghton, J., L. G. Meira Filho, B. A. Callandar, N. Harris, A. Kattenberg, and K. Maskell, eds. 1996. *Climate Change 1995. The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

IPCC. 1999. Procedures for the preparation, review, acceptance, adoption, approval and publication of IPCC reports. Annex to the *Report on the 15th Session of the IPCC*, San José, 15-18 April 1999. (available at: http://www.ipcc.ch/meet/meet.htm).

IPCC. 1995. *Second Assessment Synthesis of Scientific-Technical Information Relevant to Interpreting Article 2 of the UNFCCC*. Cambridge: Cambridge University Press (available at: http://www.ipcc.ch/pub/sarsyn.htm).

IPCC. 1994. IPCC procedures for preparation, review, acceptance, approval and publication of its reports, Excerpt from the *Report of the 10th Session of the IPCC*, Nairobi, 10-12 November 1994. Geneva: IPCC Secretariat.

IPCC. 1992. *Report of the 8th Session of the IPCC*, Harare, 11-13 November 1992. Geneva: IPCC Secretariat.

IPCC. 1990. *Climate Change. The IPCC Scientific Assessment*. Cambridge: Cambridge University Press.

IPCC. 1989. *Report of the 1st Session of the IPCC Special Committee on the Participation of Developing Countries*, Paris, 28-29 September 1989. Geneva: IPCC Secretariat.

IPCC Bureau. 1997. *Report of the 12th Session of the IPCC Bureau*, Geneva, 3-5 February. Geneva: IPCC Secretariat.

Jagusiewicz, Andrzej. 1999. The history of the Convention on Long-range Transboundary Air Pollution. *Pollution Atmosphérique*, Dec. 1999, pp. 13-21.

Jasanoff, Sheila. 1995. *Science at the Bar: Law, Science, and Technology in America*. Cambridge, MA: Harvard University Press.

Jasanoff, Sheila. 1990. *The Fifth Branch: Science Advisors as Policymakers*. Cambridge, MA: Harvard University Press.

Keck, Margaret E. and Kathryn Sikkink. 1998. *Activists Beyond Borders. Advocacy Networks in International Politics*. Ithaca, NY: Cornell University Press.

Klimecki, Ruediger and Hermann Lassleben. 1998. Modes of organizational learning. Indications from an empirical study. *Management Learning* 29(4): 405-430.

Krackhardt, David and Jeffrey R. Hanson. 1993. Informal networks: The company behind the chart. *Harvard Business Review* 71(4): 104-111.

Lahsen, Myanna. 1998. The detection and attribution of conspiracies: The controversy over chapter 8. In: George E. Marcus, ed. *Paranoia within Reason. A Casebook on Conspiracy as Explanation.* Chicago: The University of Chicago Press.

Leary, Neil. 2001. *Personal Interview with the Author*, Washington D.C., February 27th.

Lee, Kai. 1993. *Compass and Gyroscope. Integrating Science and Politics for the Environment.* Washington D.C.: Island Press.

Levitt, Barbara and James G. March. 1988. Organizational learning. *Annual Review of Sociology* 14: 319-340, reprinted in: Michael D. Cohen and Lee S. Sproull, eds. 1996. *Organizational Learning.* Thousand Oaks: Sage, pp. 516-540.

Levy, Marc. 1993. European acid rain: The power of tote-board diplomacy. In: Peter M. Haas, Robert O. Keohane and Marc A. Levy, eds. *Institutions for the Earth: Sources of Effective International Environmental Protection*. Cambridge: MIT Press, pp. 75-132.

Marquardt, Michael J. 1996. *Building the Learning Organization*. New York: McGraw-Hill.

McCarthy, James. 2001. *Personal Interview with the Author*, Cambridge, MA, March 9th.

McCormick, John. 1998. Acid pollution. The international community's continuing struggle. *Environment* 40(3): 17-45.

McCormick, John. 1997. *Acid Earth. The Politics of Acid Pollution*. London: Earthscan.

Modelski, George. 1990. Is world politics evolutionary learning? *International Organization* 44(1): 1-24.

Moss, Richard. 2001. *Personal Interview with the Author*, Washington D.C., February 27th and 28th.

Moss, Richard. 2000. Ready for IPCC-2001: Innovation and change in plans for the IPCC third assessment report. *Climatic Change* 45: 459-468.

Moss, Richard and Stephen H. Schneider. 2000. Uncertainties. In: R. Pachauri et al., eds. *Guidance Papers on the Cross Cutting Issues of the Third Assessment Report of IPCC*. IPCC Supporting Material, Geneva: IPCC Secretariat.

Moss, Richard and Stephen H. Schneider. 1996. *Characterizing and Communicating Scientific Uncertainty: Building on the IPCC Second Assessment*. Aspen, CO: Aspen Global Institute (available at: http://www.gcrio.org/ASPEN/science/science.html).

Nadeau, Richard, Richard G. Niemi, and Timothy Amato. 1995. Emotions, issue importance, and political learning. *American Journal of Political Science* 39(3): 558-574.

Nordic Council of Ministers. 2000. *Workshop on Future Needs for Regional Air Pollution Strategies.* Copenhagen: Nordic Council of Ministers.

Nordlinger, Eric. 1981. *On the Autonomy of the Democratic State*. Cambridge, MA: Harvard University Press.

North, Douglas. 1990. *Institutions, Institutional Change, and Economic Performance*. New York: Cambridge University Press.

NRC (National Research Council - Board on Sustainable Development). 1999. *Our Common Journey. A Transition toward Sustainability*. Washington D.C.: National Academy Press.

Pachauri, R., T. Taniguchi, and K. Tanaka, eds. 2000. *Guidance Papers on the Cross Cutting Issues of the Third Assessment Report of IPCC*. IPCC Supporting Material. Geneva: IPCC Secretariat.

Parry, Martin. 2001. *Telephone interview with the Author*, March 5th.

Parson, Edward and William C. Clark. 1995. Sustainable development as social learning: Theoretical perspectives and practical challenges for the design of a research program. In: L. H. Gunderson, C.S. Holling, and S. S. Light, eds. *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. New York: Columbia University Press.

Patt, Anthony. 1998. *Analytic Frameworks and Politics: The Case of Acid Rain in Europe*. ENRP Discussion Paper E-98-20. Cambridge, MA: John F. Kennedy School of Government, Harvard University (available at: http://environment.harvard.edu/gea/pubs/e-98-20.html).

Powell, Walter W. 1987. Hybrid organizational arrangements: New forms or transitional development? *California Management Review*, Fall 1987: 67-87.

Primo, Juan Carlos di. 1998. Data quality and compliance control in the European air pollution regime. In: David G. Victor, Kal Raulstiala, and Eugene B. Skolnikoff, eds. *The Implementation and Effectiveness of International Environmental Commitments: Theory and Practice*. Cambridge: MIT Press, pp. 283-303.

Probst, Gilbert and Bettina Büchel. 1997. *Organizational Learning. The Competitive Advantage of the Future*. New York: Prentice Hall.

Ramanathan, V. 1988. The radiative and climatic consequences of the changing atmospheric composition of trace gases. In: F.S. Rowland and I.S.A. Isaksen, eds. *The Changing Atmosphere*. New York: John Wiley & Sons, Ltd., pp. 159-186.

Reiter, Dan. 1994. Learning, realism and alliances: The weight of the shadow of the past. *World Politics* 46(4): 490-526.

Rose, Richard. 1994. *Lesson-Drawing in Public Policy: A Guide to Learning across Time and Space*. Chatham, NJ: Chatham House Publishers.

Rose, Richard. 1991. What is lesson-drawing? *Journal of Public Policy* 11: 1, 3-30.

Sabatier, Paul. 1988. An advocacy coalition framework of policy change and the role of policy-oriented learning therein. *Policy Sciences* 21: 129-168.

Sabatier, Paul. 1987. Knowledge, policy-oriented learning, and policy change. *Knowledge: Creation, Diffusion, Utilization* 8: 649-692

Schein, Edgar H. 1985. *Organizational Culture and Leadership*. San Francisco: Jossey-Bass.

Schneider, Stephen H. 2001. *Telephone Interview with the Author*, March 5th.

Schneider, Stephen H. 1991. Three reports of the Intergovernmental Panel on Climate Change. *Environment* 33(1): 25-30.

Schreyögg, Georg, ed. 2000. *Organisatorischer Wandel und Transformation*. Wiesbaden: Gabler.

Schreyögg, Georg. 1999. *Organisation. Grundlagen moderner Organisationsgestaltung*. 3. Aufl. Wiesbaden: Gabler.

Schunk, Dale H. 1996. *Learning Theories: An Educational Perspective*. 2nd ed. New York: Merrill.

Schwandt, David R. and Michael J. Marquard. 2000. *Organizational Learning. From World-Class Theories to Global Best Practices*. Boca Raton: St. Lucie Press.

Senge, Peter. 1990. *The Fifth Discipline. The Art and Practice of the Learning Organization*. New York: Doubleday.

Simon, Herbert A. 1991. Bounded rationality and organizational learning. *Organization Science* 2(1). Reprinted in: Michael D. Cohen and Lee S. Sproull, eds. 1996. *Organizational Learning*. Thousand Oaks: Sage, pp. 175-187.

The Social Learning Group. 2001. *Learning to Manage Global Environmental Risks: A Comparative History of Social Responses to Climate Change, Ozone Depletion and Acid Rain*. Cambridge, MA: MIT Press (available at: http://www.ksg.harvard.edu/sl).

Sundararaman, Narasimhan. 2001. *Telephone Interview with the Author*, June 25th.

Swanson, Timothy and Sam Johnston. 1999. *Global Environmental Problems and International Environmental Agreements*. Cheltenham: Edward Elgar.

Swenson, Leland C. 1980. *Theories of Learning*. Belmont, CA: Wadsworth.

Tuinstra, Willemijn, Leen Hordijk, and Markus Amann. 1999. Using computer models in international negotiations. The case of acidification in Europe. *Environment* 41(9): 33-42.

Tyndall, J. 1863. On radiation through the earth's atmosphere. *Phil. Mag*. 4: 200-207.

UNECE. 1999. *Future Priorities. Note by the Bureau*. Geneva: Executive Body for the Convention on Long-range Transboundary Air Pollution, EB.AIR/1997/3.

UNECE. 1998. *Strategies and Policies for Air Pollution Abatement. Major Review*. Geneva: United Nations.

UNECE. 1994. *Strategies and Policies for Air Pollution Abatement. 1994 Major Review*. Geneva: United Nations.

UNECE. 1979. *Convention on Long-range Transboundary Air Pollution*. Geneva: United Nations.

VanDeveer, Stacy D. 1998. *European Politics with a Scientific Face: Transition Countries, International Environmental Assessment, and Long-Range Transboundary Air Pollution*. ENRP Discussion Paper E-98-09. Cambridge, MA: John F. Kennedy School of Government, Harvard University (available at: http://environment.harvard.edu/gea/pubs/e-98-09.html).

Wasserman, Stanley and Katherine Faust. 1994. *Social Network Analysis. Methods and Applications*. Cambridge: Cambridge University Press.

Watson, Robert T. 2001. *Telephone Interview with the Author*, March 8th.

Watson, Robert T. 1997. White Paper on the Third Assessment Report and the IPCC Bureau, Annex to the *Report of the 12th Session of the IPCC Bureau*, Geneva, 3-5 February 1997.

Watson, Robert T., Ian R. Noble, Bert Bolin, N. H. Ravindranath, David J. Verardo, and David J. Dokken. 2000. *Land Use, Land-Use Change, and Forestry*. Cambridge: Cambridge University Press.

Wüster, Henning. 2001. *Personal Interview with the Author*, Geneva, March 1st.

FIGURES

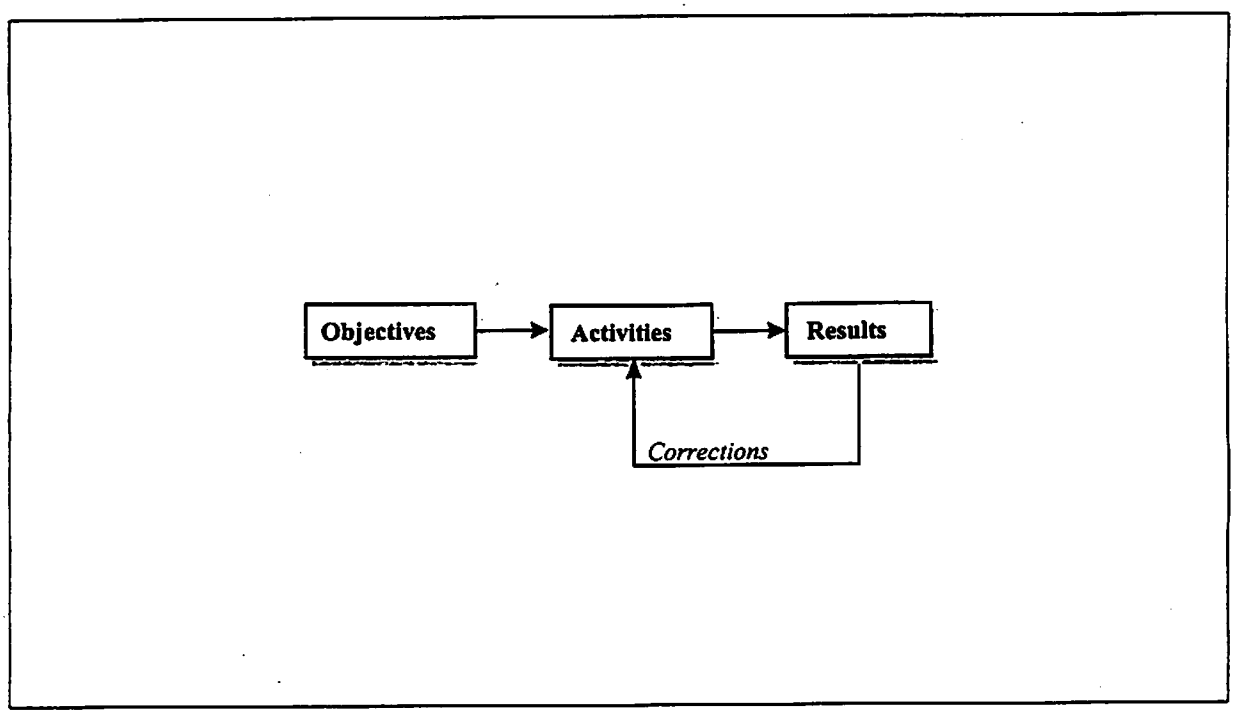

Figure 1: Single-Loop Learning (Source: Probst/Büchel 1997)

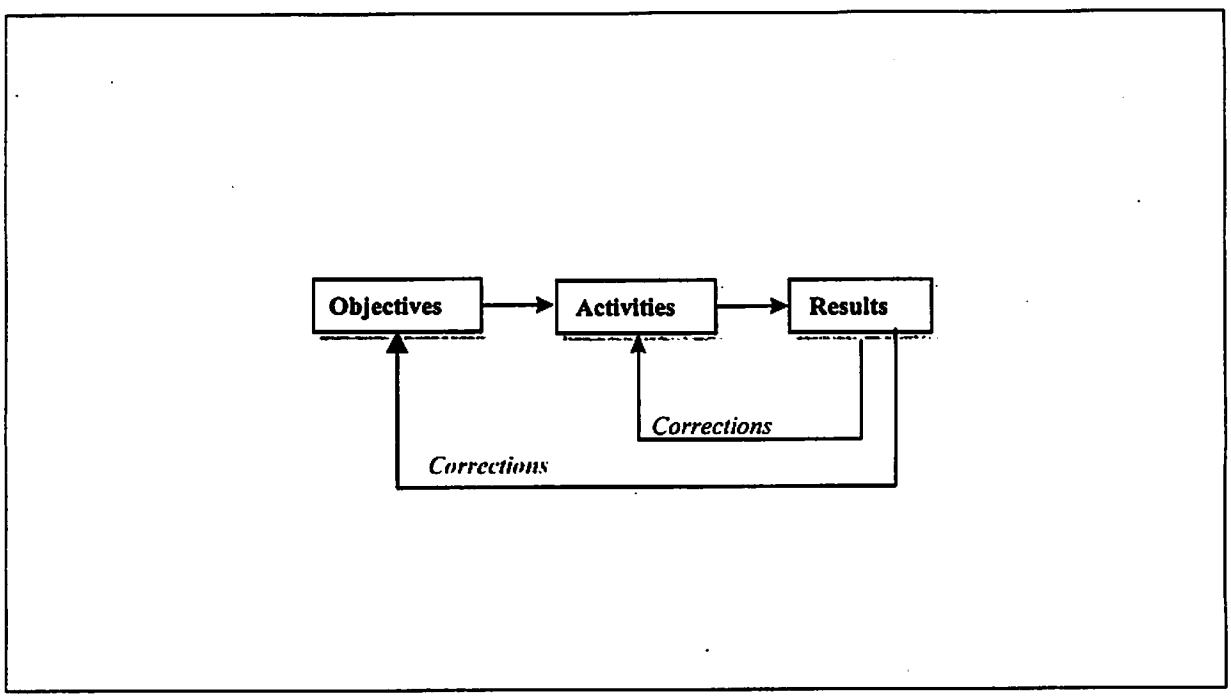

Figure 2: Double-Loop Learning (Source: Probst/Büchel 1997)

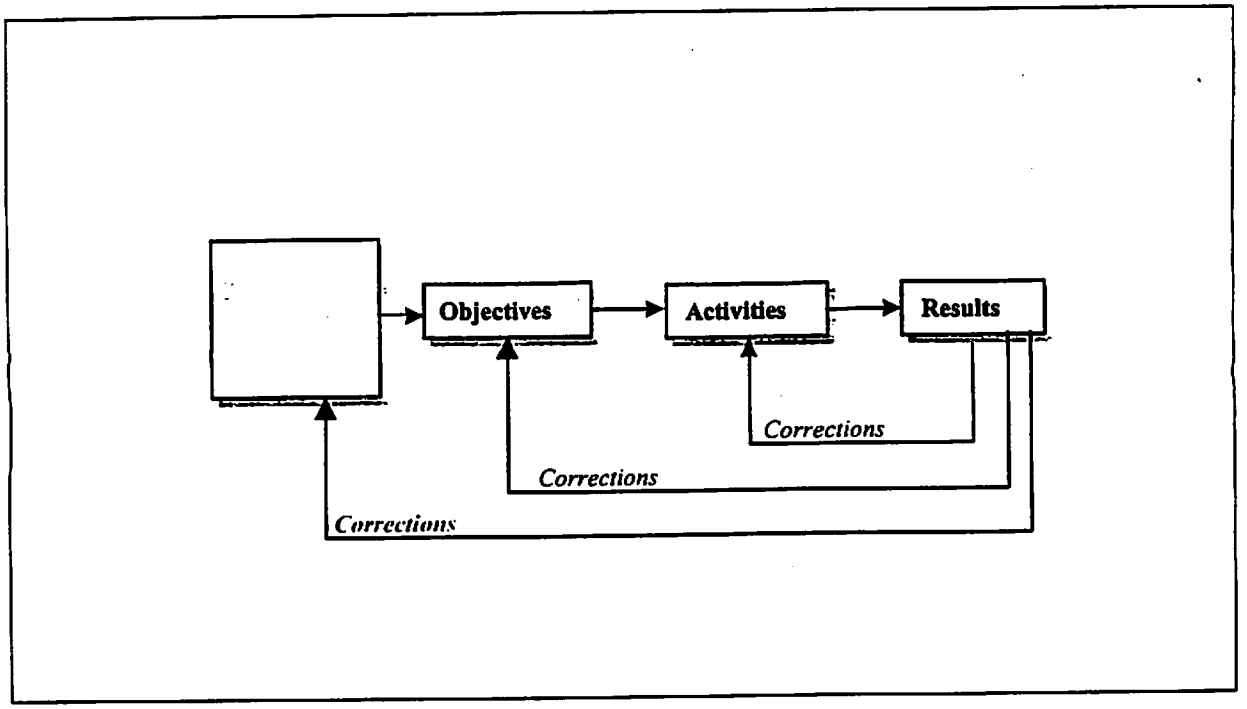

Figure 3: Double-Loop Learning (Source: Probst/Büchel 1997)

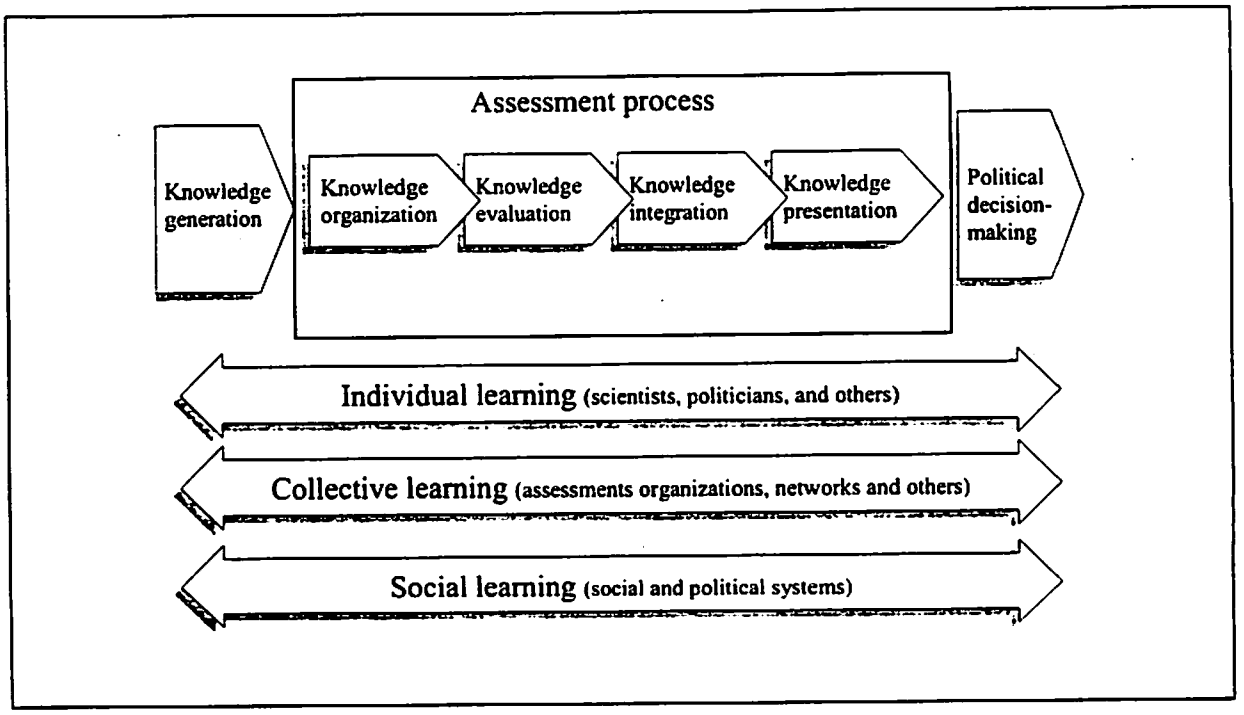

Figure 4: Assessment process and learning

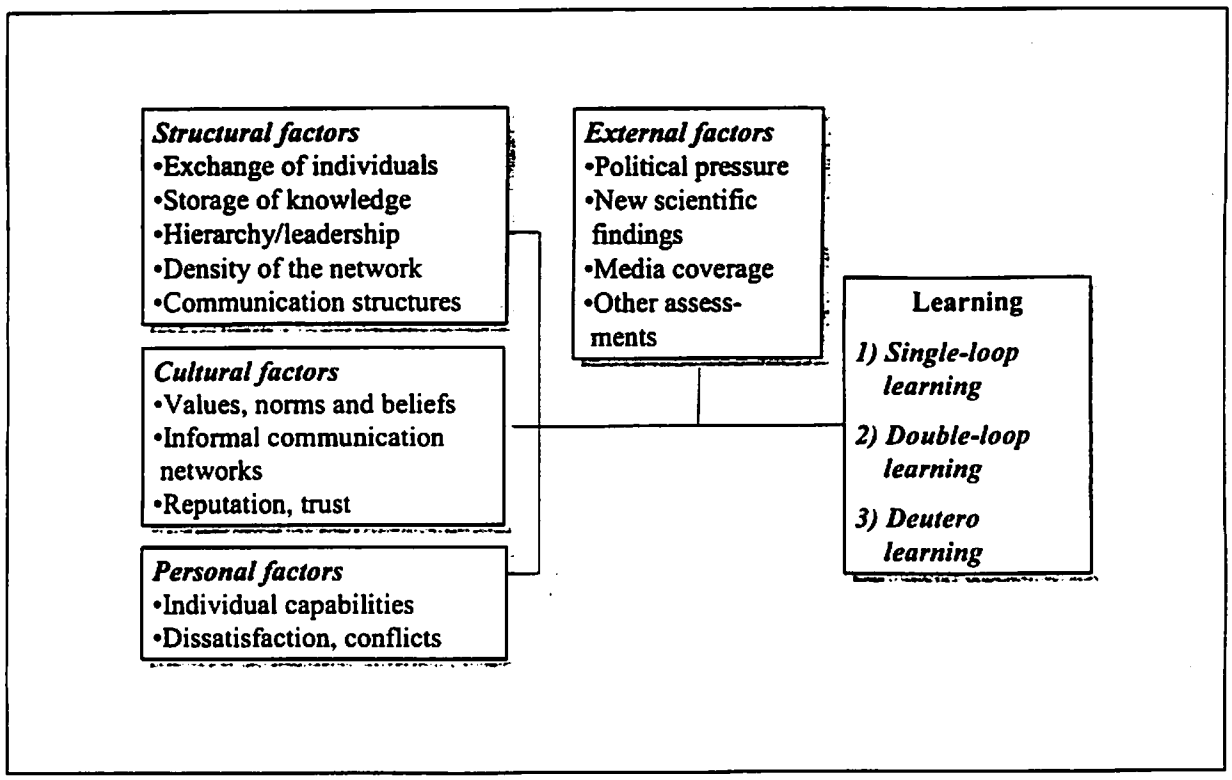

Figure 5: Conceptual framework

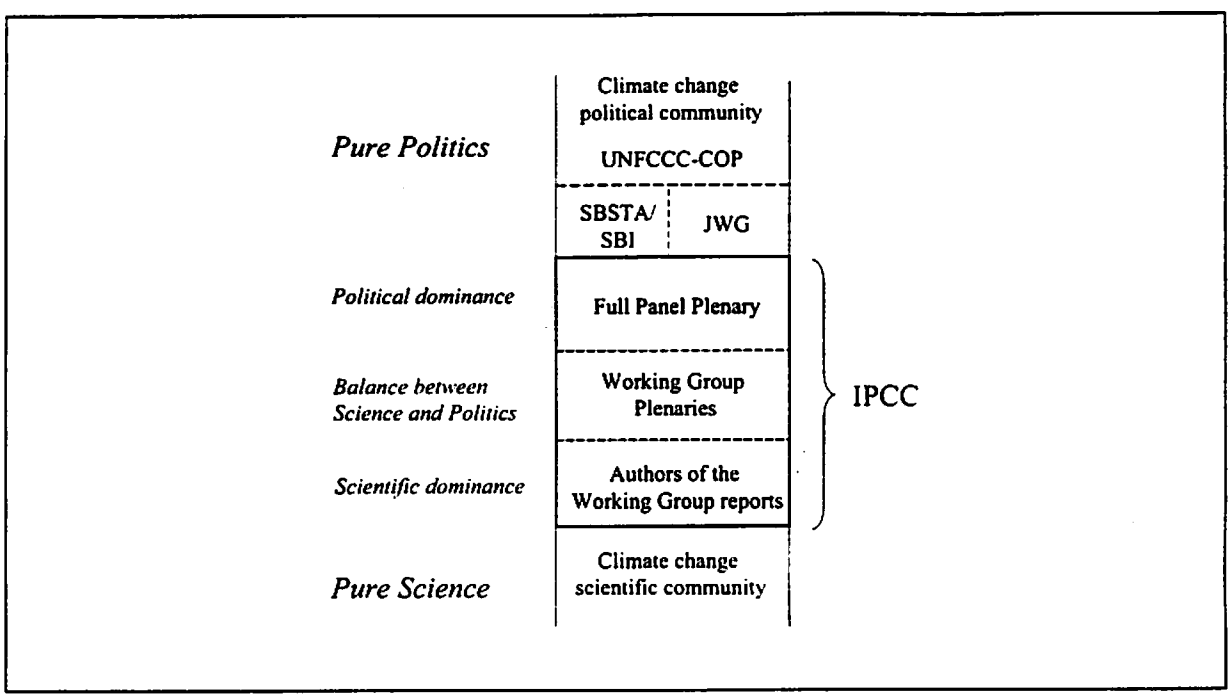

Figure 6: The Science-policy interface within the IPCC (based on Alfsen & Skodvin 1998)

ENDNOTES

[1] For contributions focusing predominantly on domestic politics see Etheredge (1981), Sabatier (1987, 1988), Hall (1989), Rose (1991, 1994). Studies of learning in international relations and comparative studies of different countries can be found in Adler (1992), Breslauer & Tetlock (1991), Heclo (1974), Haas (1990), Modelski (1990), Nadeau et al. (1995), and Reiter (1994). A meta-analysis of preexisting approaches on policy learning is included in Bennett and Howlett (1992).

[2] For general overviews on theories of learning see Bower & Hilgard (1981), Hergenhahn & Olson (1997), and Schunk (1996).

[3] By referring to changes, most of the definitions oppose the idea of a simple increase in knowledge because there always have to be losses of knowledge at the same time that allow for the acceptance and memorization of new knowledge. Hence, learning is more a change than a steady growth of the knowledge of the learning system. Some interesting questions are ingrained in this idea: In which way do learning and unlearning relate to each other? How far does learning require unlearning? Can unlearning of one thing preclude learning of another? When is unlearning desirable, even for assessments? In more practical language, how could unlearning be initiated in cases of ill-conceived, but well rehearsed, familiar, and institutionalized methods and procedures? How do I make people realize that they need to unlearn? Should they be aware of this need, or is it enough if they simply do? Given the scope of this study, these questions could hardly be answered sufficiently and further research will be necessary to provide answers to them.

[4] For related studies see Argote (1999), Argyris (1990), Argyris/Schön (1996), Carnall (1999), Denton (1998), Schwandt/Marquard (2000), Schreyögg (1999, 2000), and Senge (1995).

[5] In assessments, most of the participants play a scientific role, but there are other roles as well, such as connections to the policy community, communication and media, project management, etc. In these cases different standards have to be applied.

[6] The first mentioning of the possibility of a greenhouse effect could be found at Fourier (1827). The idea was taken up by Tyndall (1863) and was linked to anthropogenically produced carbon emissions by Arrhenius (1896). A general overview about the history of scientific debate on the climate problem could be found in Agrawala (1998a), Alfsen & Skodvin (1998), Bolin (1994a), and Ramanthan (1988).

[7] The IPCC has been described in its structure and evolution over time by Agrawala (1998a, 1998b), Alfsen & Skodvin (1998), Boehmer-Christiansen (1994a, 1994b), and Franz (1998). An overview could also be obtained on the internet at http://www.ipcc.ch.

[8] The evolution of the Working Group structure could be demonstrated by the changes in the titles of the Working Groups over the three assessment reports. Working Group I was called "The Scientific Assessment of Climate Change" in 1990 and amended its title to "The Science of Climate Change" in 1995 and kept it for the third assessment. Hence, the thematic scope of Working Group I remained largely the same. The other Working Groups, by contrast, underwent more significant changes in their thematic foci. Working Group II was entitled "Impacts Assessment of Climate Change" in 1990 and changed its title to "Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses" in 1995 and to "Impacts, Adaptation, and Vulnerability" in the third assessment report. While the issues of mitigation were incorporated in this Working Group's contribution to the second assessment, it was given to Working Group III in the third assessment. Working Group III in the first assessment was charged with "Response Strategies" and with the more general "Economic and Social Dimensions of Climate Change" in 1995. Since considerable overlaps had been detected especially concerning economic issues of adaptation and mitigation (Watson 1997), Working Group III was restructured in the third assessment to focus on nothing else but on mitigation and its scientific, technical, environmental, economic and social aspects.

[9] After the successful closure of the ozone negotiations in 1985 in Vienna and 1987 in Montreal the then UNEP director Mustafa Tolba was reported to be outspokenly optimistic to be able to repeat the ozone 'miracle' for climate (Agrawala 1998a).

[10] For example, co-chairs in the first assessment reportedly "didn't have much of an idea themselves" how to organize the assessment process. Since there was "not much centrally planned" and hardly any rules were available, one author summarized, "We made them up as we went along" (Parry 2001).

[11] Initially, the IPCC took over the general rules of procedure from the WMO. The first set of rules of procedure that were specific to the IPCC was formally approved in 1991 and filled only one page (Bolin 2001). At the end of the third assessment the document was 16 narrowly printed pages long (IPCC 1999).

[12] Schneider (1991, p. 25) refers to a discussion with Bert Bolin, the first chairman of the IPCC, in which the latter clearly delineates this aim of the IPCC work: "Bolin agreed that the diversion of talent and resources was not a trivial cost, but he emphasized the international aspect of the study. 'Right now, many countries, especially developing countries, simply don't trust assessments in which their scientists and policymakers have not participated,' he said. 'Don't you think credibility demands global representation?'"

[13] The Committee thought of scientists, high-ranking public officials, business leaders and representatives from the media in the respective countries (IPCC 1989).

[14] Alike other UN processes, non-governmental organizations are only allowed to attend negotiations under the Framework Convention on Climate Change (FCCC) – the so-called Conferences of the Parties – as observers not as negotiating parties.

[15] At the sixth session of the IPCC in early 1991 discussions developed and resulted in the suggestion to prepare a supplementary report for the preparation of a framework convention to be signed at the Rio conference in 1992 (Bolin 2001).

[16] This opinion was expressed by nearly all of the interviewees involved in the IPCC process. Although, they admitted that there have been considerable discussions and arguments at the plenary sessions over the wording of the summaries for policy makers, they said that the conflict resolution mechanisms in place worked out and lead to a neutralization of extreme positions among the government delegations. Due to the consensus principle all delegates have to agree to the final wording. Opposing positions have to be explained in the plenary session and if no compromise can be found, the discussion will be continued in smaller contact groups. Although this mechanism in most cases delivers acceptable solutions, sometimes certain countries try to push forward their claims even further. If absolutely no compromise can be found, a dissenting vote will be included in the text but since the dissenter has to be mentioned here, countries usually dislike to fall back on this option – in particular because it is mostly the same small number of countries with clear political or economic interests, like the major oil producing countries, that try to weaken certain statements in the report (for examples cf. footnotes in IPCC 1995). Therefore, they have to fear loss of reputation and credibility when they cannot provide sufficient scientific or technical arguments for their positions. Experience has thus shown that these procedures could not lead to significant changes or weakening of the final documents (Schneider 2001).

[17] The group was founded in 1993 based on an initiative by IPCC chairman Bert Bolin. After the first Conference of the Parties under the FCCC in 1995, it acquired its current title as IPCC/UNFCCC Joint Working Group (Agrawala 1998b).

[18] For instance, the Joint Working Group initiated the introduction of new types of specialized IPCC reports, the so called technical papers and the special reports on critical issues.

[19] An extensive analysis of the chapter-8-debate can be found in Lahsen (1998). An in-depth study of the arguments concerning peer-review put forward in this discussion is included in Edwards and Schneider (2001).

[20] The IPCC distinguishes between the "approval" of a document and its "acceptance". The acceptance builds on the review procedures and is merely a formal acknowledgement of the main body of the Working Group report by the Working Group Plenary. Approval, by contrast, requires the line-by-line discussion and agreement from all government delegates (IPCC 1999).

[21] This paper was based on a workshop at the Aspen Global Change Institute in 1996 (see Moss & Schneider 1996). For an overview of the related issues see Moss (2000).

[22] In particular, in the third assessment the selection of authors was a highly demanding process. In Working Group II, for example, co-chairs had to choose the 80 authors required from about 1100 nominations from governments (McCarthy 2001).

[23] Since the approval of the Synthesis Reports of the first and second assessment lead to major discussions that could hardly be consensually concluded, the procedures concerning the Synthesis Report have been changed in the third assessment. Firstly, it addresses a list of key questions that have been developed in consultation with officials from the negotiating bodies of the FCCC (see http://www.ipcc.ch/activity/tarquestion.html). Secondly, the Synthesis Report will be split into a longer document that has to undergo a hitherto unknown section-by-section approval process whereas the more focused Summary for Policymakers of the Synthesis Report has to be approved line-by-line which means in practice a word-by-word approval, according to participants in the plenary sessions (IPCC 1999).

[24] For an overview of the different bodies and organizational connections under the convention see http://www.unece.org/env/lrtap/welcome.html.

[25] The evolution of the political processes under the LRTAP convention, the protocols and their effectiveness has analyzed by Levy (1993), McCormick (1997, 1998), Primo (1998), Swanson & Johnston (1999), and Haas & McCabe (2001).
[26] For a historical overview of the political processes under the convention see Jagusiewicz (1999).
[27] EMEP has already been established in 1977 under the auspices of the UNECE, WMO and UNEP but its funding remained insecure until the first protocol under the LRTAP convention had been signed.
[28] These international cooperative programmes are the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests), the International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes (ICP Waters), the International Programme on Effects of Air Pollution on Materials, Including Historic and Cultural Monuments (ICP Materials), the International Cooperative Programme on Effects of Air Pollution on Crops (ICP Crops), the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP IM), and the International Cooperative Programme for Mapping Critical Loads and Levels and their Exceedances (ICP Mapping)
[29] For some examples of these maps see http://www.rivm.nl/cce/.
[30] The model and its submodels are described by Hordijk (1988) and Alcamo et al. (1990). The integration of the model in the political processes is discussed by Tuinstra et al. (1999).
[31] For example, at that time even the scientific delegations from eastern European countries did not accept scientists from the West-German Federal Environmental Agency (Umweltbundesamt) located in Berlin as formal representatives of the Federal Republic of Germany since they regarded West-Berlin not as part of Western Germany. They claimed that this had to be made clear in any internal document (Hordijk 2001).

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